Ecologized technology of spring wheat cultivation with application of granular organic fertilizers

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Abstract. The paper is devoted to studying the impact of granular organic fertilizers based on poultry manure on improving the environmental situation, which in some farms has deteriorated in the process of poultry farms. The production and application of granular organic fertilizers in spring wheat cultivation promotes the optimization of phytosanitary condition of agroecosystem. They activate soil microflora. In the soil and rhizosphere of spring wheat, it decreases the amount of pathogenic fungi, increases the number of antagonist fungi. The total number of soil fungi increases by 1.8 times compared to the unfertilized area. Affection of spring wheat plants by root rot is reduced by 1.5 times compared to control. Granular organic fertilizers had a significant impact on spring wheat productivity. Plants in this variant grew larger as opposed to control and variant with mineral fertilizer. Spring wheat yields increased by 63 % compared to the controls.

1. Introduction

Phytosanitary and environmental issues are important in agricultural landscapes. Farms are experiencing a shortage of organic fertilizers due to declining livestock numbers in recent years. Fertility and phytosanitary condition of soil has deteriorated significantly.

Organic fertilizers increase overall soil fertility and provide nutrients to plants [1]. However, any animal waste, especially poultry, must be applied with care, because any fresh manure can do more harm than good [2, 3].

Modern poultry factories produce large quantities of poultry meat and eggs, but also large quantities of waste (manure, slaughter and poultry processing waste). You can get 250–300 eggs, as well as 55–70 kg of litter during one year from one chicken. For each kilogram of chicken meat produced, you get 3 kg of droppings. At many poultry farms the amount of litter received during a year reaches tens and even hundreds of thousands tons. Considering the increased number of poultry farms in recent years, the disposal of bird droppings has become a difficult problem for many poultry farms. The storage of such amount of manure requires large areas of agricultural land. Recycling of waste requires large material and technical costs and money [4].

The disposal of organic poultry waste is a serious problem. When fresh bird droppings are applied directly, the ecological condition of the soil deteriorates. The condition of the upper soil layer and surface waters deteriorate [2].

Bird droppings are valuable products as an organic fertilizer, but they cannot be applied fresh to the soil. Its value is primarily due to the content of nitrogen, phosphorus, potassium, a number of trace...
elements: calcium, magnesium, copper, manganese, zinc, cobalt, sulphur, boron [5]. An alternative to the use of fresh bird droppings is the granulation of the droppings. Granulated bird droppings is a complex organic fertilizer with a full set of macro- and microelements for all agricultural crops. All nutrients are in their organic form and are therefore better absorbed by the plants. They enter the plant gradually. They provide the plant with a nutrient environment for a long time. Granular fertiliser is easier to transport and store because it is odourless and takes on a comfortable form. It requires 3–4 times less space for storage. Such fertilizers lack viable seeds of weeds, eggs and helminth larvae and flies, and it is able to preserve all its useful properties even if stored for a long time [6].

Modern agricultural production requires the development of environmentally safe technologies of cultivation of agricultural crops [7–9]. The level of species diversity of the microbial community of soil can be considered as one of the most important criteria for the stability of the basic ecological functions of the soil [10].

Decrease in fertility and worsening phytosanitary condition of soil resulted in the need to study and develop biofermented organic fertilizers based on bird droppings.

The objective of our research is to study the impact of granular organic fertilizers based on poultry manure on soil phytosanitary condition and spring wheat productivity.

2. Materials and methods

The research was conducted on the experimental field of Mari State University on spring wheat crops. Granulated organic fertilizer (GOF) based on bird droppings were applied in the beginning phase of tillering. To compare the efficiency of GOF, we used a mineral fertilizer azophoska (in a dose of 100 kg/ha). We did not apply fertilizer on the control version. GOF was used in a dose of 300 kg per 1 ha. The fertilizer was spread on the soil surface manually. Spreaders of mineral fertilizers can be used for spreading on farms.

In the process of the study we observed the growth and development of spring wheat, analyzed micromycetic composition of soil by the method of soil sowing on the nutrient medium of the Chapek-Dox [11], recorded the root rot of spring wheat by the route survey method [12].

To obtain granular fertilizers, bird droppings were first composted and treated with microorganisms that promote rapid decomposition of the droppings. After a few days, the compost was ready, then dried and granulated.

3. Results and discussion

Bird droppings are not inferior in terms of nutrients to expensive mineral fertilizers in their action. These nutrients are washed out of the soil to a lesser degree, reach the roots well and do not create high salt concentrations due to their organic form [13].

Changes in the number and composition of rhizospheric microflora occur under the influence of fertilizers. The number and composition of the microflora depend on the dosage of the fertilizer, timing of application, crop and soil type.

The arable layer of crops is the most ecologically rich, including in phytosanitary terms, in field agroecosystems. This layer contributes to the development, survival and conservation of the majority of microorganisms, which subsequently determine the phytosanitary condition of arable crops. Agroecososis of field crops contains an inherent complex of micronutrients. Fungi inhabiting the rhizosphere of plants can have beneficial, harmful or neutral effects on the plant. Pathogenic fungi and fungi that synthesize phytotoxins can inhibit and delay plant growth. They reduce crop yields.

The application of mineral and organic fertilizers increases the total number of microorganisms in the soil and rhizosphere of plants.

Introduction of mineral and organic fertilizers into the soil not only improves plant nutrition, but also changes the conditions of soil microorganisms.

From the application of organic fertilizers the number of fungi increased by 2.2 times in the phase of thawing. Antagonist fungi in the amount of 10 thousand pieces of CFU per 1 g of soil have been isolated in this variant. Later, in this variant there was an increase in the number of fungi compared to
other variants. During the earing phase, the total number of saprotrophic fungi and antagonists was 4.8 times more in comparison with control and 3.3 times more variant with mineral fertilizers. In the phase of milk ripeness of spring wheat, the number of pathogens in soil was 3.6 times less than the control and the total number of fungi was 2.3 times higher.

Fungi living in the rhizosphere of plants supply higher plants with mineral elements and stimulate their growth. Many root-dwelling fungi in plant leaves can release growth stimulants or inhibitors and thus also affect plant development. Pathogens cause root rot. From pathogenic fungi, fungi of the genus *Fusarium* spp., *Alternaria* spp., *Drechslera sorokiniana* Sacc. have been found. Of these, the following species can be considered typical for this agrocenosis: *F. culmorum* Sacc., *F. heterosporum* Hees, *F. graminearum* Sch. and *Alternaria alternata* Fr. Typical saprotrophs include such species as *Penicillium freguentans* Westl, *P. fumiculosum* Thom, *Aspergillus niger* van Tiegh, *A. clavatus* Desm. *Mucor piriformis* Fisch. The fungal antagonist *Trichoderma lignorum* (Tode) Harz was often found in variants using organic fertilizers. Antagonist fungi play an important role in inhibiting the development of phytopathogens and improving soil health. In their natural habitat, the fungus feeds on dead semi-decomposed plant remains in the soil. It is concentrated to a greater extent near the plant root system. It is actively antagonistic when in contact with phytopathogens.

Analysis of spring wheat rhizosphere for the presence of soil fungi showed that the introduction of ammonium nitrate contributed to an increase in the number of fungi, but we also observe an increase in the number of pathogenic fungi compared with control (Table 1).

**Table 1.** Population of spring wheat rhizosphere with micromycetes, thousand CFU/1 g soil

| Name of micromycetes | Experience Options | control | azophoska | GOF |
|----------------------|--------------------|---------|-----------|-----|
| 1. *Fusarium graminearum* Sch. | 10.2 | 13.8 | 0 |
| 2. *F. heterosporum* Hees | 10.2 | 7.2 | 3.4 |
| 3. *F. sporotrichiella* Bilai | 3.4 | 0 | 3.4 |
| 4. *Drechslera sorokiniana* Sacc. | 0 | 3.4 | 0 |
| 5. *Alternaria alternata* Fr. | 0 | 6.8 | 3.4 |
| **Total pathogens** | 23.8 | 31.2 | 10.2 |
| 6. *Aspergillus niger* van Tiegh | 0 | 0 | 10.2 |
| 7. *A. repens* D. B. | 0 | 3.4 | 0 |
| 8. *A. fumigatus* Fres | 0 | 0 | 10.2 |
| 9. *A. clavatus* Desm | 10.2 | 0 | 20.4 |
| 10. *Penicillium freguentans* Westl | 23.8 | 41.8 | 6.8 |
| 11. *P. fumiculosum* Thom | 8.5 | 0 | 0 |
| 12. *P. digitatum* Sacc | 0 | 23.8 | 10.2 |
| 13. *Mucor piriformis* Fisch. | 23.8 | 3.4 | 37.4 |
| 14. *Trichoderma lignorum* (Tode) Harz. | 0 | 21.0 | 61.2 |
| **Total saprotrophs** | 66.3 | 93.4 | 156.4 |
| **Total micromycetes** | 90.1 | 124.6 | 166.6 |

The number of pathogens was more by 7.4 thousand CFU/g of soil in the second variant. The number of pathogens decreased by 2.3 times in comparison with control in the third variant (with application of GOF). The application of fertilizers contributed to the increase of saprotrophic fungi in spring wheat rhizosphere. The total number of micromycetes in spring wheat rhizosphere was higher in the variant where granular organic fertilizers were applied. GOF stimulates soil micromycetes. There is an improvement in the phytosanitary condition of the soil. The phytosanitary condition of the soil has a direct impact on spring wheat plant damage by root rot and yield.

Analysis of spring wheat plants to detect root rot at the beginning of vegetation before fertilization showed that the prevalence of the disease was 16.4 %, and its development covered 8.5 %. We found that the application of organic granular fertilizers based on bird droppings helps reduce the damage
from wheat root rot (Table 2).

**Table 2.** The incidence and development of the root rot and spring wheat yield

| Options | Prevalence of the root rot, % | Development of the root rot, % | Yield, t/ha |
|---------|-------------------------------|--------------------------------|-------------|
| Control | 46.9                          | 15.6                           | 2.20        |
| Azophoska | 43.0                         | 13.1                           | 3.25        |
| GOF     | 28.2                          | 10.3                           | 3.60        |

The smallest plant lesions were in the GOF version. The prevalence of root rot decreased by 1.6 times, and the disease development was less than 1.5 times. Spring wheat plant growth and development differed depending on the application of fertilizers (figures 1 and 2).

![Figure 1](image1.png) ![Figure 2](image2.png)

**Figure 1.** Spring wheat: 1 – Control; 2 – Azophoska; 3 – GOF

**Figure 2.** Spikes of spring wheat: 1 – Control; 2 – Azophoska; 3 – GOF

The introduction of GOF has significantly increased the yield of spring wheat. The yields were 63 % higher than the controls.

4. **Conclusion**

The production of granular organic fertilizers from poultry manure will solve the problem of organic farming. Its application will reduce environmental pollution from poultry farm waste and reduce the negative impact of mineral fertilizers on the soil.

The application of granular organic fertilizers based on poultry manure will improve the phytosanitary condition of the soil. The total microbial abundance in soil and spring wheat rhizosphere increases from GOF application, while the number of pathogens decreases. GOF contributes to the reduction of spring wheat affected by root rot.

Spring wheat fertilization of GOF based on bird droppings in a dose of 300 kg/ha helps increase yield by 63 %.

4. **References**

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