

Microbiological preparations based on strains of associative bacteria in the cultivation of spring wheat in Central Yakutia

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Abstract. The studies were conducted in Central Yakutia on permafrost taiga-pale-yellow soils with a low humus content from 2016 to 2020. The use of biological products of associative bacteria is an environmentally friendly way to increase crop yields and improve soil fertility. The effect of pre-sowing inoculation of spring wheat seeds with various biological preparations of associative bacteria: Rhizoagrin, Mobilin, Mizorin was studied. The responsiveness of the culture to the use of biological preparations was noted: inoculation of seeds contributed to the formation of grain yield of spring wheat. In the experimental variants, a significant increase in the yield of spring wheat grain was noted — on average up to 1.6 t/ha in the variant using the preparation Mizorin. Pre-sowing inoculation of spring wheat seeds contributed to increased plant growth in height (up to 14%), an increase in the amount of grain (up to 16%), as well as an increase in the mass of roots (up to 35%), leaves (up to 60%), inflorescences (up to 24%), straw (up to 48%). The use of the studied biopreparations based on strains of associative bacteria had a positive effect on both the growth and development of plants and an increase in the yield of spring wheat grain.

1 Introduction

Many scientific studies, including foreign ones, have proven the beneficial effect of associative nitrogen-fixing bacteria on crop productivity [2, 3, 5, 8, 10, 11, 12]. Strains of associative bacteria propagated in special substrates have been isolated and used in production. In Russia, the Institute of Agricultural Microbiology (St. Petersburg) has a collection of production strains of associative bacteria, new breeding numbers are being created for use in agricultural production [11, 12].

The rational use of bacterial preparations makes it possible, with a lower consumption of nitrogen fertilizers, to significantly increase the productivity and quality of products of the most important agricultural crops. At the same time, the chemical load on the soil decreases and its biological activity increases. In the composition of biopreparations, bacteria more actively fix atmospheric nitrogen, as well as enhance its absorption from mineral fertilizers

and soil, stimulate the growth and development of plants, thereby accelerating the ripening of the crop. Bacteria contribute to the optimal use of mineral and organic fertilizers. In addition, free-living bacteria protect plant roots from the penetration of pathogenic microflora [7, 8, 10].

Nitrogen-fixing activity is an important indicator for agricultural crops. They are able to actively absorb molecular nitrogen from atmospheres that are difficult for plants to access and contribute to increasing their productivity and nutritional value, significantly improving soil fertility, thereby reducing pollution with environmentally hazardous nitrogen compounds [2, 3].

The scientific novelty of the research is to increase the yield of spring wheat using pre-sowing inoculation with strains of nitrogen-fixing rhizobacteria in Central Yakutia.

The study of new environmentally safe biological preparations to increase crop productivity, improve soil fertility in Yakutia, including through the use of free nitrogen fixation, is an urgent, scientifically significant problem.

In this regard, the aim of the research is to study the effect of pre-sowing inoculation with biological preparations of seeds based on rhizobacteria on the yield of spring wheat.

2 Materials and methods

Field experiments were laid at the scientific station of the Yakut Agricultural Research Institute. The isolation of soil microorganisms was carried out according to the methodological recommendations of the All-Russian Research Institute of Agricultural Microbiology [9].

Control – without inoculation. Records and observations were carried out according to the methods and recommendations of the All-Union Research Institute of Plant Breeding (VIR), All-Russian Research Institute of Agricultural Microbiology (VNIISHM).

Laboratory studies were carried out on the basis of agroecology and biochemistry laboratories existing at the Institute using the Spectra Star 2200 infrared analyzer. Mathematical data processing was carried out according to B.A. Dospikhov "Methodology of field experience" (1985) [1]. The technology of using biological preparations in crop production was carried out according to the methodology of the All-Russian Research Institute of Agricultural Microbiology "Methodology for evaluating the effectiveness of the use of microorganisms that increase plant productivity" (2012) [6]. Economic efficiency is calculated according to the methodological recommendations "Determining the overall economic effect of using the results of research and development work in the agro-industrial complex" (2007) [4].

Experimental variants: 1. Control without inoculation; 2. Rhizoagrin; 3. Mobilin; 4. Mizorin.

The area of the experimental plot is 25 m², the repetition is fourfold. The seeding rate of oat seeds is 4 mln germinating seeds per hectare, the method of sowing is row-crop planting with spacing of 15 cm. The sowing was carried out with a manual seeding machine "Senior", the seed material of spring wheat was treated with biological preparations before sowing with a consumption rate of 200 g per hectare of seeds. Harvesting of spring wheat grain was carried out with a combine harvester "Sampo 130 Rosenlew".

The object of research was the spring wheat variety Prilenskaya 19, zoned in the Republic of Sakha (Yakutia).

The research was carried out in the Khangalassky ulus of Yakutia on the II above-floodplain terrace of the middle course of the Lena River at the field station of the Laboratory of Agroecology of the Yakut Agricultural Research Institute.

According to the morphological description, the soil of the experimental site is permafrost taiga-pale-yellow. Before establishing the experiments, the humus content in the arable horizon, on average, was 2.84%. The content of nitrate nitrogen in the range of 0.10-0.17 mg per 100 g of soil, total nitrogen 0.51%-0.56%. Reaction of soil medium is pH water 8.56-8.88, pH salt 7.6-7.9. The phosphorus content is 217.8 mg/kg, potassium – 255.8 mg/kg.

Bacterial preparations (Rhizoagrin, Mobilin, Mizorin) were provided by the Laboratory of Ecology of Symbiotic and Associative Rhizobacteria of the All-Russian Research Institute of Agricultural Microbiology (St. Petersburg).

Rhizoagrin is intended for pre-sowing treatment of seeds of cereal wheat, oats, rye, barley. The biopreparation is based on a strain of associative bacteria (*Agrobacterium radiobacter*). Bacteria inhabit the root zone of plants, secrete stimulating substances for the growth of the root system of plants. Increases grain yields by 3-6 kg/ha. Increases the content of raw protein in grain by 0.5 – 1%.

Mobilin is used for pre-sowing treatment of seeds and seedlings of agricultural crops. It is of great importance when treating plants during the growing season. Bacterial preparation created on the basis of *Pseudomonas* sp strains. PG-5 belonging to the genus *Azospirillum*. Rhizospheric bacteria inhabit the root zone of plants (rhizosphere) and the surface of the roots, displace pathogenic bacteria, depriving them of space and food. Growth-stimulating substances and vitamins are isolated for plants. Additionally, plants are fed with water, nitrogen, potassium and other nutrients, transferring them from hard-to-reach forms.

Mizorin is a new environmentally safe biological preparation of complex action to increase yields and improve the quality of products of forage crops (perennial grasses), spring wheat, sunflower, potatoes, increases the effectiveness of inoculants of leguminous crops. When used together, the bacterial strain *Arthrobacter mysorens*, which is part of the preparation, has a wide range of effects on almost all groups of crops.

The treatment of the seed material with biological preparations was carried out on the day of sowing spring wheat. Preparation of suspension for seed treatment: 200 g of a solid or 200 ml of a liquid preparation is diluted in 1 liter of water and thoroughly mixed [6].

3 Results and discussion

Research on the selection of the best strains of associative rhizobacteria and the study of their effect on the yield of spring wheat was started in the conditions of the Khangalassky ulus of the Republic of Sakha (Yakutia) in 2016.

The establishment of reconnaissance experiment on the use of rhizobacteria inoculation on spring wheat crops for grain forage was carried out.

Indicators of productivity elements are presented and discussed (Table 1). These elements are formed at different stages (periods) of ontogenesis and determine the level of yield: the number of grains per plant, the mass of seeds, the number of seeds on average per plant, the mass of 1000 seeds. The number of seeds formed on plants during the critical period of flowering, grain formation and growth can be a predictive indicator of the potential yield of seeds. The variability of productivity elements largely depends on the prevailing meteorological factors during the growing season. Arid conditions inhibit the growth and development of plants.

Pre-sowing inoculation of seeds with associative rhizobacteria affects the morphological parameters of spring wheat. We have studied the effect of bacterial preparations on such morphological parameters of spring wheat as plant height, number of internodes, number of grains, weight of roots, leaves, inflorescences, straw. The data show that pre-sowing inoculation of spring wheat seeds contributed to increased plant growth in height (up to 14%), an increase in the amount of grain (up to 16%), the number of internodes at the control level, as well as an increase in the mass of roots (up to 35%), leaves (up to 60%), inflorescences (up to 24%), straw (up to 48%).

In our field experience, we noted the responsiveness of spring wheat to inoculation of seed material with rhizobacteria strains. Pre-sowing inoculation of spring wheat seeds contributed to the enhancement of morphological parameters and the accumulation of plant biomass. The most effective preparations were Misorin and Rhizoagrin.

Table 1. Effect of associative rhizobacteria on morphological parameters of spring wheat (accounting 2016-2019).

No.	Variant	Height, cm	Number of grains, pcs.	Number of internodes, pcs	Dry weight, g			
					root	leaves	inflorescence	straw
1	Control	72	39	3	0.43	0.22	1.7	0.72
2	Rhizoagrin	74	40	3	0.60	0.22	1.7	0.72
3	Mobilin	70	38	3	0.50	0.26	0.6	0.56
4	Mizorin	77	42	3	0.50	0.89	1.9	0.83

Thus, in the field experiment, we noted the responsiveness of spring wheat to inoculation with strains of rhizobacteria. Pre-sowing inoculation of spring wheat seeds contributed to the enhancement of morphological parameters and the accumulation of plant biomass. The most effective biopreparations were Rhizoagrin and Mizorin.

Over the years of research, all variants of inoculation of spring wheat seeds with rhizobacteria have given a significant increase in grain yield. It follows from the data in Table 2 that a significant increase in grain yield was obtained due to pre-sowing inoculation with Rhizoagrin and Mizorin strains - on average from 25 to 33%.

Table 2. The effect of rhizobacteria on the yield of spring wheat grain, t/ha.

Variant	Grain yield			
	2016	2017	2018	average
Monitoring	1.2	1.1	1.4	1.2
Rhizoagrin	1.5	1.4	1.6	1.5
Mobilin	1.5	1.3	1.3	1.4
Mizorin	1.7	1.5	1.5	1.6
NSR 05	0.35			

Thus, according to the conducted studies, on average over three years, the use of inoculation with rhizobacteria strains has a positive effect on the yield of spring wheat grain.

4 Conclusion

Pre-sowing inoculation with rhizobacteria (associative bacteria) of spring wheat of the Prilenskaya 19 variety had a positive effect on the main indicators:

- the increase in yield of spring wheat from control without inoculation is on average due to the use of associative rhizobacteria - 29%;
- the quality of spring wheat grain is improved to 1%;
- when cultivating spring wheat for grain with the use of nitrogen-fixing rhizobacteria, the profitability, on average, is 38%, each invested ruble during inoculation with associative rhizobacteria pays off in 1.5 rubles.

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