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EVALUATION OF INFLUENCE OF IODINE-CONTAINING FERTILIZER ON SOIL AND SPRING WHEAT PLANTS

Selyuk M. P.1, Gavrilets T. V.1, Matenkova E. A.1, Subotyalov M. A.2

1Novosibirsk State Agrarian University, Novosibirsk, Russia 2Novosibirsk State Pedagogical University, Novosibirsk, Russia E-mail:selyuck.marina@yandex.ru

The influence of iodine on the number of soil microorganisms, suppressiveness and phytosanitary state of the soil in relation to the main causative agent of spring wheat root rot Bipolaris sorokiniana was studied. The research was carried out in the Novosibirsk region in the Praktik educational and experimental farm of the Novosibirsk State Agrarian University. The soil cover is leached chernozem. When cultivating spring wheat of the Obskaya 2 variety, the main technological operations were used, corresponding to the zonal farming system. The predecessor is pure steam. Iodine was part of the mineral fertilizer Agrocen. The use of Agrocen had a positive effect on the studied parameters of soil health, as well as on the growth and development of spring wheat plants. The phytosanitary effect of Agrocene against the population of Bipolaris sorokiniana in the soil was revealed, and an increase in the level of soil suppression was also noted. The effect of iodine on groups of soil microorganisms was ambiguous. There was an increase in the number of soil saprotrophic fungi and actinomycetes by 2 times, the number of cellulolytic microorganisms increased by 2.8 times. The number of bacteria assimilating mineral and organic forms of nitrogen varied according to the variants. Spring wheat plants favorably perceived the use of fertilizer, the biological yield in the variants with the use of Agrocene was maximum, and the development of root rot decreased.

Key words: Mineral fertilizer, phytosanitary state, root rot, productivity.

INTRODUCTION

For Russia, the problem of iodine deficiency is extremely relevant, since more than 70% of the country's territory has a lack of iodine in water, soil and food of local origin. In addition, the excess, deficiency or imbalance of trace elements in the soil-plant-animal (human) system negatively affects the health of the population living in this region [1, 2]. Iodine is a necessary component of the synthesis of thyroid hormones in the thyroid gland, which regulate the rate of biochemical reactions in all cells of human and animal organs and tissues [3, 4].

It is known that soil organic matter plays a dominant role in the processes of iodine accumulation. The studies carried out in Western Siberia have shown that the soils of the northern territories are the poorest in iodine. Podzolic and soddy-podzolic soils of the middle and southern taiga, as well as gray soils of the northern forest-steppe, contain much more iodine, but its amount remains insufficient. In the zonal soils of the forest-steppe and steppe zones - chernozems, the content of iodine in the humus horizon is sufficient. When moving into the zone of dry steppes, the iodine content in soils decreases [5–8].

One of the promising ways to solve the problem of the lack of trace elements in soil, plants, respectively, in the food of animals and humans, is their use in agricultural production, in particular, the agrochemical method [9].

Trace elements are necessary for the normal development of plants, but their need is expressed in small quantities, without which they can die or develop poorly. This is due to the fact that trace elements are part of enzymes, vitamins, hormones and affect their activity. The issue of iodine enrichment of plant products in order to prevent iodine deficiency has been of scientific interest for a long time. The agrochemical method of plant enrichment with microfertilizers containing iodine is promising, since it allows the micronutrient to be converted into a safe and accessible form, improve the yield and quality of crop products [1, 10].

Iodine-based microfertilizers can be used to increase the productivity of cultivated plants and crop quality, to increase the content of microelements in them, which in turn will lead to an improvement in the microelement status of the region [11].

Spring wheat plays a leading role in world agriculture, ranking first in terms of sown area and gross grain harvest, and is the main food crop in the Russian Federation. The most important task of modern crop production is to increase the qualitative and quantitative indicators of spring wheat grain production. The introduction of new balanced mineral fertilizers into agricultural technology, which provide an increase in the quality of grain and the yield of spring wheat, and optimization of soil fertility, is relevant and practically significant [12].

Among the phytosanitary problems in the technologies of spring wheat cultivation, root rots are of particular importance, which annually reduce the yield of spring wheat by 25% or more, causing thinning of crops, growth inhibition, disruption of the dynamics of plant organogenesis, deterioration in the formation of elements of the yield structure, and a significant decrease in product quality [13 -16].

The effect of iodine on the phytosanitary state of the soil in relation to the main pathogen of spring wheat root rot, as well as on microbiological activity and suppressiveness in the forest-steppe of the Ob region, has not been studied enough. Therefore, studies on the enrichment of grain crops with microelements on the soils of Western Siberia are of particular relevance [17, 18].

In connection with the foregoing, the purpose of the research was to assess the effect of the iodine-containing fertilizer Agrocen on the components of soil biocenosis and the development of root rot of spring wheat in the forest-steppe of the Ob region.

MATERIALS AND METHODS

The influence of iodine on the phytosanitary state of the soil, its microbiological activity, suppressiveness was studied in the educational and experimental farm of the Novosibirsk State Agrarian University "Praktik". The soil cover is leached medium-thick, medium-humus chernozem with a humus content of 4.5-5.5%, pH 6.6.

When cultivating spring wheat of the Obskaya 2 variety, the main technological operations were used, corresponding to the zonal farming system. The predecessor is pure steam. Seeding rate 5.5 million pcs/ha. Before sowing, part of the seeds were treated with iodine-containing fertilizer (1 l/t). The sowing depth is 3-4 cm. The sowing of the culture was carried out on May 20 with a seeder SS-11. Under presowing cultivation, mineral fertilizers were applied - ammonium nitrate at a dose of 30 kg AI/ha. During the growing season, 1 half of the experimental area was treated with a tank mixture of herbicides Tigran (0.7 l/ha) and Oprichnik (7 g/ha), and the other half with a tank mixture of iodine-containing fertilizer (0.4 l/ha) with these herbicides. Spraying of crops was carried out using a tractor sprayer OPSh-15 with a working solution consumption rate of 200 l/ha.

Agrocen was used as an iodine-containing fertilizer. Agrocen is a liquid mineral iodine-containing fertilizer with the addition of trace elements: potassium, magnesium, selenium, zinc (pH 6-7) [18].

The scheme of the experiment is presented in Table 1.

Table 1

Scheme of a field experiment to study the effect of Agrocene on soil health indicators and spring wheat plants

No.	Option
1	Untreated seeds (control)
2	Untreated seeds + Agrocen for vegetation (0.4l/ha)
3	Seeds treated with Agrocene (1.0l/t)
4	Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)

Laboratory experiments were carried out according to generally accepted methods. The number of microorganisms was taken into account by the method of soil dilutions [19], the population of the soil by Bipolaris sorokiniana conidia was taken into account by the flotation method [20, 21], and root rot was taken into account according to V.A. Chulkina [21]. Soil suppression was determined using a new method [22]. The biological yield of spring wheat was calculated according to the method for determining the elements of the crop structure [21].

Statistical data processing was carried out by the methods of analysis of variance and correlation [23] using the SNEDECOR [24] and STATISTICA 6.0 software packages for Windows.

RESULTS AND DISCUSSION

Implementation of adaptive landscape systems and biologization of agriculture, optimization of management in agroecosystems by modes and balance of biophilic elements, organic substances other landscape and reclamation measures, including mineral fertilizers, require a comprehensive assessment of soil health in terms of phytosanitary and environmental parameters, among which an important role is played by indicators of the population of zonal soils with pathogenic micromycetes [5, 10, 25–27]. The high infectious potential of root rot pathogens in the soil determines the seasonal and long-term dynamics of the epiphytotic process and is a decisive starting factor in the development of soil infections [28].

We used the soil density index of B. sorokiniana conidia as an indicator reflecting the effect of Agrocene on the phytopathogenic soil mycocenosis, its microbiological activity and suppressiveness (Tables 2-5).

Table 2 shows that the soil biocenosis is saturated with B. sorokiniana conidia. The excess of PV (30 pieces/1 g of air-dry soil) on average for the samples was 2.7 times. The highest density of pathogenic micromycete conidia in the soil was noted in the control variant.

table 2

Influence of Agrocene on the Density of B. sorokiniana Conidia in the Soil

No.	Option	The total number of conidia / 1 g air-dry. soil	Share of degraded conidia, %
1	Untreated seeds (control)	105	24.0
2	Untreated seeds + Agrocen for vegetation (0.4l/ha)	75	67.0
3	processed seeds Agrocenome (1.0l/t)	80	24.0
4	Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	55	39.0
NSR05		4.7	

The excess of PV in the phase of full ripeness of spring wheat was 3.5 times, which corresponds to the level of epiphytosis. The maximum proportion of degraded conidia in the phytopathogen population was noted in the variants with the use of Agrocen for vegetation.

The high infectious potential of Bipolaris sorokiniana in the soil is due to the annual mass reproduction of the phytopathogen on the basal leaves of wheat, starting from the culture filling phase, and the good survival of conidia on plant debris [29, 30].

The density of B. sorokiniana conidia in the variant with seeds treated with Agrocen was (more than 2 times) higher compared to the variant (treated seeds + Agrocen). The minimum density of conidia was also noted in this variant. The biological efficiency with the double application of Agrocene (treated seeds + Agrocene) was 48%, with the use of Agrocene during the growing season, the biological efficiency was 29%.

This is explained by the fact that the use of iodine-based mineral fertilizer increased the resistance of vegetative plants to the phytopathogen, and the seeds were disinfected during their processing and in the soil. This is also evidenced by the low damage of plants by root rot (Table 3).

Table 3

Influence of Agrocene on the development of root rot of spring wheat Obskaya 2 in the middle of the growing season

Option	Average for organs				Plant average
	Perv. roots	Epicotyl	Deut. roots	Main stem	
Raw seeds (control)	7.2	7.9	7.3	2.7	6.3
Untreated seeds + Agrocen for vegetation (0.4l/ha)	6.7	6.7	7.3	2.1	5.7
processed seeds Agrocenome (1.0l/t)	3.1	5.5	3.6	1.9	3.5
Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	2.4	2.6	2.6	1.7	2.3
NSR05					2.2

In the middle of the growing season, the development of root rot of spring wheat under the conditions of Agrocen application was at a low level. None of the options reached the threshold of harmfulness (PV=15%).

The maximum development of the disease was noted in the variant with untreated seeds - 6.3%, the minimum development of the disease - in the variant with treated seeds and Agrocen applied during vegetation. The defeat of underground organs was approximately at the same level of 4.9-5.8%, which is also lower than PV. The base of the plant stem was minimally affected. The biological efficiency of Agrocen in the variant with its double application compared with the control variant was 63.5%.

By the end of the growing season, the development of root rot intensified, however, PV was not achieved in any of the options (Table 4).

In the control variant, the development of the disease was 14.6%. It was maximum, minimum - in the variant with treated seeds and Agrocen for vegetation - 9.7%. The biological efficiency of Agrocene was 33.6%.

According to the literature data, the seasonal dynamics of the development of spring wheat root rot with a sharp increase in the EP of the disease in the initial phases of plant development imposes increased requirements on the quality of seeds and the technology of their sowing. To overcome the critical period of development for plants, when they are most susceptible to biotic and abiotic stressors, it is necessary to maximize the quality of seeds by agrotechnical (calibration, heating) and chemical (treatment, growth regulators) methods, as well as the rational use of fertilizers [13, 28].

Table 4

Influence of Agrocen on the development of root rot of spring wheat cv. Obskaya 2 at the end of the growing season

Option	Average for organs				
	Perv. roots	Epicotyl	Deut. roots	Main stem	Plant average
Untreated seeds (control)	13.1	10.6	11.3	9.5	14.6
Untreated seeds + Agrocen for vegetation (0.4l/ha)	15.8	13.5	14.0	12.2	12.7
Seeds treated with Agrocene (1.0l/t)	22.8	20.5	19.6	14.5	12.3
Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	6.5	4.7	6.0	2.7	9.7
NSR05					8.2

A high correlation was found between the density of B. sorokiniana conidia in the soil and the development of root rot of spring wheat in the middle (r= 0.812±0.412) and at the end of the growing season (r=0.969±0.174), which indicates a close relationship between the discussed indicators in the forest-steppe of the Ob region .

According to the literature data, the use of mineral fertilizers can increase the suppressiveness and microbiological activity of the soil [1, 15]. Soil occupancy by phytopathogens was closely related to the index of suppression; therefore, records of this index were carried out (Table 5).

According to the table, the level of soil suppression increased in all variants where Agrocen was applied. The maximum level of suppression was noted in the variant with treated seeds and Agrocene for vegetation, which indicates its favorable effect on soil antagonists. The level of soil suppression was at an average and strong pronounced level. A high negative relationship was found between the density of B. sororkiniana conidia in the soil and its suppressiveness r=-0.965±0.184, which indicates the important role of antagonists in the control of soil infections.

Microorganisms are very sensitive indicators that react sharply to various changes in the environment.

Table 5

Soil suppressiveness against Bipolaris sorokiniana under conditions of Agrocene application

Option	Bipolaris sorokiniana	
	abs.	deviation
Untreated seeds (control)	51.9	
Untreated seeds + Agrocen for vegetation (0.4l/ha)	56.9	9.6

processed seeds Agrocenome (1.0l/t)	57.8	11.4
Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	65.4	26.0
NSR05	0.6	

Hence the high dynamism of microbiological indicators. According to the studies of Sindireva A.V. et al. [17], the effect of iodine on groups of soil microorganisms was ambiguous. Thus, the trace element had the most favorable effect on the number of oligonitrophils; it increased at low concentrations of iodine. Iodine had a favorable effect on nitrifiers, their number increased by an average of 18.6% compared with the control. However, the number of cellulose-destroying microorganisms decreased under the influence of iodine. The action of this microelement had a positive effect on the increase in the number of microscopic fungi.

The influence of Agrocene on groups of soil microorganisms on leached chernozem is presented in tables 6-7.

Table 6

The number of microscopic fungi in soil samples under the conditions of Agrocene application, CFU/g of soil

Option	Mushrooms	
	CHAx104	GSx105
Untreated seeds (control)	11.7	19.0
Untreated seeds + Agrocen for vegetation (0.4l/ha)	20.0	22.7
Seeds treated with Agrocene (1.0l/t)	24.7	24.3
Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	23.0	53.3
NSR05	1.4	1.4
*HA - Chapek's agar; GS - Hutchinson Wednesday		

The research results indicate a significant effect of iodine on the number of microscopic fungi. Saprotrophic micromycetes on HA were presented in the maximum amount in the variant with treated seeds and in the variant with double application of Agrocene. Their number has increased by an average of 2 times. The number of fungi on the GS was maximum in the variant with the double application of Agrocene. Their number increased by 2.8 times compared to the variant without the use of iodine-containing fertilizer. Thus, the use of the drug Agrocen contributes to an increase in the number of micromycetes in the soil.

Correlation coefficients between the development of root rot in spring wheat and the number of fungi on HA is r=-0.659±0.451, between the development of root rot in spring wheat and the number of fungi on HS r=-0.928±0.263. The effect of iodine on soil bacteria and actinomycetes is presented in Table 7.

Table 7

The number of bacteria and actinomycetes in the samples under the conditions of Agrocene application, CFU/g of soil

Option	bacteria	actinomycetes

	KAAx105	MPAH105	KAAH105
Untreated seeds (control)	26.7	17.0	
Untreated seeds + Agrocen for vegetation (0.4l/ha)	63.7	34.7	5.7
Seeds treated with Agrocene (1.0l/t)	28.3	19.7	8.0
Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	52.7	19.3	10.0
NSR05	5.3	1.1	1.7
*KAA - starch-ammonia agar MPA - meat-peptone agar			

The maximum number of soil bacteria consuming both mineral and organic nitrogen was noted in the variant with the use of Agrocene during vegetation. The increase was 2.4 and 2 times, respectively. Their minimum number is presented in the variant without the use of iodine-containing fertilizer. The correlation coefficient between the number of microorganisms consuming mineral forms of nitrogen and the development of root rot in spring wheat was r= -0.491±0.615, which indicates the presence of a moderate negative relationship between these indicators.

The number of soil actinomycetes also increased after the application of fertilizer. This group of soil microorganisms is characterized by much slower growth and is highly resistant to many negative environmental influences. Considering that actinomycetes play an important role in the process of soil formation and participate in the decomposition of compounds that are difficult to hydrolyze and are inaccessible to bacteria, this can lead to an increase in soil fertility. So, in the variant without the use of Agrocen, no actinomycetes were found at all.

Further, according to the options, their numbers increase. The correlation coefficient between the number of actinomycetes and the development of root rots in spring wheat was r = -0.929±0.261, which indicates the presence of a high negative relationship between these indicators.

The results of the biological yield of spring wheat are presented in Table 8.

Table 8

Yield of spring wheat variety Obskaya 2 under conditions of application of Agrocen

Option	Biological yield, centner/ha
Untreated seeds (control)	29.1
Untreated seeds + Agrocen for vegetation (0.4l/ha)	35.3
processed seeds Agrocenome (1.0l/t)	38.1
Seeds treated with Agrocen (1.0 l/t) + Agrocen for vegetation (0.4 l/ha)	47.5
NSR05	6.2

The data in the table indicate that the yield largely depended on the use of iodine-containing fertilizer. The highest yield was after the double application of Agrocen, it exceeded the control variant without fertilizer treatment by 63.5%. A high negative correlation was found between the development of spring wheat root rot and productivity (r=-0.997±0.049), between the productivity and density of B. sorokiniana conidia in the soil (r=-0.951±0.217), which once again confirms the need to maintain a favorable phytosanitary state soils for realizing the production potential of spring wheat.

CONCLUSION

1. The use of iodine-containing fertilizer Agrocen has a positive effect on the studied parameters of soil health, as well as on the growth and development of spring wheat.
2. The use of Agrocene reduces the density of B. sorokiniana conidia and increases the level of soil suppression. A high negative relationship was found between the density of B. sororkiniana conidia in the soil and its suppressiveness r=-0.965±0.184, which indicates the important role of antagonists in the control of soil infections.
3. The introduction of the drug Agrocen increases the number of soil microorganisms. Maximum quantity increase bacteria, assimilating organic and mineral forms of nitrogen, noted in the variant with the use of the drug for vegetation.
4. Due to the introduction of the drug Agrocen, the development of root rot does not reach the PV. Medium and high negative correlations were found between the development of root rot and the number of fungi per NA (-0.659±0.45)1, between the development of root rot and the number of fungi per HG (-0.928±0.263), between the development of root rot and soil suppression (- 0.965±0.184).
5. The yield largely depended on the use of iodine-containing fertilizer. The highest yield was after the double application of Agrocen, it exceeded the control variant without fertilization by 63.5%.

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ASSESSMENT OF THE EFFECT OF IODINE-CONTAINING FERTILIZERS ONTHE SOIL AND PLANTS OF SPRING WHEAT

Selyuk MP1, Gavrilets TV1, Matenkova EA1, Subotyalov MA2

1Novosibirsk State Agrarian University, Novosibirsk, Russia

2Novosibirsk State Pedagogical University, Novosibirsk, Russia

Email:selyuck.marina@yandex.ru

The effect of iodine on the number of soil microorganisms, suppressiveness and phytosanitary condition of the soil in relation to the main causative agent of root rot of spring wheat Bipolaris sorokiniana was studied. The research was carried out in the Novosibirsk region. The soil cover is leached chernozem. When cultivating spring wheat of the Ob 2 variety, the main technological operations corresponding to the zonal system of agriculture were used. The predecessor is pure steam. Iodine was part of the mineral fertilizer Agrotsen.

The purpose of this study is to assess the effect of the iodine-containing fertilizer Agrotsen on the components of soil biocenosis and the development of root rot of spring wheat in the forest-steppe of the Ob region.

The use of Agrotsen positively influenced the studied parameters of soil health, as well as the growth and development of spring wheat.

The phytosanitary effect of Agrotsen against the Bipolaris sorokiniana population in the soil was revealed, and an increase in the level of soil suppressiveness was also noted. According to our research, the biocenosis of the soil is saturated with Bipolaris sorokiniana conidia. Exceeding the threshold of harmfulness on average by samples was 2.7 times. The highest density of conidia of pathogenic micromycetes in the soil was noted in the control variant.

Due to the introduction of the Agrotsen, the development of root rot of spring wheat did not reach the threshold of harmfulness during the growing season. A high correlation was revealed between the density of Bipolaris sorokiniana conidia in the soil and the development of spring wheat root rot ($r= 0.812\pm0.412$; $r=0.969\pm0.174$), which indicates a close relationship between the discussed indicators in the forest- steppe of the Ob region.

The level of soil suppression increased in all variants where Agrotsen was used. The maximum level of suppressiveness was noted in the variant with treated seeds and Agrotsen for vegetation, which indicates its beneficial effect on soil antagonists. The level of the suppressive capacity of the soil was at an average and strongly pronounced level. A high negative relationship was revealed between the density of Bipolaris sorokiniana conidia in the soil and its suppressiveness ($r=-0.965=0.184$), which indicates the important role of antagonists in the control of soil infections.

The number of saprotrophic micromycetes increased by an average of 2 times, the number of cellulolytic microorganisms increased by 2.8 times compared to the control variant. The number of soil bacteria and actinomycetes increased due to the introduction of Agrotsen. Correlation coefficients were determined between the number of soil microorganisms and the development of root rot (-0.659±0.45; -0.928±0.263; -0.965±0.184), which indicates the presence of a high negative relationship between these indicators.

The yield of spring wheat largely depended on the use of iodine-containing fertilizer. The highest yield was after the double application of Agrotsen, it exceeded the control version without fertilizer treatment by 63.5%.

Keywords: Mineral fertilizer, phytosanitary condition, root rot, yield.

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