Efficiency of application of granulated organic fertilizers based on chicken manure in the cultivation of spring wheat

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Abstract. The construction of modern poultry farms has significantly increased the proportion of bird droppings in the total production of organic fertilizers. Due to the high concentration of poultry farms on the territory of the Mari El Republic, the need has arisen to search for and scientifically sound introduction of new technologies that are not traditional for our zone of fertilizers, techniques and methods of growing crops based on agricultural biologization in order to significantly reduce the chemical load on the soil. One of the methods to improve soil fertility is the use of granular organic fertilizers based on bird droppings. We conducted studies on the use of GOF based on chicken droppings in the cultivation of spring wheat. Studies have shown that the use of granular organic fertilizers contributed to a significant increase in spring wheat yields. The highest value was observed for the option with the introduction of GOF at a dose of 400 kg/ha, and amounted to 2.18 t/ha, which is 34.6% higher than the option without fertilizers. It should be noted that the use of GOF based on bird droppings contributed to the reduction of root rot susceptibility of spring wheat, the smallest spread and development of root rot was in the variant with 400 kg/ha - 44.7% and 24.1%, which is 28.8% and 41.4% less than in the variant without fertilizers.

1. Introduction

Bird droppings are a valuable high-speed, complete fertilizer. It contains all the essential nutrients needed for plants, much more than manure. Currently, due to the high concentration of poultry farms in the Republic of Mari El, the production of granular organic fertilizers (GOF) from chicken droppings provides an improvement in the ecological environment. Granular organic fertilizers obtained after processing by special technologies of poultry waste represent a natural source of nitrogen, phosphorus, potassium, trace elements, and may also include various consortia of highly active strains of bacteria and other forms of microflora in optimal proportions. Such symbiosis provides the accumulation of organics, improves the phytosanitary and agrophysical properties of the soil [1, 2, 3]. In the introduction of organic fertilizers, many scientists see a solution to the problem of soil improvement [4]. Organics affect the yield and quality of the resulting crop within 3-4 years after their application, in contrast to mineral fertilizers, which have a positive effect on plants for only one year, less often two [5, 6].

Based on the foregoing, it can be said that the economic and biological qualities of granular organic fertilizers indicate the prospects of its use in the cultivation of crops.
For a more complete assessment by the Mari Research Institute of Agriculture - a branch of the Federal State Budgetary Scientific Institution of the Federal Research Center of the North-East, scientific and economic experiments were conducted to study the effectiveness of the use of granular organic fertilizers in the cultivation of spring wheat.

2. Material and methods
The experimental part of the work to identify the effectiveness of the use of granular organic fertilizers based on chicken manure, made in the conditions of the Republic of Mari El, was carried out in the field on the experimental field of the Mari Research Institute of Agriculture - a branch of the Federal State Budgetary Scientific Institution of Federal Research Center of North-East.

The experimental design included the following options:

- Control (without fertilizer)
- The application of mineral fertilizers during sowing - diammofoska (N10 P20 K20 S9) - 200 kg/ha, 300 kg/ha, 400 kg/ha (in physical weight)
- The introduction of granular organic fertilizers produced by Stroy Sad LLC (N4 P2.5 K2.5) when sowing - 200 kg/ha, 300 kg/ha, 400 kg/ha (in physical weight).

The soil cover of the experimental plot is sod-podzolic medium loamy. At the time of laying the experiment, the arable layer was characterized by the following agrochemical parameters: humus content (according to Tyurin) - 2.36%, total nitrogen - 0.22%, Рн kcl - 6.3%, hydrolytic acidity was 2.21 mg - equiv / 100 g soil, the amount of absorbed bases is 7.9 mEq / 100 g of soil. Provision of soil with mobile phosphorus was within 395 mg, with exchange potassium - 173 mg per 1 kg of soil. The area of the experimental plot is 160 m². The options are repeated fourfold, the arrangement of options in the repetitions is consistent. The introduction of granular organic fertilizers and diammofoski was carried out in the spring when sowing with the SZ-3.6 seeder. Agrotechnology of cultivation of crops generally accepted for the conditions of the Republic of Mari El. As a test culture, they used a variety of spring wheat Simbirtsit, a predecessor in the rotation rotation - winter rye. The studies were accompanied by the study of environmental factors, agrochemical analyzes of soil and plants. The counts and observations were carried out by generally accepted methods according to B. A. Dospekhov [7]. The structure of the crop was determined by the method of individual analysis of plants of test sheaves, selected from constant sites. Productivity was taken into account by the division of threshing with conversion to 100% purity and standard humidity. The data of the research results were subjected to mathematical processing by the method of variance and analysis.

3. Results and its discussion
Among the biotic stress factors that influence the formation of the crop and the quality of crops, a special place is occupied by root rot of various etiologies. In our region, root rot of mixed etiology, with a predominance of Fusarium infection is most often found. Their harmfulness consists in thinning, inhibition of growth, disruption in the dynamics of plant organogenesis, deterioration in the formation of all systemically important elements of the crop structure, a significant decrease in product quality and its possible contamination with phytopathogen toxins. During the growing season of spring wheat, we carried out an analysis to detect damage to plants by root rot (table 1). Studies have shown that the application of mineral and organic fertilizers had a significant impact on the distribution and development of root rot of spring wheat. In the tillering phase, the spread of the disease in the variants was relatively the same and varied from 27.4 to 30.4%. In the bumping phase, the lowest prevalence of root rot was observed in the variant with the use of diammofoski at a dose of 300 kg/ha - 35.1%, which is 24.2% less than the control. In the variant with of granular organic fertilizers, the lowest prevalence of the disease was observed at a dose of 400 kg / ha - 19.1% less compared to the control variant. The opposite tendency is observed in the phase of full ripeness in the experimental variants: while in the phase of tubing the least prevalence was in the variants with mineral fertilizers, then in the phase of full...
ripeness in the variant with the use of granular organic fertilizers. This happened, most likely, because the diammofoska quickly dissolved in the soil and spring wheat received nutrients before the bumping phase. The dissolution of GOF in the soil took place gradually, and the release of nutrients occurred more slowly than the comparative diammophoski. Therefore, in the phase of complete ripeness, the spread of the disease with the use of granular organic fertilizers was less than in the experimental plots using mineral fertilizers, and in all cases. In the control, root rot spread was 62.8%. This is an average increase of 19.3% compared with the diammophos. The smallest spread and development of root rot was observed in the variant with the addition of granular organic fertilizers \(400 \text{ kg/ha}\) - 43.8% and 23.6% less than in the control variant, respectively.

**Table 1. The prevalence and development of root rot, %.

| Fertilizers                  | Fertilizer doses, kg/ha | Start of vegetation | Mid vegetation | End of vegetation |
|-----------------------------|-------------------------|---------------------|---------------|------------------|
|                             |                         | P\(^a\)             | R\(^b\)       | P\(^a\)          | R\(^b\)         |
| Control (without fertilizer)| -                       | 32.1                | 9.0           | 46.3             | 17.3            | 62.8 | 41.1 |
| Diammofoska (N10P20K20S9)   | 200                     | 27.4                | 7.3           | 35.3             | 13.1            | 50.4 | 28.4 |
|                             | 300                     | 28.1                | 7.6           | 35.1             | 13.0            | 49.7 | 27.6 |
|                             | 400                     | 25.6                | 6.9           | 36.5             | 13.4            | 52.1 | 27.9 |
| average                     |                         | 27.0                | 7.2           | 35.6             | 13.1            | 50.7 | 27.9 |
| GOF LLC "Stroy Garden" (N4P2.5K2.5) | 200                    | 30.4                | 8.4           | 41.8             | 15.6            | 45.6 | 24.5 |
|                             | 300                     | 29.5                | 8.1           | 39.8             | 15.8            | 43.3 | 23.4 |
|                             | 400                     | 28.4                | 7.8           | 37.5             | 15.6            | 42.5 | 23.1 |
| average                     |                         | 29.4                | 8.1           | 39.7             | 15.6            | 43.8 | 23.6 |

Note: \(^a\)P - distribution; \(^b\)R - root rot development

The yield of grain crops is a comprehensive indicator of all conditions that occur during the growth and development of plants. It primarily depends mainly on the number of productive plants and stems per unit area, the number of spikelets in the ear, the number of grains in it, and the mass of 1000 grains. The results of field experience showed that fertilization had a positive impact on the growth and development of spring wheat. The introduction of granulated organic fertilizers significantly increased the structure elements of the spring wheat crop.

**Table 2. Structure of the spring wheat crop.**

| Types of fertilizers | Fertilizer doses | The length of the plants cm | Productive stems with 1 m\(^2\), PCs | Grain weight per 1 ear, gr | weight of 1000 grains, PCs |
|----------------------|-----------------|-----------------------------|--------------------------------------|---------------------------|---------------------------|
| Without fertilizers  | –               | 73                          | 318                                  | 0.55                      | 31.69                     |
| (control)            | 200 kg/ha       | 74                          | 354                                  | 0.75                      | 38.24                     |
|                      | 300 kg/ha       | 75                          | 351                                  | 0.76                      | 42.70                     |
|                      | 400 kg/ha       | 78                          | 345                                  | 0.79                      | 43.60                     |
|                      | average         | 75.3                        | 351                                  | 0.76                      | 40.14                     |
|                      | 200 kg/ha       | 76                          | 345                                  | 0.56                      | 38.33                     |
| Diammofoska          | 300 kg/ha       | 74                          | 325                                  | 0.68                      | 37.20                     |
|                      | 400 kg/ha       | 76                          | 352                                  | 0.65                      | 40.18                     |
|                      | average         | 74.5                        | 337                                  | 0.61                      | 37.62                     |
| GOF LLC "Stroy Garden" | 300 kg/ha     | 74                          | 325                                  | 0.68                      | 37.20                     |
|                      | 400 kg/ha       | 76                          | 352                                  | 0.65                      | 40.18                     |
|                      | average         | 74.5                        | 337                                  | 0.61                      | 37.62                     |
As can be seen from table 2, the variants with diammofoski and the introduction of granular organic fertilizers show an increase in the value of the elements of the crop structure. The length of the stem of spring wheat in the control version was 73 cm. The length of the stems on the variant with the use of granular organic fertilizers varied from 74 cm with a dose of 300 kg/ha to 76 cm with doses of 200 and 400 kg/ha. The use of the mineral fertilizer diammofoska increased the length of the stem from 74 cm with a dose of 200 kg/ha to 78 cm with a dose of 400 kg/ha. Analyzing the remaining indicators of the crop structure, we can conclude that the increase in yield was formed due to a larger number of productive stems. If the control variant produced 318 PCs/m² of productive stems, then the diammophosk variant had 27 ... 36 more plants. In the variant with granulated organic fertilizers, the productive stems were less than in the variant with diammofoska, but significantly more than the control variant. The same trend in the structure of the spring wheat crop looks like the weight of grains from 1 ear. So in the control version, the weight of grain from 1 ear was 0.55 g. A little more (by 10.9%) looked like the weight of grain from 1 ear on the variant with the application of granular organic fertilizers. Even more – 38.2% compared to the control and 24.6% compared to granulated organic fertilizers looked like the weight of grain 1 per ear on the variant with diammofoska. The same indicators were for the mass of 1000 grains.

The main criterion for the effectiveness of fertilizer application in the cultivation of crops is the harvest. Crop yields are a comprehensive indicator of all conditions prevailing during the growth and development of plants. It primarily depends on the number of productive plants and stems per unit area, the number of spikelets in an ear, the number of grains in it and the mass of 1000 grains. The results of the field experiment showed that the application of fertilizers had a positive effect on the growth and development of spring wheat, significantly increasing the yield (table 3).

Table 3. Yield of spring wheat, t/ha.

| Types of fertilizers | control | Fertilizer doses | Dose average |
|----------------------|---------|-----------------|--------------|
|                      |         | 200kr/ra | 300kr/ra | 400kr/ra |              |
| diammofoska          | 1.62    | 2.50     | 2.64     | 2.74     | 2.58         |
| Increase in control  |         | +0.88    | +1.02    | +1.12    |              |
| GOF                  |         | 1.90     | 2.10     | 2.18     | 1.98         |
| Increase in control  |         | +0.28    | +0.48    | +0.56    |              |

Regardless of the application doses, mineral and organic fertilizers increased the yield of spring wheat grain. The lowest yield of spring wheat was in the control variant, where neither mineral nor organic fertilizers were used. The use of granulated organic fertilizers increased the yield of spring wheat by 0.28...0.56 t/ha (depending on the dose of GOF application). The highest value is observed in the variant with the introduction of 400 kg/ha and is 2.18 t/ha, which is 34.6% higher than the control variant. The largest increases in yield are observed on variants with the use of mineral fertilizers. Thus, the increase in yield on the background of diammofoski application at a dose of 200 kg / ha, compared with the control, was 0.88 t/ha, compared with the same dose of granulated organic fertilizers – 0.60 t/ha. At a dose of 300 kg/ha, the yield increase was 1.02 (+0.54) t/ha, and at a dose of 400 kg/ha, 1.12 (+0.56) t/ha, respectively.

4. Conclusion

The use of granular organic fertilizers based on bird droppings contributed to a decrease in the root rot susceptibility of spring wheat, starting from the booting phase: the smallest spread and development of root rot was observed in the variant with the introduction of GOF at a dose of 400 kg / ha - 43.8% and 23.6% less than in control, respectively. A significant increase in spring wheat yield is observed in the variants with the addition of 300 and 400 kg / ha of GOF.

The results confirm the value of granular organic fertilizers based on bird droppings. The use of such fertilizers enriches the soil with essential nutrients, increasing the yield and quality of crops.
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