Effect of effluent on spring barley yield and soil microbiological activity indicators

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Abstract. The use of organic fertilizers is an integral part of the transition to biologization of agricultural production. The chemical active ingredients of modern pesticides can have an impact not only on cultivated plants, but also on the environment. They accumulate in the soil, water, and are absorbed by wild plants, which leads to deterioration of human and animal health. The use of the biogas plant effluent makes it possible to increase the share of biological fertilizers in the technology of spring grain cultivation. At the same time, the yield of spring barley increases, and the quantitative composition of soil microflora changes. The research was conducted on the territory of the Agricultural Technology Park of the Vyatka State Agricultural University (Russia) on sod-podzolic soils. It was found that the greatest yield of barley is provided by seed treatment with effluent and Pseudobacterin-2, as well as pre-sowing application of effluent to the soil. The increase in seed yield was 1.74 dr / ha with a yield of 32.9 dr / ha. When the effluent is applied directly to the soil on the roots of plants, a significant decrease in the content of ammonifying microorganisms is observed and the number of microorganisms that assimilate the mineral nitrogen of the soil increases. When an effluent of 32 t / ha is added to the soil, the greatest accumulation of microorganisms that consume mineral forms of nitrogen occurs.

1 Introduction

Grain production, which is a strategic resource of the country, is one of the main sectors of the agro-industrial complex that affects the formation of food security. Russia, as one of the key wheat exporters to the foreign market, is also among the top five in terms of barley supplies [1]. The yield of grain crops depends on the varietal characteristics of the plant, natural and climatic factors, the state of the soil and the fertilizers used.

Chemical pesticides, being highly effective, have a significant impact on the environment, as well as on increasing the resistance of phytopathogenic microflora, which subsequently leads to an increase in the consumption rates of chemical plant protection products. Synthetic plant protection products tend to accumulate in the soil and water bodies, which accordingly contributes to an increase in their content in cultivated and wild plants. This has a negative impact on human and animal health [2, 3].

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Consumer demand for organic products determines priority directions in the development of organic agriculture with the use of agrobiotechnologies in the cultivation of crop products and compliance with the requirements of the Russian Federal Law "On Organic Products and on Amendments to Certain Legislative Acts of the Russian Federation " of 03.08.2018 N 280-Federal Law regarding the prohibition of the use of agrochemicals and pesticides. In the near future, it is planned to include at least 2000 agricultural producers into organic agricultural production sector. Preserving and improving the fertility of soil resources is the main problem of their rational use to increase grain yields and improve soil ecology, which requires a systematic approach to the use of organic fertilizers.

In the conditions of the existing shortage of organic fertilizers in the soil, there is a need for more complete use of organic matter resources, including waste from the functioning of livestock complexes and poultryfarms, sapropels and secondary resources of plant raw materials [4]. Organic fertilizers increase the amount of nutrients in the soil needed for plant growth [5]. On humus lands, at least 10-12 tons of organic mass per 1 ha of arable land is necessary for the balance of deficient humus, and 15-18 t/ha should be added to loamy-sandy soils [6]. The use of vermicompost helps to improve the technological properties of spring wheat grain. The maximum effective dose of 6 t/ha of vermicompost was established to increase gluten and macronutrient content [7].

Biologics agricultural products in their effectiveness correspond to chemical analogues, at the same time being safer at lower costs. Biologization of agriculture is a modern trend in grain farming. Until a few decades ago, manure was considered an organic fertilizer. According to the modern classification of waste, manure is a factor of environmental pollution.

One of the ways to dispose of manure on a minimal area is the processing of manure in biogas plants [8]. This occurs under certain conditions by anaerobic thermophilic fermentation with the help of bacteria that process manure to form a fermented effluent-organic fertilizer and gas with its use instead of natural gas for heating rooms and cooking [9-11]. The technology of processing manure and secondary food resources (waste) has a complex effect: obtaining biogas energy, improving the ecological situation around livestock and poultry complexes, and obtaining an effluent biofertilizer [12]. We propose to use a special effluent as a fertilizer. The proposed effluent is a safe fertilizer, since it contains ammonium and organic forms of nitrogen, phosphates and potassium salts that are easily absorbed by plants. Currently, studies are continuing to study the effect of the effluent on agricultural crops [13, 14].

The proposed biogas effluent contains an average of 3.7% nitrogen, 2.6% phosphorus, 9.4% potassium per dry substance, as well as trace elements such as molybdenum, boron, copper, zinc, manganese, and iron. In addition to the mineral component, the effluent contains rhizosphere microorganisms, which are represented by the genera *Klebsiella*, *Pseudomonas,* and *Bacillus*, plant growth stimulators of the auxin class, and humin -like compounds [15].

The aim of the research is to study the effect of the proposed biogas plant effluent on the yield of spring barley and changes in the species composition of soil microflora during the cultivation of spring grain crops in the non-humus zone of Russia.

2 Materials and Methods

The material of the research analysis is of mixed nature, i.e. spring barley crop of the c.v. «Rodnik Prikamya», the soil of experimental plots, and the proposed biogas plant effluent.

Characteristics of spring barley plants of the c.v. «Rodnik Prikamya»: plants from short to medium length. The ear is cylindrical, loose or of medium density. Grain size varies from large to very large. Weight of 1000 grains : 44-50 g. The average yield in the region is 41.6 dr / ha.

Characteristics of liquid biofertilizer based on the proposed effluent are as follows. The effluent was produced by LLC «Selkhozbiogaz» in the form of liquid organic fertilizer, made from cow litter manure by thermophilic fermentation in a biochemical reactor. It includes live microorganisms that accelerate the decomposition of organic matter in the soil and the formation of humus. It is enriched with special bacteria: antagonists of pathogenic microflora, nitrogen-fixing, phosphatemobilizing and lactic acid cultures. The effluent is rich in macro-and microelements.

We conducted a series of field experiments. The fertilizers were applied either as minerals in the form of nitrophoska with the ratio of N:P:K in the amount of 17: 17: 17, or as an effluent. Control (B0) for fertilizers-nitroammophoska was conducted in a total dose of $N_{80}P_{80}K_{80}$. The dose of effluent, similar to the control for nitrogen, was 32 t / ha.

The experiment was based on two factors. Factor «A» - seed treatment before sowing, factor «B» - introduction of effluent into the soil. Factor A0 is untreated seeds, A1 is moistening of seeds with a 5% aqueous solution of the effluent, A2 is joint treatment of seeds with a 5% solution of the effluent and Pseudobacterin-2, the liquid norm is normal 1 l/t. The effluent was applied to the soil either completely before sowing (B1) and during the tillering phase (B2), or in fractional equal parts (sowing and tillering), in the same dosage. The experimental scheme is shown in Table 1.

Table 1. Scheme of experimental options for studying the effect of the effluent on the yield of spring barley and on soil microflora

InAriant	Factors
Untreated seeds	
A0B0	control
A0B1	effluent application during
sowing	A0B2 effluent application during tillering
A0B3	effluent application during sowing and in phasee tillering
Seeds treated with effluent	
A1B0	control
A1B1	A1B1 effluent application during
sowing	A1B2 effluent application during tillering
A1B3	A1B3 effluent application during sowing and in phasee tillering
	Seeds treated with effluent + Pseudobacterin-2, liquid
A2B0	control
A2B1	effluent application during
sowing	A2B2 effluent application in the tillering
A2B3	phase A2B3 effluent application during sowing and ine the tillering phase e

For microbiological analysis, dried plant roots with soil adhering to them with a layer of no more than 3 mm were used. To characterize soil microorganisms, the method of seeding on standard nutrient media was used. Ammonifying microorganisms were sown on meat-peptone agar (MPA); microorganisms assimilating mineral nitrogen were determined on starch-ammonia agar (CAA). For each sample, the total number of microorganisms forming colony units (KBE/g of substrate) was calculated.

3 Results and Discussion

When determining the influence of certain factors and elements of the cultivation technology of agricultural plants, it is important to change the yield. The barley yield is shown in Table 2.

Table 2. Barley yield

Option	Yield, dr / ha	Option	Yield, dr / ha	Option	Yield, dr / ha
A0B0	25.34	A1B0	25.95	A2B0	31.16
A0B1	28.09	A1B1	29.87	A2B1	32.90
A0B2	27.29	A1B2	27.40	A2B2	26.60
A0B3	28.94	A1B3	26.36	A2B3	28.27

The maximum yield of barley grain was recorded in the A2B1 variant (32.9 dr / ha). The increase from the influence of the studied factors was 1.74 dr / ha. The maximum increase in the influence of factors compared to the control was recorded in variants A1B1 (3.92 dr / ha) and A0B3 (3.61 dr / ha).

During the research, quantitative changes in the microbiological composition were detected. Starting from the phase of development of the third leaf of cereals, there is a slight decrease in ammonifying microorganisms in variants with seed treatment, in variants with the introduction of the effluent directly into the soil, a significant decrease in the number of these microorganisms on the roots of plants. A sharp decrease in microflora is seen in the tillering phase in variants A0B2, A0B3, and A1B2. A1B3, A2B2, A2B3, due to the introduction of an additional dose of biofertilizer. When using the effluent, there is a decrease in the number of ammonifying microorganisms in the phase of the third leaf, but a significant depression occurs (up to 5024...8022 thousand tons KBE/g) is noted in the variants with a double introduction of the effluent during sowing and in the tillering phase.

Quantitative changes in the microbiological composition that assimilate mineral sources of nitrogen (NAA) in the soil during seed sowing are shown in Figures 1 and 2.

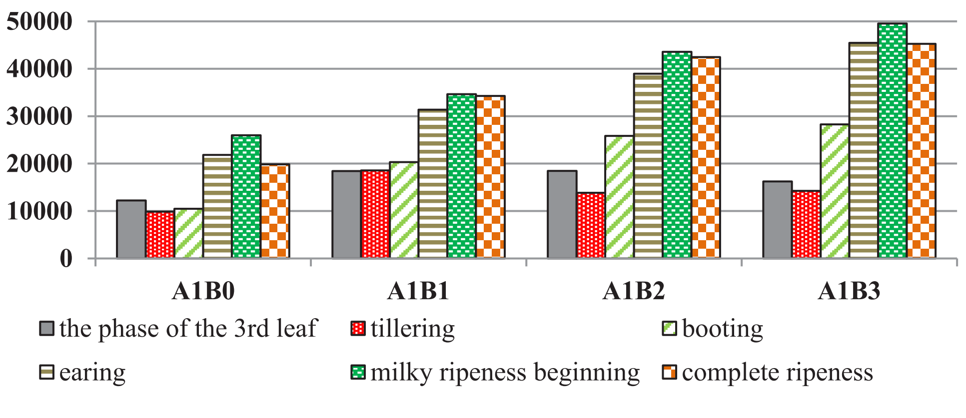

Fig. 1. The number of microorganisms that assimilate mineral sources of nitrogen (na CAA) in the soil when sowing seeds treated with the effluent, 1000 KBE/g

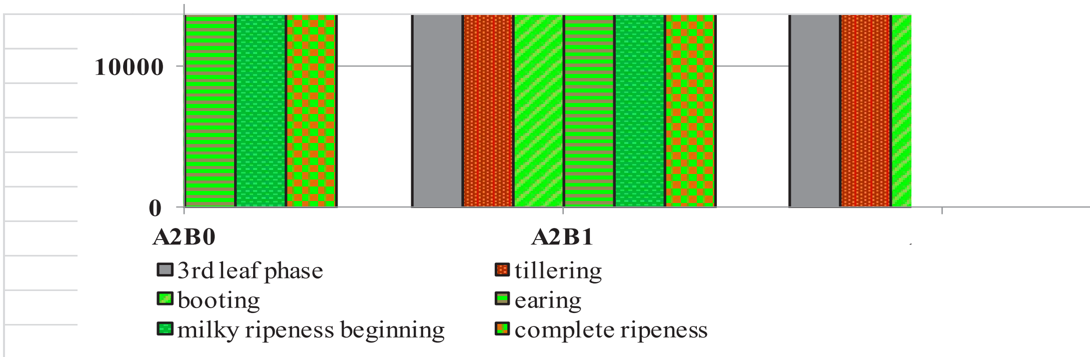

Fig. 2. The number of microorganisms that assimilate mineral sources of nitrogen (na CAA) in the soil, when sown with seeds treated with the effluent and Pseudobacterin-2, Liquid, 1000 KBE/g

4 Conclusion

As a result of the conducted studies, it was found that in the conditions of the north-east non-humus zone of Russia, the effluent of a biogas plant introduced into the soil in an equivalent amount of mineral fertilizer results in the decrease of ammonifying microorganisms in the soil and the increase in the content of microorganisms that assimilate mineral nitrogen. At the same time, the highest yield of barley grain (32.9 dr / ha) was recorded in variant A2B1, in which the seeds were treated with the effluent with Pseudobacterin-2, G before sowing, and the effluent was introduced into the soil during sowing. The increase in grain yield relative to the control was within the experimental error range. When the effluent is introduced into the soil before sowing, the number of ammonifying microorganisms decreases starting from the third leaf phase, but there is a significant depression (up to 5024...8022 thousand tons KBE/g) noted in variants with its fractional introduction into the phase of booting and tillering. The effluent introduced into the soil during the tillering phase and with fractional application before sowing and during the tillering phase in an amount similar to the application of mineral fertilizers N17 : P17 : K17 provides the greatest accumulation of microorganisms that consume mineral forms of nitrogen and convert it into organic matter.

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