ОБЩЕЕ ЗЕМЛЕДЕЛИЕ И РАСТЕНИЕВОДСТВО/GENERAL AGRICULTURE AND CROP PRODUCTION

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EFFECT OF GRANULAR ORGANIC FERTILISER ON SOIL MICRO-MYCETE COMPOSITION AND YIELD OF SPRING WHEAT

Research article

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Abstract

There are presented the results of long-term studies on the effect of granular organic fertiliser (GOF) from poultry manure on soil phytosanitary condition, development and spread of root rots and yield of spring wheat. A granular organic fertiliser improves the phytosanitary condition of the soil. The number of saprotrophic fungi and antagonists in the soil increases, and the number of pathogens decreases by 2 times. The total number of micro-mycetes increased by 1.6–2.1 times at the application of GOF at a dose of 500 kg/ha. The species diversity of fungi increases in the soil. Application of GOF significantly reduces the prevalence and development of root rots of spring wheat. The prevalence of the disease was less than the control by 1.5–1.9 times. Disease development was less by 1.9–2.1 times. In contrast, the prevalence was reduced by 6.1–12.9% and the development by 4.4–8.5% compared to azophoska. Application of organic fertiliser significantly increased the yield of spring wheat. The highest yield of spring wheat was obtained with application of 500 kg/ha (3.66 t/ha) of GOF. The yield increase was 1.42 t/ha.

Keywords: agroecological substantiation, granular organic fertiliser, spring wheat, soil micro-mycete composition, root rot, yield.

ВЛИЯНИЕ ГРАНУЛИРОВАННОГО ОРГАНИЧЕСКОГО УДОБРЕНИЯ НА МИКРОМИЦЕТНЫЙ СОСТАВ ПОЧВЫ И УРОЖАЙНОСТЬ ЯРОВОЙ ПШЕНИЦЫ

Научная статья

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Аннотация

В статье представлены результаты многолетних исследований по изучению влияния гранулированного органического удобрения (ГОУ) из птичьего помета на фитосанитарное состояние почвы, развитие и распространение корневых гнилей и урожайность яровой пшеницы. Гранулированное органическое удобрение улучшает фитосанитарное состояние почвы. Количество сапротрофных грибов и антагонистов в почве увеличивается, а количество патогенов снижается в 2 раза. Общее количество микромицетов в почве при внесении ГОУ в дозе 500 кг/га увеличилось в 1,6–2,1 раза. В почве увеличивается видовое разнообразие грибов. Внесение ГОУ значительно снижает распространенность и развитие корневых гнилей яровой пшеницы. Распространенность болезни было меньше контроля в 1,5–1,9 раз. Развитие болезни меньше в 1,9–2,1 раза. В отличие от азофоски распространенность снизилась на 6,1–12,9%, а развитие — на 4,4–8,5%. Внесение органического удобрения существенно повысило урожайность яровой пшеницы. Наибольшая урожайность яровой пшеницы получена при внесении ГОУ 500 кг/га (3,66 т/га). Прибавка урожая составила 1,42 т/га.

Ключевые слова: агроэкологическое обоснование, гранулированное органическое удобрение, яровая пшеница, микромицетный состав почвы, корневые гнили, урожайность.

Introduction

Spring wheat, as one of the most important food crops, is cultivated in almost all agricultural enterprises in the Republic of Mari El. In the current market economy, significant attention is paid to improving cultivation technologies when growing agricultural crops. The technology should facilitate the maximum realization of the potential productivity of wheat and the production of high-quality grain. New intensive-type spring wheat varieties are increasingly being introduced in farms. These varieties have higher requirements for mineral nutrition conditions. When cultivating new varieties using traditional methods and applying recommended rates of mineral fertilizers, the crop yield often turns out to be lower than that of older varieties. To achieve the primary goal of crop production, which is to obtain the maximum yield, it is necessary to provide the plants with balanced mineral nutrition. Currently, the prices of mineral fertilizers are high, which limits their application. Achieving high yields of spring wheat in the Republic of Mari El is impossible without the use of fertilizers. The sod-podzolic soils in the republic have low natural fertility. The lack of nutrients in the soil is the reason for the low yield of wheat and other crops [1].

One of the key methods for increasing the yield of agricultural crops is the optimal use of mineral and organic fertilizers [2].

The complex economic situation in the agro-industrial complex and crop production has prompted the search for various alternatives to improve soil fertility and increase yields [3]. In the Republic of Mari El, granulated organic fertilizer based on poultry manure is produced. Poultry farming is actively developed in the region, producing a large amount of manure. Using chicken manure as an organic fertilizer in its pure form is dangerous, so it must be processed. During the processing of manure and the production of granules, it is treated with a biological preparation and subjected to thermal exposure. This fertilizer has a prolonged effect on plants. It allows for the partial replacement of mineral fertilizers with organic ones [4].

The production and use of granulated organic fertilizer solves the problem of poultry farming waste disposal. This is also important from an environmental perspective [5]. Granulated organic fertilizer contains, in addition to macronutrients (nitrogen, phosphorus, and potassium), a large amount of various micronutrients [6]. The use of active strains of bacteria in the biological preparation during the processing of manure before granulation contributes to the improvement of the phytosanitary condition of the soil due to the presence of beneficial microorganisms [7], [8]. Granulated organic fertilizer increases the biological activity of the soil and positively affects crop yield and product quality [9], [10].

The aim of the research is to evaluate the effectiveness of granulated organic fertilizer in increasing the yield of spring wheat and improving the soil's mycological composition.

Research methods and principles

Field experiments were conducted on the experimental field of Mari State University from 2018 to 2022. Fertilizers were applied as top dressing during the tillering phase of spring wheat. To compare the effectiveness of granulated organic fertilizer (GOF), we used mineral fertilizers azophoska a. The experimental design was as follows:

1) control (no fertilizers);
2) azophoska a (100 kg/ha);
3) GOF (300 wkg/ha);
4) GOF (500 kg/ha).

The area of each plot is 50 m^2. The repeatability of the experiment is threefold, the arrangement of plots is systematic. Granulated organic fertiliser is made from poultry manure by biofermentation by microorganisms. Poultry manure is placed in piles, it is treated with biopreparation and then tedded. Then the pellets are made. Agrochemical composition of GOF: pH is 8.8, moisture content is 19%, total nitrogen is 5.0%, total phosphorus is 5.0%, total potassium is 3.9%, organic matter is 37.2%. No patent has been obtained for this fertiliser, but there is TS 20.15.80-001-93165337-2018.

The soil was sod-podzolic, medium loamy, with a humus content of 1.61–1.74%, pH of 5.6–5.8, easily hydrolyzable nitrogen of 140 mg/kg, phosphorus of 163 mg/kg, and potassium of 118 mg/kg.

Spring wheat was cultivated using conventional agricultural practices. The preceding crop was a vetch-oat mixture for grain. After harvesting the preceding crop, autumn tillage was carried out, followed by spring harrowing, cultivation, and rolling. To study the mycological composition of the soil and the rhizosphere of spring wheat, samples were taken three times during the wheat growing season. Samples were taken during the tillering, heading, and milk ripening phases.

Soil samples were taken at a soil depth of 0-10 cm along the diagonal of the plot in three locations. The average sample weight was 200–300 g. It was thoroughly mixed and a small amount of soil was taken for analysis. Then it was placed in a sterile porcelain mortar and sieved through a sieve. After that, we took a 1 g sample for preparation of soil suspension. The suspension was poured into a sterile flask with cotton gauze lid and was added 9 ml distilled water. The resulting suspension was shaken for 10–15 minutes, then it was allowed to stand for 2–3 minutes.

The analysis of the samples was carried out by the method of soil inoculation on a solid nutrient Czapek medium. Fungal species were identified using the key by N.M. Pidoplichko [11]. The development and spread of root rot in spring wheat were assessed using the route survey method [12].

Main results

Soils of any agrocenosis have certain physical, chemical and biological characteristics. They contain microorganisms typical of the given agroecosystem, and a biological equilibrium is established. The presence of microorganisms and their species composition can vary depending on growing conditions and weather. Agricultural practices play an important role in shaping and altering the microbiological composition of the soil. Plants release various sets of substances, which can lead to changes in the composition of the microbiota depending on the type of vegetation. Plant roots form symbiosis with fungi (mycorrhiza). Mycorrhiza not only improves the plant's nutrient uptake but also promotes the development of certain groups of microbes in the soil. These symbiotic relationships can significantly alter the microbiological composition, increasing the number of beneficial microorganisms. Microorganisms are involved in the decomposition of plant residues.

Fertilizers used in plant cultivation affect the quantity and species composition of the rhizosphere microflora. Organic fertilizer improves plant nutrition and alters the living conditions of soil microorganisms [13]. Long-term research demonstrates that granulated organic fertilizer affects soil microbiology. We analyzed the species diversity of soil micromycetes and found that more than twenty typical fungal species predominate in spring wheat soil.

Fungi of the genera Alternaria spp., Drechslera, and Fusarium spp. are pathogens and causative agents of root rot in spring wheat. The following species can be considered typical for this agrocenosis: *Drechslera sorokiniana Sacc., Fusarium culmorum Sacc., F. graminearum Sch., F. oxysporum Schl., and Alternaria alternata Fr.*

Typical representatives of saprophytic fungi in our agrocenosis include species such as *Penicillium frequentans Westl., P. viridicatum Westl., P. funiculosum Thom., Aspergillus niger van Tiegh., A. clavatus Desm., and Rhizopus nigricans Ehr*. The fungus *Mucor piriformis Fisch*. was also frequently encountered.

Special attention was paid to the presence of the antagonistic fungus *Trichoderma lignorum (Tode) Haz*. in the soil. This fungus plays an important role in suppressing the development of phytopathogens and improving the phytosanitary condition of the soil. In natural habitats, this fungus feeds on dead, partially decomposed plant residues and is concentrated mainly near the root system of plants. Upon contact with phytopathogens, it actively exhibits antagonistic activity.

We analysed soil micro-mycete composition by phases of spring wheat development. The data of studies on average for 5 years showed that the application of organic granular fertiliser increases microbiological activity. The total number of soil fungi increases. In the tillering phase of spring wheat in the control variant, the total number of fungi was 36.4 thousand CFU per 1 g of soil, of which 4.5 thousand CFU were pathogenic fungi. The amount of fungi in the variant with azophoska was 27.5 thousand CFU per 1 g of soil, of which the number of pathogens was 2.5 thousand CFU per 1 g of soil.

The application of granular organic fertiliser at a dose of 300 and 500 kg/ha increased the total number of fungi in the soil by 5.2 and 23.4 thousand CFU /g soil. The antagonist fungi Trichoderma lignorum Tode were detected in these variants. The amount of pathogens in these variants were 1.5 and 2.0 thousand CFU/g, respectively, and antagonists were 8.3 and 10.5 thousand CFU/g of soil.

The analysis of soil micromycete composition in the earing phase showed that the number of saprotrophic and antagonistic fungi increased in the variants with GOF. There were 20.5 thousand CFU / g of soil in the fourth variant of antagonists, and there were 12.5 thousand CFU per 1 g of soil in the third variant. There is a tendency of increase of antagonist fungi with increasing rate of application of granular organic fertilisers. The number of pathogens in variants with GOF was by 2 times less in the earing phase compared to the control and the variant with azofoska. The total number of fungi increased with increasing dose of organic fertiliser.

Discussion

The maximum number of fungi in the phase of milk ripeness was in the fourth variant (110.5 thousand CFU per 1 g of soil). The number of pathogens in variants with organic fertiliser was smaller by 2.0–2.2 times than in the control and in the second variant. The number of saprotrophic fungi, on the contrary, increases.

The results of soil analysis showed that the total number of fungi varied among variants and phases of plant development (Figure 1).

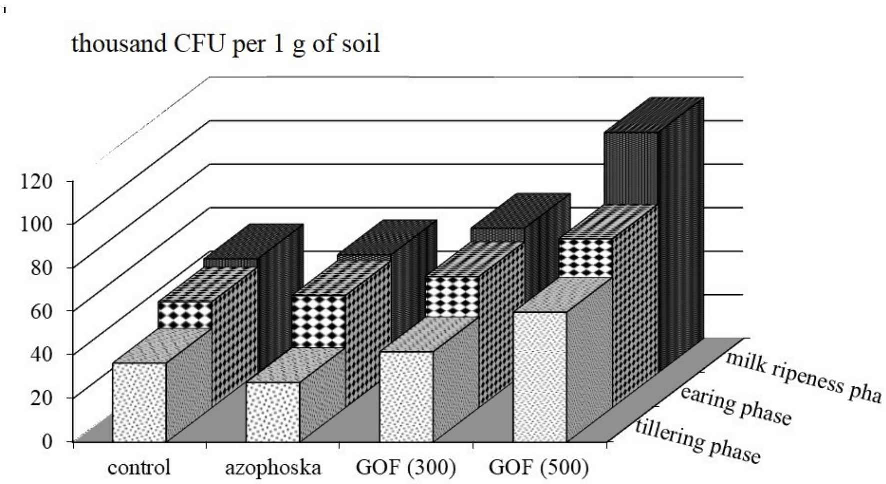

Figure 1 - Total number of fungi in soil

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Therefore, the application of granular organic fertilisers increases saprotrophic and antagonistic fungi in the soil and reduces the number of pathogens. The application of GOF increased the species diversity of fungi in the soil. The best results were in the variant with application of 500 kg/ha of GOF. The total number of fungi was higher than the control by 1.6-2.1 times. The number of pathogens by phases does not increase, and antagonist fungi become more.

Soil micromycete composition affects the defeat of spring wheat by root rots. The composition of micro-mycetes, the ratio of saprotrophic and pathogenic fungi and the presence of antagonists in the soil are changed by fertiliser application (Table 1).

Table 1 - Distribution and development of root rots of spring wheat, averaged over 2020-2022

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Variants	Tillering phase		Earing phase		Milk ripeness phase	
	P, %	R, %	P, %	R, %	P, %	R, %
1. Control	23.1	12.3	36.2	16.8	43.1	22.4
2. Azophoska	18.2	10.3	28.7	13.3	42.4	19.0
3. GOF (300)	16.6	7.7	26.5	10.2	38.8	12.2
4. GOF	12.1	5.9	22.3	8.9	29.5	10.5

Variants	Tillering phase		Earing phase		Milk ripeness phase	
	P, %	R, %	P, %	R, %	P, %	R, %
(500)						

Note: P is prevalence of root rots, R is development

The spring wheat plants were most affected in the control variant (without fertiliser). From the application of azophoska in the tillering phase of plants, prevalence decreased by 4.9% and development by 2.0%. There was a decrease by 7.5 and 3.5% in earing phase. There was a decrease by 0.7 and 3.4% in milk ripeness phase. The application of GOF significantly reduced the incidence and development of root rots of spring wheat. The greatest reduction was at the application of GOF at a dose of 500 kg/ha. The prevalence of the disease was less than the control by 1.9; 1.6 and 1.5 times by phases of plant development. Development was less by 2.1; 1.9 and 2.1 times. In contrast to azophoska, the prevalence of root rots was less by 6.1–12.9% and development was less by 4.4–8.5%.

The application of fertilisers leads to an increase in the amount of stubble and root residues. Their decomposition favours the appearance of new organic colloids in the arable layer. The contents of the mass fraction of nitrogen, phosphorus and potassium in the soil change depending on the application of organic fertiliser (Table 2).

Table 2 - The dynamics of total nitrogen, phosphorus and potassium content in soil during the growing season of spring wheat

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Variants	Tillering phase			Earing phase			Milk ripeness phase		
	N	P	K	N	P	K	N	P	K
Control	140	163	118	76	156	113	94	165	125
Azofoska (100 kg/ha)	140	163	118	91	172	130	96	177	145
GOF (300 kg/ha)	140	163	118	96	168	120	103	180	145
GOF (500 kg/ha)	140	163	118	97	182	130	101	224	170

Note: N is nitrogen; P is phosphorus; K is potassium

The analysis data showed that the application of organic and mineral fertilisers to sod-podzolic soil changed the content of nitrogen, phosphorus and potassium in the soil. The highest amount of them was in the variant with application of GOF at a dose of 500 kg/ha. Correlation analysis of soil micro-mycete composition and nutrition elements content showed a close relationship. The correlation coefficient between the content of micro-mycetes and nitrogen in the soil was 0.72...0.60, with phosphorus was 0.84...0.98, with potassium was 0.55...0.90.

Fertiliser application contributes to the increase of spring wheat yield (Figure 2).

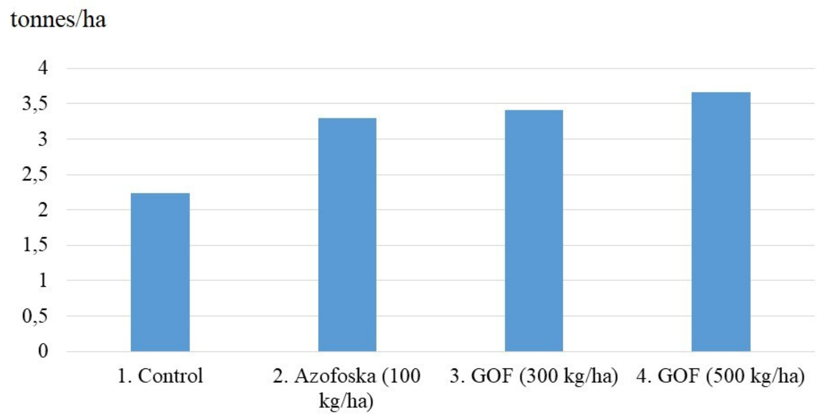

Figure 2 - Spring wheat yields
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Note: least significant difference in 2020 = 0.24; in 2021 = 0.18; in 2022 = 0.27

The application of organic fertiliser significantly increased spring wheat yield compared to the variant without fertiliser. So, at the application of 300 kg/ha the yield increase in average for 3 years was 1.06 tonnes/ha. Compared to mineral fertiliser, the increase was higher 0.11 t/ha. The highest yield of spring wheat was obtained with the application of GOF 500 kg/ha (3.66 t/ha). The yield increase was 1.42 t/ha.

Conclusion

1. The application of granular organic fertiliser from poultry manure improves the phytosanitary condition of soil. The number of saprotrophic fungi and antagonists in the soil increases, and the number of pathogens decreases. The total number of micro-mycetes in the soil increased by 1.6-2.1 times when applying GOF at a dose of 500 kg/ha.

2. The application of GOF significantly reduces the prevalence and development of root rots of spring wheat. The greatest reduction was at the application of GOF at a dose of 500 kg/ha. The prevalence of the disease was less than the control by 1.5-1.9 times. Disease development was less by 1.9-2.1 times.

3. The application of fertilisers substantially increases the yield of spring wheat. The highest yield of spring wheat was obtained with the application of GOF at a dose of 500 kg/ha (3.66 t/ha). The yield increase was 1.42 tonnes/ha.

Конфликт интересов

Не указан.

Рецензия

Все статьи проходят рецензирование. Но рецензент или автор статьи предпочли не публиковать рецензию к этой статье в открытом доступе. Рецензия может быть предоставлена компетентным органам по запросу.

Conflict of Interest

None declared.

Review

All articles are peer-reviewed. But the reviewer or the author of the article chose not to publish a review of this article in the public domain. The review can be provided to the competent authorities upon request.

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