Efficiency of liquid bio-organic fertilizer on potatoes

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Abstract. The effective methods of increasing the yield of potatoes in the application of liquid bioorganic fertilizer obtained after anaerobic processing of organic waste are considered. It is noted that the liquid bioorganic fertilizer does not have a negative impact when applied to the soil on the environment and to increase the content of heavy metals in the soil.

1. Introduction

The agro-industrial complex of Russia is increasingly faced with the problem of recycling a huge amount of waste from livestock complexes and farms. Liquid forms of organic fertilizers that accumulate in huge quantities have a number of adverse features: an increased number of pathogens, poor organoleptic and physical properties, etc., which makes their use in agroecosystems environmentally unsafe and technically difficult [1, 2].

Currently, science is considering a variety of ways to dispose of animal waste; one of the promising ways is anaerobic processing [3, 4]. Such bioenergy installations are successfully operating not only abroad, but also in Russia, and they have appeared in Chuvashia. Manure, manure, straw, potato tops, beets and other organic waste can be subjected to methane fermentation. As a result of anaerobic processing of organic waste, combustible biogas is obtained, which can be used for the needs of the farm, and a liquid effluent. Liquid sludge can be used as a liquid bio-organic fertilizer (ZHBU). The composition of fertilizers obtained as a result of anaerobic fermentation includes mineralized nitrogen in the form of ammonium salts (the most easily digested form of nitrogen), mineralized phosphorus, potassium, and other macro and microelements in a soluble form. With thermophilic methane fermentation, environmental purification occurs: complete destruction of pathogenic (pathogenic) microflora, helminth eggs, weed seeds, and specific fecal odors. The effectiveness of using liquid bio-organic fertilizers on potatoes is confirmed by the work of a number of scientists in Russia and abroad [5, 6, 7]. Based on the results of these works, a reduction in the environmental burden on the environment was established, and resource-saving technologies for using fertilizers for planting potatoes were developed. Unlike mineral fertilizers, which are digested only by 30-50 %, biofertilizers are digested almost completely. Maintaining high productivity, biofertilizers do not increase the content of nitrates in products and soil [8]. There is no doubt that evaluating the effectiveness of such a fertilizer in increasing crop yields and soil fertility requires setting up field experiments with appropriate observations and analyses.

The purpose of these studies is to evaluate the effectiveness of the use of liquid bio-organic fertilizer (ZHBU) obtained as a result of methane fermentation of organic waste in the production of potatoes on gray forest soils in the southern part of the Volga-Vyatka region of Russia.
2. Materials and methods
Research in 2018-2019 was carried out on the experimental field of the Chuvash research Institute, the soil is gray forest heavy loam with a humus content of 4.6, the neutral reaction of the soil solution-5.6, the availability of mobile forms of phosphorus is high (P2O5) – 230 mg/kg, increased potassium (K2O) – 180 mg/kg.

Scheme of experience:

- Control;
- ZHBU 9 t / ha.

The plot area is 32.4 m², the area is 21.6 m². Repeatability is three times. Records and observations were made according to generally accepted methods [9, 10]. Economic evaluation of options was carried out by comparing the cost of produced potatoes with the cost of one hectare.

The predecessor of potatoes is winter wheat. Agricultural equipment in the experiment is generally accepted for potato cultivation in the Chuvash Republic. The introduction of complex mineral fertilizers and ZHBU was carried out before cultivation. Tubers of the seed fraction of the Ryabinushka variety (elite reproduction) were planted in the third decade of May with a rate of 56 thousand tubers per hectare.

During the growing season, all potato plantings were subject to agrotechnical measures to protect them from weeds, pests and diseases.

3. Results
Meteorological conditions of vegetation periods in the years of research differed from each other both for precipitation and for the nature of their distribution, and in the air temperature during the growing season, which allowed us to give an objective assessment of the studied varieties of spring soft wheat.

In 2018, the growth and development of field crops took place in conditions of lack of moisture against the background of high temperature conditions throughout the growing season. 2019 was a moderately warm year with a lack of moisture at the beginning of vegetation and high water availability during the tuber formation phase.

Analysis of soil samples taken both before planting and after harvesting potatoes showed that the use of ZHBU in the studied dose does not significantly affect the agrochemical indicators of the soil. The use of ZHBU on heavy-loamy dark-gray forest soil led to a slight increase in heavy metals in the soil. No excess of the MPC was detected. There were no changes in the content of mobile forms of food elements.

Before removing the potato tops in the first option (9 t/ha), there was more weed vegetation in comparison with the control. This indicates that during methane fermentation of organic waste, a certain amount of weed seeds remains viable and in the future, when they get into the soil, they actively germinate.

Powerfully developed potato tops are a crucial factor in the formation of high yields of tubers, although they do not always provide the highest yield. Table 1 shows the results of determining the biometric indicators of potato plants. For vegetation, the best biometric indicators were observed in the variant with a dose of 9 t/ha, relative to the control.

| Table 1. Biometric indicators of potato plants, on average in 2018-2019. |
|-------------|-----------|-----------|-----------|
| Option      | Plant height, cm | Number of stems, pieces | Total plant weight, gram |
| ZHBU – 9 t / ha | 64.9      | 3.3       | 345       |
| Water – 9 t / ha | 62.2      | 2.9       | 324       |
| Control     | 61.2      | 2.8       | 236       |
In order to determine the dynamics of tuber crop accumulation, trial digs of 10 plants from the plot were performed in 2 repetitions at the onset of 45 and 55 days after the emergence of seedlings (table 2). On 45th day after germination in water formed the highest number of tubers with 6.7 PCs/Bush, that more control by 1.8 units (37 %) and more option with GBU 1.6 PCs (31 %).

By weight of tubers the best option for 45 days after germination there was an option with the use of GBO, but on the 55th day after the emergence of variants with the use of IBU and water equal to both the number and weight of tubers.

**Table 2. Dynamics of crop accumulation per 1 Bush, on average for 2018-2019.**

| Option         | 45 days  | 55 days  | Increase  |
|---------------|----------|----------|-----------|
|               | number of tubers, pcs. | weight of tubers, g. | number of tubers, pcs. | weight of tubers, g. | number of tubers, pcs. | weight of tubers, g. | increase |
| ZHBU – 9 t / ha | 5.1    | 443    | 6.9    | 601    | 1.8    | 158    |
| Water – 9 t / ha | 6.7    | 376    | 6.9    | 600    | 0.2    | 224    |
| Control       | 4.9    | 358    | 5.6    | 427    | 0.7    | 69     |

In General, the largest increase between the two counts (45 and 55 days after germination) in the number of tubers was observed in the variant with ZHBU – 1.8 pcs. / bush, which was 2.5 times more control, and the weight of tubers in the version with water – 224 g / bush, which was 3 times higher than the control version. According to the results of the dynamics of crop accumulation, it was found that options 1 and 2 (ZHBU and water at a dose of 9 t / ha) have a watering effect.

As a result of the conducted research for two years, it was found (figure 1) that an increase in the yield of potato tubers on average for two years of study was obtained by adding 9 tons of ZHBU to the soil for 1 hectare of 309 c / ha. The increase in yield was 76.5 c / ha, respectively, 32.9 % of the control.

![Figure 1](image.png)

**Figure 1. Potato yield when using ZHBU, t / ha.**

When harvesting potatoes, the structure of the crop was determined. The results obtained over two years of research make it possible to judge the fractional state of the crop when applying ZHB to the soil. In all variants, there is a predominance of commercial potatoes weighing more than 80 g. The highest yield of food potatoes 63.7 % was observed in the variant with ZHBU at a dose of 9 t / ha, while in the control it was 60.0 %. The yield of seed potatoes in the variant with water was the maximum –
27.8 %, exceeding the control by 1.8 %. The analysis of the yield structure in the variant with ZHBU showed that the increase in yield when making 9 t / ha of ZHBU occurred as a result of a greater yield of small (up to 50 g) potatoes. This indicates that these options do not differ in the percentage of marketable potatoes obtained to the total yield.

Cost-effectiveness analysis based on experience with the introduction of ZHBU into the soil. Showed that with this technology of potato cultivation, the level of profitability is 50.1 %.

4. Conclusions
From the results of the research, the following conclusions can be drawn that the use of liquid bio-organic fertilizer at a dose of 9 t / ha on heavy-loamy gray forest soils, subject to all protective measures with the use of a full range of mineral fertilizers:

- liquid bio-organic fertilizer obtained in the process of anaerobic methane fermentation, introduced with incorporation into the soil before planting potatoes, contributed to an increase in the quantitative composition of weed cenosis;
- does not have a negative impact on the environment when applied to the soil and on the increase in the content of heavy metals in the soil;
- contributes to an increase in yield up to 33 % with a return of 50.1 %.

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