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The influence of the methods of primary tillage on the biological activity of ordinary chernozem

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Abstract. The article discusses topical issues related to the improvement of the main tillage systems for agricultural crops. The authors draw attention to the general problem of agricultural soil degradation caused by depletion as a result of prolonged non-rational use. The perennial studies conducted by the authors are aimed at preserving soil fertility by reducing the mechanical load on the soil cover. The results of the research make it possible to evaluate the effect of treatments on the activity of the microbial community, one of the main indicators of the orientation of soil-forming processes of chernozem soil types.

1. Introduction

Obtaining high stable yields of agricultural crops with the maximum possible reduction of the cost of their cultivation while maintaining soil fertility is a priority task of modern agriculture.

One of the main ways to solve it is to improve the tillage systems in order to reduce energy consumption and negative mechanical impact on the soil. According to a number of scientists, surface treatment, as compared with plowing, does not cause significant differences in the agrophysical properties of the soil [1-3]. Many scientists have concluded that the most rational is the combination of surface with traditional methods of tillage [4-7]. Microorganisms as part of the terrestrial ecosystem occupy a key position in the flow of energy and the cycle of nutrients, determine the biochemical potential of the soil. Microorganisms and their metabolites allow early diagnosis of any environmental changes, which is important when predicting changes under the influence of natural and anthropogenic factors, control over the state of soil microflora is a necessary condition for the maintenance and reproduction of fertility when developing new technologies in agriculture.

In this regard, when evaluating various methods of primary tillage, it is important to identify their influence on the biological activity of the arable layer.

The article discusses the possibilities of minimizing tillage for spring wheat in the forest-steppe conditions of the Middle Volga region of the Samara region.

2. Objects, terms and methods of research

Microbiological and biochemical studies were conducted in 2005-2015 during the field experiment laid down in 2003 in a five-field grain-pair crop rotation with the following crop alternation: pure steam, winter wheat, soybean, spring wheat, barley in spring wheat crops in the experimental fields of the



Department of Agriculture, Soil Science, Agrochemistry and Land Cadastre of the Samara State Agrarian University. In order to study the long-term minimization of tillage, three variants of basic tillage are studied. The soil of the plot is black heavy ordinary loamy medium humus soil.

Spring wheat in crop rotation is cultivated according to the following main tillage options:

- Plowing at 20-22 cm;
- Shallow ripping 10-12 cm;
- Zero processing

The selection of the main agronomically useful groups of microorganisms from the soil was carried out by microbiological sowing [8] of soil extraction on solid nutrient media: for micromycetes (mold fungi) - Chapek's medium; for actinomycetes - ammonium starch agar (ASA); for bacteria, meat-peptone agar (MPA) [9]. The average soil samples were taken in three terms (beginning, middle and end of the growing season of the culture) for all variants of the experiment in the topsoil 0-30 cm. Dilution of the soil extract for fungi, actinomycetes and bacteria was 10^3 ; 10^4 ; 10^5 , respectively. Microbiological seeding was carried out in quadruplicate. Peroxidase and polyphenol oxidase enzyme activity was determined according to the generally accepted method [10-11] and expressed in mg of purpurugalline per 1 g of soil, repeated three times. The dynamics of decomposition of plant residues in the soil was carried out by the soil monolith method. Soil samples were taken in two terms: before sowing and after harvesting crops to a depth of 0-10, 10-20, 20-30, 30-40 cm. Repetition is threefold.

One of the factors that shape and determine soil fertility is the activity of the microorganisms inhabiting it, whose active surface reaches several hundred hectares per 1 hectare of the surface of the arable layer of soil. An important role in the creation of soil fertility is the number of the main groups of microorganisms, which, being catalysts of metabolism, objectively reflect the nature of biochemical processes. When analyzing the total biogenicity of the soil, it should be noted that changes in the living conditions of microorganisms associated with the use of various soil treatment systems, to a certain extent, bring the microbiocenosis from equilibrium. The number of soil fungi - destructors of organic matter, which are obligate aerobes, was the highest in the variant peeling with plowing 23.81 thousand CFU / g ab.s.p. their distribution over the soil layers was more uniform than in the other two studied variants. This is due to the fact that in the process of plowing, the water-air properties of the soil are improved, which creates favorable conditions for the development of fungi in the topsoil. With loosening and zero treatment, favorable conditions for soil fungi were formed in a layer of 0-10 cm and 0-5 cm, which corresponded to 21.93 thousand CFU/g ab.s.p. and 20.88 thousand CFU/g ab.s.p. (table 1).

Table1. The biogenicity of the soil in spring wheat crops, depending on the main processing (average for 2005-2015).

Main tillage	Soil layer	Fungi, thous. CFU/g ab.s.p.	Bacteria, mln. CFU/g ab.s.p.	Actinomycetes, mln. CFU/g ab.s.p.	Total biogenicity, mln. CFU/g ab.s.p.
Plowing at 20-22 cm	0-5	29,52	4,12	2,08	6,22
	5-10	22,45	2,52	2,33	4,87
	10-20	23,54	2,44	1,72	4,18
	20-30	19,73	2,27	2,18	4,46
	0-30	23.81	2,84	2,08	4,94
Loosening at 10-12 cm	0-5	27,80	2,97	1,99	4,98
	5-10	25,56	1,79	2,13	3,94
	10-20	16,71	1,60	2,32	3,93
	20-30	17,68	1,90	1,53	3,44
	0-30	21.93	2,07	1,99	4,08
Zero tillage	0-5	35,31	3,64	3,74	7,41
	5-10	18,32	2,59	1,83	4,43

10-20	15,63	1,66	2,61	4,28
20-30	14,28	1,94	3,14	5,09
0-30	20,88	2,46	2,83	5.31

Determining the quantitative composition of the number of bacteria and actinomycetes revealed the following pattern, expressed in reducing the number of these groups of microorganisms in the form of a soilless loosening. Actinomycetes develop on the half-life of organic matter, followed by fungi and bacteria, producing melanins, the precursors of humic substances. The highest abundance of actinomycetes was noted in the zero-processing variant of 2.83 million CFU/g ab.s.p., which led to a sharp increase in the total biogenicity in this variant - 5.31 million CFU/g ab.s.p.

The highest degree of decomposition of cellulose on average for the years 2005-2015 was marked in the variant of plowing at 20-22 cm, and when loosening at 10-12 cm and zero tillage, a decrease of 5 and 8%, respectively, is observed (table 2).

Table 2. Cellulose decomposing activity in the soil layer of 0-30 cm depending on the main tillage,% (average for 2005-2015).

Main tillage	% of linen cloth decomposition			
	0-10	10-20	20-30	0-30
Plowing at 20-22 cm	18.3	19.6	18.2	18.7
Loosening at 10-12 cm	17.4	13.1	10.2	13.5
Zero tillage	15.1	9.1	7.9	10.7
Average	16.9	13.9	12.1	14.3

The regularity is traced by the layer-by-layer indicators of the cellulose-decomposing activity of the soil depending on the method of primary processing, so in the variant with plowing, the intensity of decomposition of flax cloth was almost uniform throughout the topsoil 0-30 cm, and with zero treatment, more active decomposition was noted in the upper 10 centimeter layer. The decrease in the cellulose-decomposing ability of the soil during its surface treatment can be explained by a decrease in the degree of soil aerobicity, and the microflora that carries out the decomposition of cellulose is mainly represented by aerobic forms - these are mold fungi and cellulose-decomposing bacteria.

A necessary condition for humus formation is the continuous flow of plant residues into the soil and their microbiological transformation. A major role in regulating the transformation of plant residues is assigned to the main tillage. By applying various methods and depths of processing, it is possible to influence the speed of microbiological processes and decomposition of organic matter, therefore, the supply of available nutrients for plants and the formation of soil organic matter. Therefore, when evaluating various agrotechnical methods, it is necessary to take into account their influence on the flow, as well as the speed and specificity of the transformation of organic residues.

The determination of plant residues on average over the years of research shows that they are quite intensively decomposed in the 44% plowing variant, which is likely due to the transformation of organic matter throughout the topsoil and an increase in the number of soil fungi. The decomposition of plant residues in the version with shallow cultivation and zero treatment was slower and amounted to 36% and 31%, respectively. Moreover, with zero treatment, organic residues were localized in a layer of 0–10 cm, which apparently slowed down their transformation (figure 1).

A positive correlation was established between the data on the decomposition of organic matter and the total number of microorganisms ($r = 0.76$).

Peroxidase and polyphenol oxidase are the main agents for the humification of lignins, which make up 15-30% of the dry matter of plant residues entering the soil. These enzymes catalyze the oxidation of aromatic compounds and their derivatives to quinones, which enter into condensation reactions with amino acids and peptides to form primary molecules of humic acids.

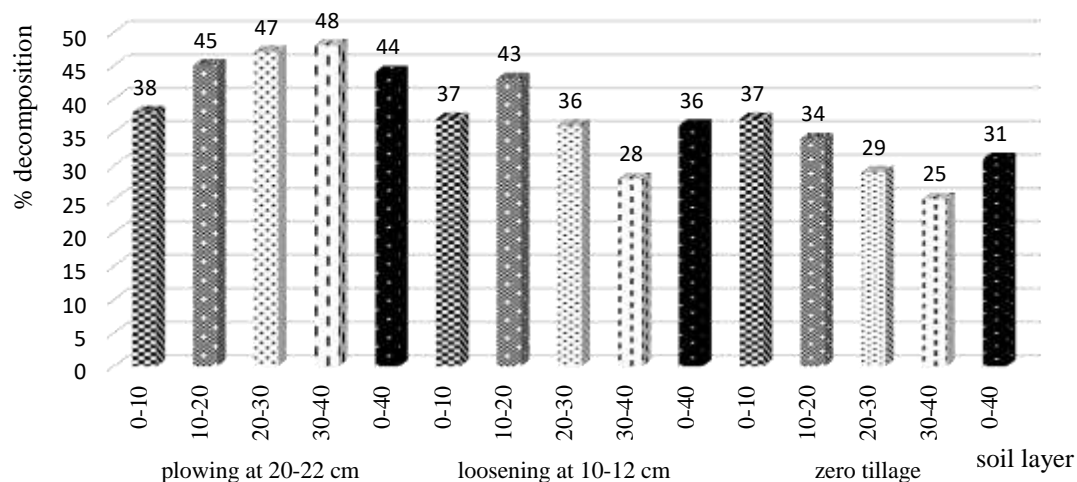


Figure 1. The decomposition of plant residues depending on the main tillage, % (average for 2005-2015).

On average over the years of research, the activity of the enzyme peroxidase was significantly higher in the variants of loosening and plowing compared with zero treatment. (table 3).

Table 3. Peroxidase and polyphenol oxidase enzyme activity in a soil layer of 0-30 cm, depending on the main tillage, mg/100g of soil.

Main tillage	2013	2014	2015	Average for 2005-2015
Peroxidase enzyme activity				
Plowing at 20-22 cm	0.666	0.653	0.739	0.686
Loosening at 10-12 am	0.701	0.618	0.677	0.665
Zero tillage	0.504	0.465	0.643	0.537
Polyphenol oxidase enzyme activity				
Plowing at 20-22 cm	1.345	0.587	1.008	0.976
Loosening at 10-12 am	1.561	0.645	1.214	1.140
Zero tillage	1.702	0.585	1.365	1.217

The indicators of the activity of the enzyme polyphenol oxidase, on the contrary, increase in the variants with zero treatment, which may be indicative of the directionality of the soil processes associated with the synthesis of humic molecules.

3. Conclusion

When studying the feasibility and effectiveness of various methods of primary tillage, there was a positive effect of zero tillage on the growth of actinomycetes, and, on the other hand, a decrease in the number of soil fungi, which can be attributed to the deterioration of subsurface aeration. The decrease in the number of fungal microflora led to a decrease in the level of cellulose-decomposing activity and slowing down the decomposition of plant residues in the variant with zero treatment, while the indicators of enzymatic activity indicate a positive effect of zero treatments on the stabilization of organic matter in the soil.

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