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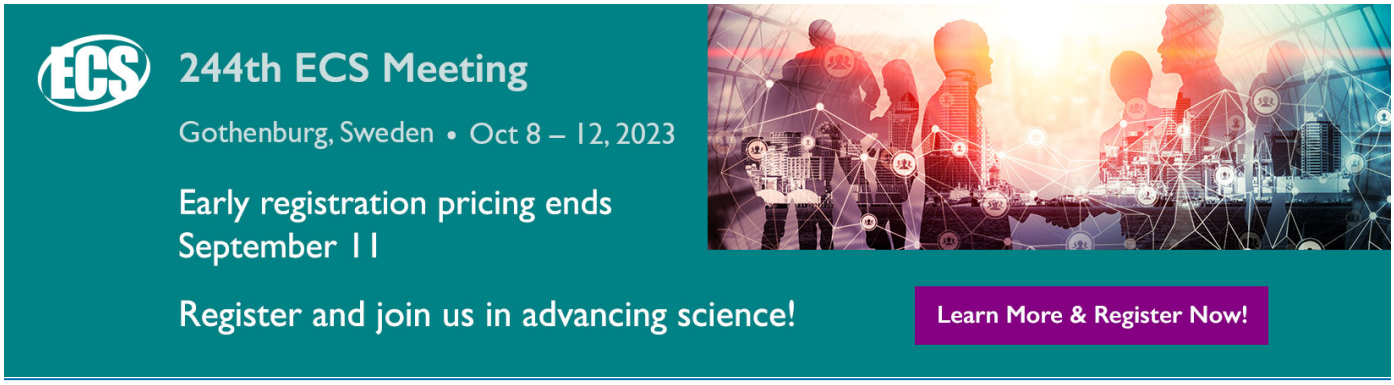

The influence of the systems of basic tillage and biological products on the agrochemical properties of the soil and productivity of field crops

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Abstract. The agrochemical properties of the soil make it possible to assess the level of its fertility. The search for new forage crops is an urgent task in agriculture. Under the conditions of a high anthropogenic impact of man on soils through the introduction of mineral fertilizers and pesticides, the use of biological products in the cultivation of field crops is a solution to most environmental problems in the soil. This article presents materials on the study of the influence of various systems of basic soil cultivation and biological products on the agrochemical properties of the soil, as well as the productivity of field crops. The content of organic matter, the content of mobile phosphorus, the content of exchangeable potassium, hydrolytic and exchangeable acidity, and the amount of absorbed bases were determined. The yield of green mass and the yield of feed units of new promising crops for the soil and climatic conditions of the Yaroslavl region - soybeans, amaranth and buckwheat - were assessed. The studies were carried out under the conditions of a field stationary three-factor experiment on sod-podzolic medium loamy gley soil of the experimental field of the Yaroslavl State Agricultural Academy. The positive role of using Baikal EM-1 in the system of moldboard processing in buckwheat crops is shown. In this case, there is an improvement in most agrochemical indicators of fertility and it is possible to obtain maximum productivity.

1. Introduction

Agrochemical properties of the soil are a combination of the chemical properties of the soil that determine the regime of nutrients, the transformation of applied fertilizers and the conditions for plant nutrition [1-2]. The main indicators are: the content of humus, mobile forms of macro- and microelements, their gross reserves, acidity, redox potential, buffering capacity, absorption capacity, absorbed cations and the degree of saturation with bases [3-4].

The main technological operation in agriculture is tillage [5]. Its main task is to create optimal conditions for the cultivation of agricultural crops. It has been established by theory and verified by practice that a rational system of tillage in crop rotations contributes to the preservation and increase of soil fertility [6].

Soil cultivation is used to incorporate mineral and organic fertilizers, weeds, and stubble residues of previous crops [7].

According to various authors, it has been proven that for processing from 30-35% of energy and from 20-35% of labor costs used in the cultivation of crops [7-8]. At the same time, it should be noted

that not all even the most pressing issues of soil cultivation have been fully resolved in theoretical and practical aspects. The main ones are questions about the methods and depth of tillage [9]. Heated debates about the advantages of moldboard and non-moldboard, shallow and deep tillage have been going on from the very beginning of the emergence of agriculture [10]. These issues have not been resolved to this day either. Consequently, the problem of developing optimal and rational systems of soil cultivation is still urgent.

One of the most acute problems of agriculture is the preservation of soil fertility by timely control of changes in their properties [12]. The current level of soil fertility is determined by a complex of the main factors of the farming system, among which are the structure of crop rotation, processing, fertilizers and plant protection products [13].

For the agricultural sector of the Russian Federation, the development of animal husbandry is one of the main directions for the formation of a full-fledged food market. An increase in livestock production and an increase in its efficiency is impossible without a solid forage base. Unconventional forage crops can help agricultural production achieve high yields of good quality.

One of the directions of the intensification of crop production, which is based on ecological principles, is the use of various biological products in the cultivation of crops. The use of biological products leads to an increase in plant growth due to a decrease in the stress effect of unfavorable environmental conditions, contributes to a more complete disclosure of the potential of the variety, which refers to both quantitative and qualitative indicators of agricultural products [14].

The yield of agricultural crops depends on many conditions and factors, such as the content of humus, the level of nutrients, physical and chemical properties, and others [15]. However, there is no deep study of the influence of agricultural practices on the change in fertility factors. We are considering the results of studies on the influence of processing, biological products and crops on the agrochemical properties of the soil and the yield of field crops.

2. Materials and methods

The work was carried out in 2019 on the experimental field of the Yaroslavl State Agricultural Academy on sod-podzolic medium loamy gley soil.

Scheme of a field stationary three-factor experiment:

Factor A. Culture group, "K":

- Legumes (in 2019 - soybeans), "K_1";
- Row crops (in 2019 - amaranth), "K_2";
- Spring cereals (in 2019 - buckwheat), "K_3".

Factor B. System of basic tillage, "O":

- Plowing, "O_1";
- Surface tillage, "O_2".

Factor C. Biological product, "B":

- Without biological product, "B_1";
- Biological product 1 (2019 - Baikal EM-1), "B_2";
- Biological product 2 (2019 - Potassium humate), "B_3".

The weather conditions of the growing season in 2019 were distinguished by increased temperature indicators at the beginning of the growing season (May-June) and decreased at the end (July-August), while the amount of precipitation significantly differed from the average long-term observations in July - the excess was 77%. In general, meteorological conditions can be characterized as atypical.

The content of organic matter in the soil was determined by the method of I.V. Tyurin in the modification of TsINAO. The content of mobile phosphorus and exchangeable potassium was determined by the Kirsanov method as modified by TsINAO. Exchangeable acidity was determined by potentiometric method. Hydrolytic acidity was determined by the Kappen-Gilkovits method. The amount of absorbed bases was determined by the Kappen-Gilkowitz method. The yield is taken into account by a continuous plot method, taking into account humidity and weediness. Crop data are processed by analysis of variance.

3. Results

On average, for the factors of the studied cultures, there were no significant differences in the content of organic matter, with the highest value for the variant with amaranth 3.16%. The application of surface treatment did not cause significant changes (table 1).

Table 1. Influence of the studied factors on the agrochemical properties of sod-podzolic soil.

Variant	Organic matter content, %	Mobile phosphorus content, mg / kg	Exchangeable potassium content, mg / kg	Hydrolytic acidity, mEq / 100 g	Exchangeable acidity, pH	The amount of absorbed bases, mg-eq. / 100 g
Factor A. Culture group, "K"						
Legumes, "K_1"	3.14	174.83	101.41	1.77	5.39	10.53
Row crops, "K_2"	3.16	176.89	99.86	2.01	5.32	10.91
Spring cereals, "K_3"	3.13	186.50	91.31	1.94	5.33	11.12
LSD_{05}	$F_f<F_{05}$	6.97	$F_f<F_{05}$	0.08	$F_f<F_{05}$	0.16
Factor B. System of basic tillage, "O"						
Plowing, "O_1"	3.10	173.83	99.08	1.87	5.36	10.89
Surface tillage, "O_2".	3.18	184.98	95.97	1.94	5.33	10.82
LSD_{05}	$F_f<F_{05}$	$F_f<F_{05}$	$F_f<F_{05}$	$F_f<F_{05}$	$F_f<F_{05}$	$F_f<F_{05}$
Factor C. Biological product, "B"						
Without biological product, "B_1";	3.06	167.03	93.68	1.97	5.31	11.14
Biological product 1, "B_2";	3.29	189.78	104.75	1.83	5.36	10.46
Biological product 2, "B_3".	3.07	181.42	94.15	1.92	5.38	10.96
LSD_{05}	0.12	9.28	6.76	0.08	0.05	0.50

On average, for groups of crops and soil cultivation, the use of Baikal EM-1 caused a statistically significant increase in the studied indicator in all soil layers.

Cultivation of buckwheat, on average, according to the systems of basic tillage and biological products, leads to a significant increase in the content of mobile phosphorus in the 0-20 cm layer by 11.67 mg / kg of soil. The application of surface treatment did not cause significant changes. The use of Baikal EM-1 and Potassium Humate led to a statistically significant increase in the studied indicator.

On average, according to the factors of the studied crops, there were no significant differences in the content of exchangeable potassium with the highest value for the variant with soybeans 101.41 mg / kg of soil. The use of surface treatment did not cause significant changes in the above indicator. The use of Baikal EM-1 on average for groups of crops and soil cultivation contributed to a significant increase in the studied indicator in the 0-20 cm layer.

On average, according to the factors in the crops of the studied crops, a significant increase in the hydrolytic acidity of the soil is observed. The use of surface tillage did not cause significant changes in the arable horizon as a whole. The use of Baikal EM-1 caused a statistically significant decrease in the above-mentioned indicator as a whole for the arable horizon.

On average, according to the factors of crop groups, there were no significant changes in the exchangeable acidity of the soil, with the highest value for the variant with soybeans - 5.39. The use of soil cultivation systems on average for groups of crops did not cause significant changes in exchangeable acidity. On average, for the groups of crops and soil cultivation, the use of Baikal EM-1 and Potassium Humate caused a statistically significant decrease in soil acidity in the 0-20 cm layer.

In the crops of the studied crops, an increase in the amount of absorbed bases as a whole along the arable horizon is observed. The application of surface treatment did not cause significant changes. The use of Baikal EM-1 on average for groups of crops and soil cultivation caused a significant decrease in the studied indicator by 0.68 meq / 100 g.

Cultivation of buckwheat, on average, according to the systems of basic tillage and biological products, leads to a significant increase in the yield of green mass by 31.7 c / ha. When cultivating amaranth and buckwheat, a significant increase in the yield of feed units by 9.9 and 14.9 c / ha was observed (table 2).

Table 2. Influence of the studied factors on the yield of field crops, kg / ha.

Variant	Productivity, c / ha	
	green mass	feed units
Factor A. Culture group, "K"		
Legumes, "K_1"	67.4	14.8
Row crops, "K_2"	72.8	24.7
Spring cereals, "K_3"	99.1	29.7
LSD_{05}	8.3	2.7
Factor B. System of basic tillage, "O"		
Plowing, "O_1"	84.3	24.3
Surface tillage, "O_2".	75.2	21.8
LSD_{05}	2.7	0.8
Factor C. Biological product, "B"		
Without biological product, "B_1";	76.8	22.2
Biological product 1, "B_2";	82.4	23.8
Biological product 2, "B_3".	80.2	23.3
LSD_{05}	$F_f<F_{05}$	$F_f<F_{05}$

On average, by factors, the use of the surface treatment system led to a statistically significant decrease in the yield of both green mass and fodder units by 9.1 and 2.5 c / ha, respectively. The use of biological products caused a slight increase in the yield of field crops at the maximum values in the variant with Baikal Em-1.

4. Discussion

For the first time, in the conditions of the central region of the Non-Black Earth Zone, non-traditional fodder crops were studied: soybeans, amaranth and buckwheat. There are practically no studies on them [16]. The use of a surface treatment system practically did not affect the agrochemical properties of the soil, but at the same time, a decrease in yield was observed by 2.5 centners / ha of fodder units.

Of the studied biological products, the use of Baikal EM1 caused a significant improvement in agrochemical properties at maximum yield, especially buckwheat. A more comprehensive and detailed study of the technologies for growing the studied crops for forage purposes is required. It is necessary to study in detail the effect of soybeans, amaranth and buckwheat under the influence of a biological product on soil properties under conditions of minimizing soil cultivation.

5. Conclusion

Thus, the results of studies in 2019 on sod-podzolic soil indicate the advantage of growing buckwheat for forage purposes with a moldboard processing system against the background of using Baikal EM-

1. This contributes to the improvement of the agrochemical properties of the soil, with the highest yield of green mass and fodder units, and is also the most economically and energy efficient.

References

[1] Osmanova S 2019 Study of agrochemical and physical-chemical properties gray-brown soils of the Karabakh Plain. *Bulletin of Science and Practice* **5(2)** 135-141
[2] Gamzikov G P, Barsukov P A and Varvain O D 2007 Change in agrochemical properties of sod-podzolic soil during long-term fertilization. *Russian Agricultural Sciences* **33** 314-317
[3] Aziz M A, Hazra F, Salma S and Nursyamsi D 2016 Soil Chemical Characteristics of Organic and Conventional Agriculture. *J Trop Soils* **21** 19-25
[4] Russell E W and Keen B A 1938 Studies in soil cultivation: VII. The effect of cultivation on crop yield. *The Journal of Agricultural Science* **28(2)** 212-233
[5] Van den Putte A, Govers G, Diels J, Gillijns K and Demuzere M 2010 Assessing the effect of soil tillage on crop growth: A meta-regression analysis on European crop yields under conservation agriculture. *European Journal of Agronomy* **33(3)** 231-241
[6] Miner G L, Delgado J A, Ippolito J A and Stewart C E 2020 Soil health management practices and crop productivity. *Agric Environ Lett*. **5** 20023
[7] Tshuma F, Rayns F, Labuschagne J, Bennett J and Swanepoel P A 2021 Effects of long-term (42 years) tillage sequence on soil chemical characteristics in a dryland farming system. *Soil and Tillage Research* **212** 105064
[8] Mana M, Wagner-Riddleb C, Dunfieldb K E, Deenc B and Simpsona M J 2021 Long-term crop rotation and different tillage practices alter soil organic matter composition and degradation. *Soil and Tillage Research* **209** 104960
[9] Berg S 2019 Effects of commercial microbial biostimulants on soil and root microbial communities and sugarcane yield. *Biology and Fertility of Soils* **56** 565-580
[10] Juhos K, Szabo S and Ladanyi M 2015 Influence of soil properties on crop yield: A multivariate statistical approach. *Int. Agrophys*. **29** 425-432
[11] Ghosh M and Dev A 2019 Assessment of crop growth, soil properties and crop yield in an upland acidic soil with inorganic fertilizer blended with organic amendments in summer rice cropping seasons. *International Journal of Recycling of Organic Waste in Agriculture* **8** 1-9
[12] Mandal A 2020 Chapter 7-Impact of agrochemicals on soil health. *Agrochemicals Detection, Treatment and Remediation. Pesticides and Chemical Fertilizers* 161-187
[13] Bhattacharyya C 2020 Chapter 11-Biofertilizers as substitute to commercial agrochemicals. *Agrochemicals Detection, Treatment and Remediation. Pesticides and Chemical Fertilizers* 263-290
[14] Ganguly R K, Arpan M, Chakraborty S K and Verma J P 2021 Chapter 2 - Impact of agrochemical application in sustainable agriculture. *New and Future Developments in Microbial Biotechnology and Bioengineering. Phytomicrobiome for Sustainable Agriculture.* 15-24
[15] Zhang H 2021 Responses of soil organic carbon and crop yields to 33-year mineral fertilizer and straw additions under different tillage systems. *Soil and Tillage Research* **209** 104943
[16] Trufanov A M, Voronin A N and Schukin S V 2021 Application of fertilization and microbiological preparations in ecological technologies of agricultural enterprises. *IOP Conference Series: Earth and Environmental Science* **624(1)** 012234
[17] Gubanov M M, Morkovkin D E, Begmurodzoda E, Sharipov F F and Romanova J A 2020 Differentiation of power supply systems for consumers in the Arctic zone. *IOP Conference Series: Materials Science and Engineering* **837(1)** 012011
[18] Zhichkin K A, Nosov V V, Zhichkina L N, Ramazanov I A, Kotyazhov A V and Abdulragimov I A 2021 The food security concept as the state support basis for agriculture. *Agronomy Research* **19(2)** 629–637