Research on the efficiency of soil melioration with modified organic fertilizer from pig manure

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Abstract. The most effective doses of the modified organic-mineral fertilizer (MOF), produced from non-contact pig manure in the conditions of the Rostov region for the purpose of soil reclamation, were determined. Experimental studies were carried out to determine the most effective dose of MOF based on non-contact pig manure. The dependence of the spring wheat yield on the use of a modified organic-mineral fertilizer based on liquid waste from pig farms fermented bird droppings and mineral fertilizers is determined. The equivalence of the effect of a modified organic-mineral fertilizer based on liquid waste from pig farms and fermented bird droppings, introduced in an equivalent dose, on plant biomass was established. When comparing the effects of different types of fertilizers, their toxicity was not established. The introduction of a modified organic-mineral fertilizer based on liquid waste from pig farms at a dose of 2 t/ha provided the highest biomass yield of 34-day-old plants of spring wheat of the “Zlata” variety, which reached 0.9 g/vessel and was 28.5% higher than the control value. A new organic mineral fertilizer with a pH of 8-10, with an organic content of up to 73% per dry weight, can be used for supporting the quality of liming and improving soil.

1. Introduction
The acute shortage of organic components in the soil of Russia, which is typical of the present time, requires the development of new methods for the most complete use of available resources from liquid organic waste of cattle breeding. The analysis of the literature sources revealed the lack of sound scientific data on the issues of soil reclamation when using fertilizers based on liquid waste from pig farms. In particular, there is no information on the choice of optimal doses of organic-mineral fertilizers in agricultural production, as well as on their impact on the increase in biomass indicators in relation to other types of organic fertilizers.

Scientists from different countries [1-4] conducted research on the effectiveness of using pig manure for the accumulation of biogenic elements in the soil layer and increasing the yield.

In this regard, the study of the agronomic efficiency of MOE based on liquid waste of pig complexes in the agricultural production of grain crops is relevant [5,6].

When conducting a laboratory experiment on the cultivation of spring wheat, the following tasks were set: selection and determination of the effective amount of modified organomineral fertilizer obtained from liquid organic waste of pig farms obtained in the Rostov region.
2. Materials and research methods
The study of the effect of MOF based on liquid waste of pig farms was carried out in the conditions of the VNIIA phytotron in accordance with the methodological instructions. The test crop was spring wheat of the variety "Zlata" selected by Moscow Research Institute of Agriculture "Nemchinovka".

During the experiment, the seeds of spring wheat of the "Zlata" variety were soaked and seeded on June 22, 2019. The appearance of plentiful shoots was observed on June 25. By the reference time of the biomass assessment – July 26-the phase of the beginning of the release of plants into the tube was observed.

The research considered four increasing doses of modified organic-mineral fertilizer based on liquid pig waste (MOF): 2, 4, 6 and 8 tons per 1 ha. In addition, the experiment plan included a variant of fertilizer based on dry bird droppings at a dose equivalent to 2 t/ha of MOF and a variant with mineral fertilizers-NPK, which were applied at a dose equivalent to 2 t/ha of MOF. The experiment was carried out in three repetitions.

The plough layer soil from the territory of the RGAU-MSHA field station was studied. The type is soil-sod-podzolic loam. The composition of the soil is in a layer of 0-20 cm: pH\textsubscript{KCl} - 5.9 contained humus (according to Tyurin) 1.1% C, total nitrogen 0.24%, mobile phosphorus (P\textsubscript{2}O\textsubscript{5}) and potassium (K\textsubscript{2}O) (according to Kirsanov) 247 mg/kg and 188 mg/kg, respectively.

In all variants, tap water was used for watering, the soil moisture was maintained at the level of 60-70% PPV. The temperature range during the day was 22-25°C, at night - 18-21°C, humidity - 40-60%. The photo-period was 16 hours. Illumination was 11-13 Klk (120-150 mmol / m\textsuperscript{2} * s).

For the experiment in the phytotron, drainage vessels of 60 g of expanded clay were used, in which 1680 g of dry soil was placed, and then a mineral fertilizer-ammonium nitrate phosphate (N\textsubscript{20}P\textsubscript{20}K\textsubscript{20}) was carefully mixed.

At the end of the experiment, the amount of biomass and leaves in each vessel was determined, and the height of the wheat was measured.

The bird droppings used in the experiment contained (per dry weight) 39.6% C, 79.1% organic substance, 3.3% total nitrogen, 3.1% phosphorus (P\textsubscript{2}O\textsubscript{5}), 2.7% potassium (K\textsubscript{2}O) at a pH of 7.1, and fulfilled the requirements for the agrochemical qualities of dropping fertilizers according to GOST R 53117-2008.

The method for obtaining the MOF was developed at M.I. Platov South-Russian State Polytechnic University.

According to the formula of the invention, the liquid waste was introduced (g / dm\textsuperscript{3}):
- lime milk in terms of CaO 1,2-1,5;
- suspension of calcium carbide in terms of Cao 2.0 to 3.0;
- mixture of milk of lime and sludge of calcium carbide, accordingly, in respect of 0.5-1:1-2,5 to pH 10-12, and oxalic acid of 1.0-2.0 g/dm\textsuperscript{3} as acidifying reagent to achieve a pH of 6.5 to 8.0 with the release of sediment.

The benefits of oxalic acid in the release of inorganic nutrients are described in [7-11].

The method of preparation of MOF is aimed at the disposal of liquid organic waste from cattle breeding complexes in order to use fertilizer in agricultural production. And we also obtain a technical solution that significantly simplifies the process of preparing the reagent and reduces the cost of obtaining fertilizer and its use in agriculture. The proposed method will reduce the settling time, increase the efficiency of fractionation while achieving minimal risks to the natural environment by reducing emissions and discharge into the atmosphere and reservoirs. That is excluded the eliminates of the heavy metal content in the sediment. As a result, we can consider the creation of a new modified organic-mineral fertilizer with a high content of nutrients and no toxic effects, and, consequently, the possibility of wider use of the finished product in agriculture.

The MOF fertilizer based on pig manure contained (per dry weight): organic substance - 73%, nitrogen - 2.8-3.0%, P\textsubscript{2}O\textsubscript{5} - 1.9-2.0 %, K\textsubscript{2}O - 1.8-2.0%, pH - 6.5-8.0. It should be noted there is high fertilizer value of MOF and the content of the main biogenic elements-NPK, physiologically required for the normal maturation of grain crops. The reaction of the medium is neutral or slightly alkaline.
3. The results obtained and their discussion.
For the research, spring wheat was selected with a grain germination rate of 98 and a weight of 38 g per 1000 pieces. Intensive development of plants was observed in absolutely all vessels and at harvest, and at the control measurement on day 34, they had 3-4 real developed leaves.

As can be seen from the data in Table 1 and Figure 1, in the control sample, the dry biomass of spring wheat was 0.7 g/vessel. The introduction of a modified organic-mineral fertilizer based on liquid waste from pig farms at a dose of 2 t/ha allowed to increase the biomass by 28.5% compared to the control. The following increase in the applied doses did not cause a significant increase in the yield of dry biomass. The application of a dose of 8 t/ha resulted in an increase in yield to 0.8 g/vessel compared to the application of previous doses (options 3 and 4), that is, there was an increase in biomass by 0.1 g/vessel, or by 14.2% compared to the control without fertilization.

Table 1. Effect of the use of various fertilizer options on the yield of spring wheat

| No. variant | Experiment variant                        | Dry biomass, g/vessel | Increase g/vessel | %   |
|-------------|------------------------------------------|----------------------|-------------------|-----|
| 1           | Control                                  | 0.7                  | -                 | -   |
| 2           | MOF at a dose of 2 t/ha                  | 0.9                  | 0.2               | 28.5|
| 3           | MOF at a dose of 4 t/ha                  | 0.7                  | -                 | -   |
| 4           | MOF at a dose of 6 t/ha                  | 0.6                  | -                 | -   |
| 5           | MOF at a dose of 8 t/ha                  | 0.8                  | 0.1               | 14.2|
| 6           | Bird droppings at a dose equivalent to 2 t/ha of MOF | 1.0                  | 0.3               | 42.8|
| 7           | Mineral fertilizers - NPK, equivalent to 2 t/ha MOF | 1.2                  | 0.5               | 71.4|

LSD₀.₀₅ 0.2

Figure 1. Growth of dry biomass with different fertilizer options (in brackets there are doses of fertilizers in t/ha)

The use of variant 6 (granular fermented bird droppings) and variant 7 (mineral fertilizers) resulted in an increase in the amount of cultivated grain in comparison with the control fertilizer to 1-1.2 g/vessel, which is 42.8-71.4% higher than the control. The resulting effect can be explained by the high content of biogenic components in the studied fertilizers.

Comparison of the variants of the experiment 2, 6, 7, where MOF, bird droppings, mineral fertilizers (NPK) were studied, showed a significant increase in the yield of wheat biomass in relation
to the control variant. At the same time, the impact on the biomass of the modified organic-mineral fertilizer based on liquid waste from pig farms, as well as bird droppings, was equal. As for the option with mineral fertilizers, their impact on the amount of biomass was higher than the effect of MOF by 33.3%.

The absence of toxicity of the studied fertilizers was assessed by the biological activity of the soil in terms of carbon dioxide emission (Fig. 2), according to the patent for invention No. 2660380. An increase in carbon dioxide emissions from 45 to 83 micrograms of CO\textsubscript{2}/g*day compared to 50 micrograms of CO\textsubscript{2}/g*day in the control was observed when the dose of the modified organic-mineral fertilizer was increased to the maximum value. The indicator of the biological activity of the soil in variants 2, 6 and 7 remained almost at the same level and was close to the control value.

Of all the fertilizers studied in the experiment, the highest value of carbon dioxide emission was characterized by a modified organic-mineral fertilizer based on liquid waste from pig farms at a maximum dose of 8 t/ha, where it reached 83 micrograms of CO\textsubscript{2}/g*day, that is, it was 1.7 times higher than the control.

![Figure 2. Carbon dioxide emissions in soil](image)

When assessing the impact of the modified MOF on yield, it is necessary to take into account the relationship of the reaction of the medium with the physical and chemical properties of the soil, especially with pH. In the course of further research, the effect of MOF on the metabolic and hydrolytic acidity of various soils will be studied. It should be noted that when treating pig manure with a suspension of Ca(OH)\textsubscript{2} followed by neutralization, the pH value can vary over a wide range. If the soils are acidic, the MOF can be obtained with a pH of 8-10 and considered as liming or supporting liming. It is important that the organic substances contained in pig manure are also introduced. In the modified MOF, they are 73% of dry weight. Especially effective one is the use of the new MOF for technopolluted soils.

It should be taken into account that the modified MOF includes insoluble phosphates, in particular, aluminum phosphates. Almost all the sod-podzolic soils that were used in our experiments contain huge gross amounts of aluminum and therefore the granulometric amount has little effect on the content of its moving forms. Aluminum is toxic, as it impairs carbohydrate, protein and phosphorus metabolism in plants. Adding a MOF with a pH of 4-5 will bind aluminum to phosphates and reduce its negative effect. From the above, it follows that the new modified MOE obtained by the authors improves the quality of the soil and its fertility.
A comparison of the use of air-dry MOF based on pig manure and traditional manure of natural humidity showed great advantages of the former, in view of the rapid decrease in transportation costs and methods of application. The introduction of MOF into the soil can be carried out by various mechanisms designed for mineral fertilizers (seeders or special machines such as AMAZONE). Thus, at the Central Experimental Station of VNIIA, dry granular organic fertilizers were successfully applied to the fields for grain crops in doses of 2-2.5 t/ha by the SB 5 machine.

4. Conclusion
When comparing the effects of different types of fertilizers, a new modified organic-mineral fertilizer is based on liquid waste from pig farms, fermented bird droppings and mineral fertilizers (NPK) applied in equivalent doses; their toxicity was not established when growing spring wheat of the “Zlata” variety. This makes it possible to improve the reclamation indicators of soils and increase their fertility. New MOF with a pH of 8-10, with an organic content of up to 73% per dry weight, can be used for supporting liming of soils. The indicator of the biological activity of the soil was close to the control one and ranged from 44 to 48 micrograms of CO$_2$/g/day. The application of modified organic fertilizer based on pig manure at a dose of 2 t/ha provided the highest biomass yield of 34-day-old plants of spring wheat of the “Zlata” variety in comparison with other increasing doses of fertilizer (from 4 to 8 t/ha), which reached 0.9 g/vessel, which was 28.5% higher than the control value. The equivalence of the effect of a modified organic-mineral fertilizer based on liquid waste from pig farms and fermented bird droppings, introduced in an equivalent dose, on plant biomass was established.

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