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Universidad del Zulia
Facultad Experimental de Ciencias
Departamento de Ciencias Humanas
Maracaibo - Venezuela

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Effect of biological preparations on crop productivity in Central Yakutia

Polina P. Okhlopkova agronii@mail.ru
Fevronia V. Nikolaeva yad250673@mail.ru
Maria T. Yakovleva maryatimofeevna@mail.ru
Federal State Budgetary Scientific Institution Yakut Scientific Research Institute of Agriculture named after M.G. Safronov

Abstract

The aim of the study is to investigate effect of biological preparations on crop productivity in Central Yakutia. Field experiment was carried out on pale-yellow cryogenic taiga soil in sharply continental climate of Central Yakutia as a method. The results of the study indicate that the use of biological preparations for potatoes increases the daily gain of tuber mass by 7.31 g per plant. In conclusion, the use of biopreparations in the cultivation of potatoes had a positive effect on the content of dry matter, starch and ascorbic acid, and reduced potato disease rates during the growth season and storage.

Key words: Diseases, Inoculation, Oats, Potatoes, Storage.

Efecto de los preparados biológicos sobre la productividad de los cultivos en Yakutia Central

Resumen

El objetivo del estudio es investigar el efecto de las preparaciones biológicas en la productividad de los cultivos en Yakutia Central. El experimento de campo se llevó a cabo en un suelo de taiga criogénica amarillo pálido en un clima fuertemente continental de Yakutia Central como método. Los resultados del estudio indican que el uso de preparaciones biológicas para papas aumenta la ganancia diaria de masa de tubérculos en 7.31 g por planta. En conclusión, el uso de biopreparaciones en el cultivo de papas tuvo un efecto positivo en el contenido de materia

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seca, almidón y ácido ascórbico, y redujo las tasas de enfermedad de la papa durante la temporada de crecimiento y almacenamiento.

Palabras clave: Enfermedades, Inoculación, Avena, Papas, Almacenamiento.

1. INTRODUCTION

To preserve soil fertility in order to efficiently provide plants with nutrients is one of the main goals of modern agriculture, which ensures sustainable development of agricultural landscapes and production of high-quality crops for food and fodder purposes. Currently, the use of mineral and organic fertilizers in agriculture in Russia does not fully compensate for the lack of nutrients removed from the soil with the crop, and does not support the balance of nutrients. Compared with 1990, the use of mineral fertilizers decreased multiple times, there was an acute shortage of organic fertilizers, the use of which decreased 4 times and the national average dropped to 0.9 tons of manure equivalent per 1 hectare of arable land. In this light, there is a search for additional sources of nutrition that are capable of meeting the needs of agricultural crops in the most essential elements, among which an important role is played by nitrogen.

Production of biopreparation derived from strains of various bacteria made it possible to use associative microorganisms fixing nitrogen from the air to improve the nitrogen supply of plants. To date, a high sensitivity of a number of crops to the use of

biological preparations based on associative microorganisms has been established. These preparations contribute to the accumulation in plants of the key elements of mineral nutrition. This is due to the use by plants of atmospheric nitrogen, as well as the increased absorption of nitrogen, phosphorus, potassium from the soil and fertilizers by the root system due to the production of physiologically active substances by microorganisms. Biopreparations can boost the nutritive efficiency of fertilizers as well as their effectiveness and economic return expressed in the increase of the yield (Zavalin and Kozhemyakov, 2010). Thus, the goal of this research is to study the effect of Rhizoagrin and Misorin biopreparations on the yield and quality of oats, and Bactisubtil, Misorin and Agrofil – on the yield and quality of potatoes.

2. METHODOLOGY

The effectiveness of microbial preparations was evaluated at field research stations in Central Yakutia on pale-yellow cryogenic taiga soil. The content of humus in the soil was 2.38%, pH – 7.87; the content of labile phosphorus was 187 and potassium, 230 mg/kg of soil, respectively. The replication was fourfold. Placement of experimental cultures was randomized. The oats variety of Pokrovsky and potatoes varieties Yakutyanka and

Severny were used as experimental cultures. The setting of the field experiment, observations and registration were carried out according to (Dospekhov, 1986: Pshechenkov et al., 2002). The dry matter content in tubers was determined by the weight method, the starch content – by the Ewers method, vitamin C – by the Murri method, sugars – by the Bertrand method, the nitrate content – by the quantitative ionometric method.

Tuber analysis was carried out before laying potatoes for storage and before planting according to GOST 7001–91 (Pshechenkov et al., 2003). Experimental studies of phytopathogens were carried out according to standard methods recognized by VIZR, VNIIF, VNIIKKh, ARRIAM, etc. (Okhlopkova, 2004; Prokopyev, 2015): soil samples were taken using the standard method described in Metody. Microorganisms from soil and tubers were isolated using a microbiological culture on solid media technique (Ezhov, 1974). The field experiment was carried out on pale-yellow cryogenic taiga soil in the sharply continental climate of Central Yakutia using standard methods of oats and potato cultivation, as well as the methods recognized by VIZR, VNIIF, VNIIKKh and ARRIAM. Mobilin, Misorin and Agrofil preparations were produced at ARRIAM on the basis of rhizospheric associative microorganisms. They are a liquid solution enriched with nutrients. 1 g of the preparation contains 6–10 billion bacterial cells. According to ARRIAM recommendations, inoculation was carried out on the day of sowing at the rate of 200 g

of the preparation per 5 million viable seeds (Zavalin, 2000; Khotyanovich, 1991).

MISORIN – Arthrobacter mysorens or Misorin Kozhemyakov (1989) is a new environmentally friendly biopreparation of complex action designed to increase yields and improve the quality of forage crops (perennial grasses), spring wheat, sunflowers and potatoes and increase the efficiency of inoculants for leguminous crops when used together. Bacterial strain, which is part of the preparation, has a wide spectrum of effects on almost all groups of crops (Kozhemyakov, 1982; Kozhemyakov and Dorosinskiy, 1981; Kozhemyakov et al., 2012). Flavobacterium (based on Flavobacterium strain) is designed for processing of a sowing material and for vegetation of such plants as beet, colza, potatoes, and wheat (Kozhemyakov, 1989). Special effects of the preparation are: it increases forage crop yield by 18–35%, cereals yield – by 12–15%; improves the product quality, increasing the content of sugar by 1–1.5%, protein – by 0.5–1.2%; stimulates plant growth and development by producing physiologically active substances; reduces the development of diseases such as root rot, anthracnose, powdery mildew, late blight and scab; is environmentally friendly. Application: Before planting, the hectare amount of seeds is treated with a biopreparation suspension. Suspension preparation: 300–1,500 g or 300–1,500 ml of a liquid preparation (depending on the culture) is diluted in 4–5

liters of water. The seeds must be moistened evenly with a biopreparation suspension.

When planting seedlings, the root system of plants is immersed in the preparation suspension (600 g of the drug per 10–15 liters of water), then planted into the soil. Rhizoagrin is designed for pre-sowing treatment of seeds of cereals: wheat, oats, rye and barley. The biopreparation is based on a strain of associative bacteria (agrobacterium radiobacter). Bacteria colonize the root zone of plants and produce growth-stimulating substances. Special effects of the preparation are: it increases grain yield by 3–6 centner/ha; increases the content of crude protein in grains by 0.5–1%; increases plant resistance to disease; is highly competitive to phytopathogenic fungi; increases resistance to stress; strengthens plant resistance to drought and critical temperatures; is environmentally friendly. Application: Before planting, the hectare amount of seeds is treated with a biopreparation suspension and 4–5 liters of water. Bactisubtil – Bacillus subtilis TNP-5-DEP bacterial preparation isolated from the permafrost-transitional medium-loamy soil of Yakutia, which has antagonistic activity against pathogenic and conditionally pathogenic microorganisms and is used in agriculture. The strain is deposited in the ARRIAM collection of microorganisms based on spore-forming bacteria of the genus Bacillus and Misorin, based on associative nitrogen-fixers. One cubic centimeter of the drug contains at least 5 billion CFU.

The specific feature of the climate of Central Yakutia, as well as of Yakutia in general, is its sharp continental character, manifested in acute annual temperature fluctuations and a relatively small amount of precipitation, arid first half of summer, peculiar light regime, permafrost and cold soils with low natural fertility. The warmest month is July, and the coldest is January at –640C (Elovskaya et al., 1966). Weather conditions during the study period were different. In 2015, the precipitation rate from May to August was almost twice as low as the normal level (89.9 mm versus 159.5 mm), the sum of active temperatures above +50 C was less than standard, the hydrothermal coefficient (HTC) from May to August was 0.51, which suggests arid weather conditions during the growing season, with normal HTC being 0.88 during this time. In 2016, 165.6 mm of precipitation fell at an average air temperature of 15.20 C during the growing season. The cool weather and dry conditions of the year lead to the spread of diseases, secondary regrowth of weed vegetation and overall lengthening of the growing season, which affected crop yields.

3. RESULTS

Pre-sowing seed inoculation with associative rhizobacteria affects the growth performance of oats. We studied the effect of bacterial preparations on such growth indicators of oats as plant

height, number of internodes, number of grains, the mass of roots, leaves, inflorescences and straw. The data in Table 1 show that pre-sowing inoculation of oat seeds contributed to the increase in plant growth in height (up to 6.25%), the number of grains (up to 13%) and the number of internodes (up to 25%), as well as the mass of the roots (up to 43%), leaves (up to 30%), inflorescences (up to 19%) and straw (up to 60%).

Table 1. The effect of associative rhizobacteria on oat growth indicators (for 2015)

№	Variants	Height, cm	Number of grains	Number of internodes, units	Mass, g			
					Root	Leaves	Inflorescences	Straw
1	Control	96	51	4	16.0	26.0	57.0	25.0
2	Flavobacterin	101	54	5	17.0	29.0	58.0	34.0
3	Misorin	102	58	5	23.0	34.0	68.0	40.0
4	Rhizoagrin	94	48	4	19.0	27.0	60.0	30.0

Thus, the field experiment showed oats' sensitivity to inoculation with rhizobacterial strains. Pre-sowing inoculation of oat seeds contributed to increased growth rates and accumulation of plant biomass. The most effective preparations were Misorin and Flavobacterin (Yakovleva, 2018). A reconnaissance experiment was carried out on the use of rhizobacteria inoculation on oat plantings for grain forage. During the growing season of 2015, all

variants, when inoculated with oat rhizobacteria, showed a significant increase in the grain yield (Table 2). The data shows that the yield increased due to pre-sowing inoculation with strains 7 (Misorin), Rhizoagrin and Flavobacterin – by 7– 42% on average.

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

Strains	Grain yield	Increase in the grain yield	
		+ - compared to the control	%
Control	1.4	-	-
Rhizoagrin	1.5	+0.1	7%
Misorin	2.0	+0.6	42%
Flavobacterin	1.8	+0.2	11%
$HCP_{0,5}$	0.35		

Thus, according to 2015 data, inoculation with rhizobacteria strains after their application has a positive effect on oat productivity (Shirokikh et al., 2007; Yakovleva et al., 2014). Pre-sowing inoculation positively affects the biochemical composition of oats (Table 3). Inoculation with the strain of flavobacterin lead to an increase in the crude protein content in the grain by 0.54% (19.31% in the control variant) and a decrease in

crude fiber by 0.16% (in the control variant - 12.88%), whereas the content of the rest elements fell within the zootechnical norm.

Table 3. Influence of rhizobacteria on the oats quality

Strains	Crude protein	Crude fat	Crude fiber	Crude ash	Nitrogen-free extractive substances
Control uninoculated	19.31	5.7	12.88	2.60	59.51
Rhizoagrin	18.94	5.7	12.92	2.49	59.95
Misorin	19.41	6.4	12.76	2.52	58.91
Flavobacterin	19.85	5.7	12.72	2.65	59.08

Thus, according to the data for the growing season of 2015, inoculation of oats with nitrogen-fixing rhizobacteria has a positive effect on the quality of the grain. Net profit from the study is determined as the cost of the yield gain, minus the amount of additional costs (Table 4). The greatest net profit was obtained when using Misorin, which was 35 thousand rubles at 60 thousand rub/ha. The highest cost of 1 center of the product was registered for the control variant which had not been inoculated. Pre-sowing inoculation with rhizobacteria helped make 2.4 rubles for each invested ruble showing 40% profitability.

Table 4. Economic efficiency of oats cultivation with rhizobacteria (by the example of Misorin)

Indicator	Control	Misorin
Yield, t/ha	1.4	2.0
Product price, thousand rub/ha	42	60
Costs associated with the experiment, thousand rubles/ha	20	25
Cost of 1 centner of feed unit	1,428	1,250
Payoff, rub/rub	2.1	2.4
Net profit, thousand rub	22	35
Profitability, %	10	40

Thus, as the data of the vegetative period of 2015 show, the cultivation of oats using nitrogen-fixing rhizobacteria is economically beneficial (Okhlopkova et al., 2018). The experiment to study the effect of biological preparations on the yield and quality of potatoes used Yakutyanka and Severny potato varieties (zoned in the Republic of Sakha (Yakutia)). The nature of potato growth and development is a biological feature of varieties. The results of phenological observations showed no significant difference in the onset of development phases in two potato varieties (Yakutyanka and Severny), depending on the application of biological preparations. The development phases in the varieties began simultaneously with 1–2 day fluctuations. The height of the plants depending on the preparations used was 50–60 cm. The flowering phase in plants treated with Agrofil began 3 days later than in control plants that have not been treated with biological preparations. This is due to the fact that, when cultivated using intensive technology, plants have better access to elements of mineral

nutrition, including nitrogen, which prolonged the budding phase and delayed flowering.

An analysis of daily gain of potato tubers of one plant during three important periods of vegetation revealed peculiarities in mass gaining in different varieties depending on the preparations used. The use of biological preparations increases the daily gain of the tuber mass, and single-crop farming of potatoes shifts the time of tuber gain maximum to a later period – the beginning of ripening – harvest. The maximum daily gain of tubers was 7.31 g per plant. Pre-harvest lifting (the third decade of August) showed that the tubers of the Yakutanka variety gained mass more intensively when treated with the Bactisubtil 5 billion CFU + Ridomil Gold during the growing period + Kuproxat, which yielded the gain of 57 g per plant. The Severny variety had higher gain rate when treated with Misorin. In general, as the preliminary data show, regardless of the varietal features, tuber gain was affected the most when the plants received treatment with Mirosin and complex treatment with Bactisubtil 5 billion CFU + Ridomil Gold during the growing period + Kuproxat.

An analysis of the harvesting structure shows that the use of biological preparations facilitates the formation of more tubers in one plant. Thus, when treated with Agrofil + Ridomil Gold during the growing period + Kuproxat, the Yakutyanka variety formed a three-year-average of 7.0 tubers per bush. Other indicators, such as the mass of tubers from one plant and the mass of one tuber, also increased when potatoes were cultivated in this variant. The Severny variety

proved most sensitive to Bactisubtil 5 billion CFU, whereby the number of tubers was 6.7 per bush. Marketability in all variants was low and ranged from 60 to 70%. The study has shown that an increase in tuber productivity in the wet year of 2015 was accompanied by a decrease in their size. Thus, 9.9 tubers formed on one plant on average by varieties with an average mass of 33.7 g. In other years, at 6.5–7.6 tubers per plant the average weight of the tubers was 39.6 and 58.2 g. The largest tubers are those of the Severny variety. It normally formed larger tubers in all years, although their number was not less than that in other varieties. An analysis of potato yield showed a significant advantage of cultivating it using biological preparations and ensuring good agrometeorological conditions during the vegetative period.

Thus, the use of biological preparations increased the yield of potatoes when it was cultivated using an environmentally friendly technology by 2–3 t/ha on average by the variants over three years compared to the control variant. The yield ranged from 12.2 to 16.7 t/ha. The reaction of varieties to drought and over-humidification depended on the preceding culture and cultivation technology. Yakutyanka is an adaptive variety, which gives relatively stable yield in different heat and moisture conditions for all variants. Thus, the yield was 12.2 t/ha on average by the technologies and predecessors in the colder and wetter year 2015, 16.1 t/ha – in the extremely dry year 2013, and 14.3 t/ha in close to the normal year 2014. Yakutyanka tubers proved more responsive to treatment with Bactisubtil 5 billion CFU + Ridomil Gold during the growing period + Kuproxat in terms

of yield, whereby the gain compared to the control variant was 4.2 t/ha. The tubers of the Severny variety turned out the most productive when treated with Bactisubtil 5 billion CFU, whereby the gain was 1.1 t/ha.

Table 5. Potato yield and marketability

	Yield, t/ha		Marketability, %	
	Yakutyanka	Severny	Yakutyanka	Severny
Control – no treatment	12.2	12.2	66	60
Treatment of tubers with Bactisubtil 5 billion CFU before planting	15.0	8.9	65	61
Treatment of tubers with Misorin before planting	12.5	13.3	64	55
Treatment of tubers with Agrofil before planting	16.2	12.2	64	56
Treatment of tubers with Bactisubtil 5 billion CFU before planting + Ridomil Gold during the growing period + Kuproxat	16.7	12.6	60	61
Treatment of tubers with Misorin before planting + Ridomil Gold during the growing period + Kuproxat	13.7	12.7	70	61
Treatment of tubers with Agrofil before planting + Ridomil Gold during the growing period + Kuproxat	14.2	12.7	63	61
HCP 05	2.1	1.8		

Important criteria of potato quality are the content of starch, protein and dry matter in it. The content of starch and dry matter in tubers in all variants was the same. In terms of the content of ascorbic acid in tubers, the variant treated with Misorin preparation stood out at 10.6 mg percent, which exceeded the control variant without treatment that contained 10.3 mg of ascorbic acid percent. The amount of ascorbic acid in tubers in the rest variants was the same. The amount of nitrates in tubers in all variants was at the MPC level (250 mg/kg) and ranged from 140.8 to 158.5 mg/kg on average in the Yakutyanka variety, and from 145.9 to 157.0 mg/kg in the Severny variety. In terms of the sum of positive effects in general (the increased or average amount of starch, dry matter and ascorbic acid), the variants of the treated Yakutyanka variety that stood out were those that received treatment with Mirosin and complex treatment with Agrofil + Ridomil Gold during the growing period + Kuproxat. For the Severny variety, the variant with the largest amount of dry matter and starch was that treated with Misorin. The content of ascorbic acid in tubers in all variants was at the same level. The content of nitrates in tubers fell within the MPC for all variants as well. In terms of the sum of positive effects (increased or average amount of starch, dry matter and ascorbic acid), the strongest positive effect on the amount of dry matter, starch and ascorbic acid among the treated Severny variants was observed in the variant treated with Misorin.

Table 6. Qualitative criteria of potato tubers

Variant	Yakutyanka				Severny			
	Dry matter, %	Starch %	Ascorbic acid, mg/%	Nitrates mg/kg	Dry matter, %	Starch %	Ascorbic acid, mg/%	Nitrates mg/kg
Control – no treatment	25.2	19.0	10.3	145.5	24.6	19.3	10.1	156.7
Treatment of tubers with Bactisubtil 5 billion CFU before planting	25.3	19.4	10.4	145.0	25.0	19.2	10.4	149.6
Treatment of tubers with Misorin before planting	24.5	20.5	10.6	158.5	25.2	22.0	10.4	145.9
Treatment of tubers with Agrofil before planting	25.5	18.1	10.0	140.8	23.6	20.1	10.0	174.6
Treatment of tubers with Bactisubtil 5 billion CFU before planting + Ridomil Gold during the growing period + Kuproxat	25.3	19.3	10.4	144.2	24.6	19.5	10.6	157.0
Treatment of tubers with Misorin before planting + Ridomil Gold during the growing	25.3	19.3	10.4	144.1	25.2	20.7	10.4	146.0

period + Kuproxat								
Treatment of tubers with Agrofil before planting + Ridomil Gold during the growing period + Kuproxat	24.8	20.4	10.5	153.6	24.6	19.9	10.6	156.2

In all experimental variants the sprouts were even and strong, no outliers were registered. Visual assessment of plantings during mass flowering, depending on the year, showed such potato diseases as singular cases of Rhizoctonia, leaf spots and viral diseases. In general, over the three years, the widest-spread potato diseases in the Republic of Sakha (Yakutia) were Rhizoctonia (0.5 thousand hectares surveyed, 0.27 thousand hectares infected), late blight (0.55 thousand hectares surveyed, 0.12 thousand infected), macrosporiosis (0.5 thousand hectares surveyed, 0.26 thousand hectares infected), viral diseases (0.5 thousand hectares surveyed, 0.26 thousand hectares infected), ring rot (0.88 thousand hectares surveyed, 0.41 thousand hectares infected) (Prokopyev, 2015). The predecessor on the experimental site was potatoes. Continual cultivation of potatoes leads to accumulation of propagules of Rhizoctonia solani fungus in the soil. Thus, in 2015, the number of colonies varied from 27.7 to 136.3 of propagules per 100 g of soil. Treatment of seed material with such biological preparations as

Misorin, Agrofil and Bactisubtil significantly reduces the amount of Rhizoctonia solani propagules in the permafrost soils of the experimental site (Table 7).

Table 7. The amount of propagules of Rhizoctonia solani in the soil of experimental sites, units per 100 g of soil

Variant of the experiment	Yakutyanka	Severny
Control – no treatment	136.7	152.0
Treatment of tubers with Bactisubtil 5 billion CFU before planting	102.7	80.7
Treatment of tubers with Misorin before planting	59.7	51.0
Treatment of tubers with Agrofil before planting	76.0	58.7
Treatment of tubers with Bactisubtil 5 billion CFU before planting + Ridomil Gold during the growing period + Kuproxat	113.3	105.0
Treatment of tubers with Misorin before planting + Ridomil Gold during the growing period + Kuproxat	93.7	27.7
Treatment of tubers with Agrofil before planting + Ridomil Gold during the growing period + Kuproxat	80.0	50.7

According to an autumn tuber analysis, positive effect on Yakutyanka tubers' resistance to Rhizoctonia was observed in variants treated with Bactisubtil 5 billion CFU before planting + Ridomil Gold during the growing period + Kuproxat and Misorin before planting + Ridomil Gold during the growing period + Kuproxat; to common scab – if treated with Misorin before planting + Ridomil Gold during the growing period + Kuproxat and Agrofil before planting + Ridomil Gold during the growing period + Kuproxat. Bacterial diseases were not detected after harvest (Table 8). The Severny variety was mainly infected by Rhizoctonia, no signs of common scab were found, but some tubers were infected with netted scab. This is largely due to the varietal features and the

proneness of the variety to netted scab and its resistance to common scab.

Table 8. Potato tuber analysis after harvest

Variant of experiment	Diseases, %					
	Rhizoctonia	Common scab	Bacterial diseases	Netted scab	Mechanical damage	Total
Yakutyanka variety						
1	14	12	-	-	8	34
2	16	10	-	-	6	32
3	14	8	-	-	10	32
4	12	10	-	-	8	30
5	-	10	-	-	6	16
6	-	2	-	-	6	8
7	18	-	-	-	6	24
Severny variety						
1	18	-	-	-	6	24
2	8	-	-	8	12	38
3	16	-	-	-	8	24
4	12	-	-	4	4	20
5	12	-	-	2	-	14
6	20	-	-	-	8	28
7	16	-	-	8	5	29

Thus, the tuber analysis carried out after harvest showed that the soil and climatic conditions of the vegetative period

contributed to the development of diseases such as Rhizoctonia and common scab. Yakutyanka was mainly affected by Rhizoctonia and common scab in 2–18% of cases, while Severny was predisposed to Rhizoctonia in 8–20% of cases, that is, the proneness and resistance of tubers to diseases largely depend on varietal features. After storage of potato tubers, tuber analysis was performed on Yakutyanka and Severny varieties. Climate conditions of Yakutia, compared to other regions of Russia, cause a longer storage period of potatoes. The storage period here lasts more than eight months. In Yakutian conditions, tubers in the field do not have time to form a dense peel and are harvested under-ripe. This leads to their increased damage during the harvest, greater consumption of oxygen during respiration, which leads to a risk of self-heating and negatively affects tuber storability during winter (Okhlopkova, 2004; Matsubara & Yoshida, 2018).

The tuber analysis showed that treatment of potato seeds and plants before planting and during vegetation period helps reduce the tubers' proneness to disease during storage. The treatment of the Yakutyanka variety tubers before planting helps reduce the proneness to diseases during storage: fungal diseases – by 3.0% and bacterial diseases – by 1.5%. The number of fungal diseases in the Severny variety decreased by 1.1%, bacterial – 2.1 %. The tubers of both varieties in variants where the plants were sprayed with Ridomil Gold and Kuproxat during the growing

period were characterized with higher resistance to skin necrosis and other fungal diseases during the storage (Table 9).

Table 9. The results of tuber analysis by varieties before planting, %, 2016

Variety	Name of the disease	Variant of the experiment						
		1	2	3	4	5	6	7
Yakutyanka	Healthy tubers	75.5	92.9	93.8	90.9	75.8	90.0	94.5
	Fungal diseases, including							
	Healthy tubers	3.1	0.7	1.5	0	3.0	0	0
	Common scab	3.8	3.1	1.4	0	1.5	1.4	0.7
	Late blight	0	0	0	0	0	0	0
	Skin necrosis	3.3	0	0	0	0	0	0
	Fusarium dry rot	4.6	1.0	2.2	4.0	2.1	2.2	2.7
	Bacterial diseases, including							
	Soft rot	4.4	0	0	0	2.5	2.2	0
	Ring rot	1.3	0	0	0	1.6	1.8	0
	Black rot	0	0	0	0	0	0	0
	Mechanical damage	4.0	2.2	1.1	5.1	3.0	2.4	2.1
Severny	Healthy tubers	80.6	94.8	95.5	90.7	86.1	86.0	89.8
	Fungal diseases, including							
	Healthy tubers	3.2	2.4	0.8	2.0	2.2	2.1	0
	Common scab	0.8	0	0	1.2	2.4	1.2	1.3
	Late blight	0	0	0	0	0	0	0
	Skin necrosis	0	0	0	0	0	0	0
	Fusarium dry rot	0.9	0.4	0.7	1.0	2.3	0.4	0.7
	Bacterial diseases, including							
	Soft rot	6.9	0.2	0.4	0.4	3.6	4.2	2.7
	Ring rot	3.1	0	0	0	2.6	2.7	3.0
	Black rot	0	0	0	0	0	0	0
	Mechanical damage	4.5	2.2	2.6	4.7	3.1	3.4	2.5

Treatment of tubers before planting with biological preparations Bactisubtil, Agrofil and Misorin helped reduce the losses from bacterial diseases during storage in the winter. As for the varietal characteristics, the tuber analysis showed that during the storage, tubers of the Severny variety are affected by the soft rot, Rhizoctonia and fusarium dry rot, whereas the Yakutyanka variety is mainly affected by Rhizoctonia, common scab and fusarium dry rot. Under the conditions unfavorable for the growth and development of potato plants of 2015, the greatest economic effect was obtained in the variant where tubers were treated with Bactisubtil 5 billion CFU before planting + Ridomil Gold during the growing period + Kuproxat in Yakutyanka variety, where the yield gain relative to the standard was 4.2 t/ha. The total profit from the gain minus the waste and foreign bodies was 175,000 rubles per hectare (50 rubles for 1 kg). The cost of treatment and harvesting was 100,000 rubles per ha. Total conditionally net income from the use of this preparation was 75,000 rubles per ha. Pay-off was 1.0 ruble.

4. DISCUSSION

Over recent years, Russian scientists have created biological preparations, which ensure increased yields of

agricultural crops (Yakovleva, 2014). As is known, the main mechanisms of microorganism effect on plants is the following: improvement of nitrogen nutrition (fixation of atmospheric nitrogen); stimulation of growth and development (faster development and ripening of the crop); suppression of phytopathogens (control of disease development and reduction of plant's proneness to disease, improvement of storage); increase of fertilizer and soil nutrient recovery rates; increase of the resistance of plants to stress conditions (deficiency of atmospheric precipitation, adverse temperatures, increased acidity, salinity or soil contamination by substances of different nature) **.**

In the acutely continental climate of Central Yakutia, which manifests itself in acute annual temperature fluctuations and relatively small amount of precipitation, arid first half of summer, peculiar light regime, permafrost and cold soils with low natural fertility, biological preparations have a positive effect on potato growth and development, by reducing the development of such potato diseases as common scab, Rhizoctonia, black rot. Inoculants stimulate an increase in the plant biomass by vegetation phases, and the nature of their action is determined by the type of preparation used and the varietal characteristics of the plants. The results of the

experiments described above indicate that in the conditions of Yakutia too, the integrated application of the techniques we have developed allows us to obtain fairly high potato yields. A singnificant effect on tuber storability during winter is observed when they are treated with such biological preparations as Misorin, Agrofil and Sahabactisubtil**.**

5. CONCLUSION

Thus, the results of the study indicate that the use of biological preparations for potatoes increases the daily gain of tuber mass by 7.31 g per plant, facilitates the formation of more tubers in one plant, increases its yield by 4.2 t/ha and reduces losses from bacterial diseases during winter storage. Based on the results of the research, in 2018 a methodological guideline Potato Diseases and Ways to Control them in Yakutia Conditions was developed in 2018. In the conditions of Central Yakutia, to yield 15.7 t/ha of high-quality potato tubers, it is recommended that potato tubers be treated with biological preparations, in particular with Bactisubtil 5 billion CFU before planting combined with treatment with Ridomil Gold during the growing period and treatment with Kuproxat. According to the preliminary data of 2015, inoculation of the Pokrovsky variety of oats with rhizobacteria (Misorin) before planting during the

reconnaissance experiment positively affected the main indicators**:**

-The increase in oats yield compared to the uninoculated control variant was 42%**;**

-The quality of oats improved by up to 5%**;**

When oat is cultivated for grain using nitrogen-fixing rhizobacteria (Misorin), average profitability is 40%, the conditionally net income is 35 thousand rub/ha.

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