Yield and quality of potatoes depending on the use of biological preparations

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Abstract. In biologized agricultural production, together with minimized chemical agents, promising preparations based on various subspecies of spore-forming bacteria are widely used. The aim of the study was to determine the effectiveness of the use of biological preparations of Kartofin (based on the Bacillus subtilis strain I5-12/23) and BisolbiSan, (based on the Bacillus subtilis strain h-13) according to the following indicators: – germination of tubers, plant growth and development, prevalence and development of diseases on plants, crop weight and its marketability. The results of the studies showed that pre-planting treatment of seed tubers with Kartofin and BisolbiSan biologics had a positive effect on the germination of potato tubers, increasing it by 6.3 – 8.7% compared to the control. Under field conditions they showed high biological effectiveness against pathogens of fungal diseases of potatoes: late blight (from 37.5% to 100%). Accounting for the total yield showed that the highest yield indicators were noted on the variant with the use of the biological preparation BisolbiSan – 38.4 t/ha (20.5% higher than the control variant).

1 Introduction

In addition to traditional mineral fertilizers and pesticides, modern potato growing technologies also include the use of new-generation organic preparations [1,2]. This optimizes nutrition, stimulates the growth and development of plants, increases resistance to harmful environmental factors and a number of pathogens, contributes to increasing potato yields and environmental safety of agrocenosis [4,5,6]. The most effective and widely used biological preparations are preparations based on gram-positive spore-forming bacteria of the Bacilliaceae family [7]. They have the ability to secrete antibiotics that suppress competing phytopathogens, enhance the fixation of atmospheric nitrogen by plants, and dissolve mineral compounds of the soil that are difficult for plants to access [8,9].

When combined with agricultural practices biological preparations are important elements of organic farming [10]. The high physiological and bactericidal activity of many biological products is expressed in low concentrations of 5-50 mg/ha with no harmful

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effects on the soil and the environment [11].

2 Materials and methods

Experience in the study of biological preparations was laid in the conditions of the foothill zone of the North Caucasus, at the experimental base of the SKNIIGPSKH VSC RAS in Mikhailovskoye village in 2018-2020.The experiment was carried out in accordance with the standard methods described in the following manuals: "Methodology of held trial", " Educational and methodological guidelines for conducting research in agronomy" [13].

The area of the experimental plots was 25 m^2 (100 plants), in four-fold repetition. Spraying of planting tubers with the studied preparations was carried out based on the calculation of the flow rate of the working fluid (a mixture of water and the preparation) 10 liters per ton of tubers. Spraying during the growing season of potatoes based on the consumption of working fluid was 350-400 liters per hectare of area. In the research one used the potato variety Udacha.

The soil of the experimental field is leached chernozem, underlain by gravel. Predecessor: annual herbs. Tillage: disking followed by under-winter plowing (November), cultivation of plowing in two tracks, pre-planting ridge tillage (March). Planting potatoes with the introduction of mineral fertilizers at the rate of $N_{45}P_{45}K_{90}$. Plant care: inter-row cultivation, plant hilling; chemical spraying of plants against pests with Actara insecticide (active ingredient – Thiamethoxam) consumption rate: 60 g/ha. Harvesting potatoes by hand.

Description of biological preparations by manufacturers:

Kartofin (*Bacillus subtilis* I5-12/23) – biological preparation, has a high fungistatic effect, protects potato plants from r Rhizoctonia blight, early blight and late blight in the field, also protects new crop tubers from dry rot during storage.

BisolbiSan (*Bacillus subtilis H-13*) – biological contact fungicide, protects against a wide range of pathogens of fungal and bacterial diseases, has a protective, regulatory effect on the plant. Increases the germination rate and the vigor of seed sprouting. Induces plant immunity to bacterial and fungal diseases.

The experiments were carried out according to the scheme presented in Table 1.

The studied biological preparations were used at the concentrations recommended by the manufacturers

Table 1. Scheme of the experiment on the testing of Kartofin and BisolbiSan in the held trial.

Preparation	Treatment of tubers before planting	spraying during the growing season
Control	No treatment	
BisolbiSan	3 g/t (10 l/t)	5 g/ha, (400 l/ha)
Kartofin	2 l/t (10 l/t)	2l/ ha, (400 l/ha)

Note: 3g/t – consumption of preparation per ton of tubers, (10 l/t) – consumption of working fluid per ton of tubers.

2.1. Meteorological indicators

The foothill zone of the North Caucasus is relatively humid, moderately hot, with a hydrothermal coefficient of 1.5. The average annual precipitation is 630-670 mm.

3 Results

Accounting for the emergence of potato seedlings showed that pre-planting treatment of seed tubers with biologics had a positive effect on germination, increasing it by 6.3% and 8.7%. compared to the control. Thus, the treatment of potato tubers of Udacha variety with the potato biological product germination on 16, 23 and 30 day was 53.8; 82.1 and 95.3% of plants, and in the control 27.8; 58.8 and 72.2% of plants (Table 2). The results of the second and third checkings of germination dynamics confirmed the results of the first checkings.

Table 2. The effect of potato biologics treatments on the dynamics of seedlings, % (average for 2019-2020).

Experiment options	Udacha					
	16th day	% to control	23rd day	% to control	30th day	% to control
Control	27,8	-	58,8	-	72,2	-
BisolbiSan	37,9	131,9	71,0	134,2	98,0	135,9
Kartofin	47,1	163,5	80,3	118,7	95,0	131,7

*planting of potatoes on April 25-30, when the soil warms up to 18-22° C.

Due to the fact that the potato flowering time is a very important stage in individual development, since it is at this time that the formation of the number of tubers and stems is completed, during this period there were observed the greatest mass of the tops and the leaf surface index and were measured biometric indicators. According to them, it is possible to predict the yield value, which is an integral factor of all processes (growth, physiological and biochemical) occurring in potato plants.

Table 3. The effect of biologics on the biometric indicators of potatoes (average for 2019-2020)

Experiment options	Number of main stems		Plant height		Number of tops tubers (1 plant)		Weight of tubers (1 plant)		Weight of the (1 plant)	
	pcs	% to control	cm	% to control	pcs.	% to control	g	% to control	gl	% to contro
1. Control	6,6	100,0	54,0	100,0	15,2	100	365,0	100,0	401,0	100,0
2.BisolbiSan	6,6	100,0	60,9	112,7	15,7	103,2	372,2	108,1	420,0	104,7
3. Kartofin	7,0	106,0	73,1	135,3	17,5	115,1	428,3	117,3	384,5	95,8

From the data given in Table 3 it follows that the use of BisolbiSan did not affect the number of main stems significantly, the number of tubers in the seedbed compared to the control. However, it contributed to an increase in the height of the potato plant by 6.9 cm. The biological preparation of Kartofin has an effect on the height of plants, the number of main stems, and a stimulating effect on the yield of potatoes.

Weather conditions in 2020 contributed to the significant development of late blight on potato plants. According to the results of the analysis there was noted the inhibitory effect of the biological preparation Kartofin and BisolbiSan on the causative agent of this disease. A decrease in the prevalence was observed with the use of both biologics, but a higher

effect was obtained with the use of Kartofin, the decrease in the prevalence of the disease reached 15.2 %, and with BisolbiSan – 10.9 %. The highest biological effectiveness of both biologics was noted in relation to the initial stage of development of the fungus *Phytophthora infestans Mont. de Bary*, spores are formed at high humidity on the mycelium located on the stem near the ground surface, which was widespread in the agrometeorological conditions of 2020. The effectiveness of biologics thus significantly reduced the stock of pathogen infection in the soil. By mid-July the prevalence of the disease in the variants with biologics reached 20.2-21.4%, in the control – 42.5%.

Table 4. The effect of biological preparations on the spread and development of late blight on potato plants, % (2020).

Experiment options	29.06		15.07		30.07	
	P	R	P	R	P	R
1. Control	17,3	4,1	42,5	18,1	58,0	19,3
2. BisolbiSan	13,2	0,2	21,4	9,7	47,1	13,3
3. Kartofin	0,8	0,0	20,2	1,5	42,8	11,0

Note: P – degree of extension, %; R – degree of development, %

Accounting for the total yield in the held trial showed that with Udacha variety, all the studied biological products have a positive effect on the yield indicators compared to the control. The highest indicators were noted in the variant using the BisolbiSan biological product – 38.4 t/ha, while in the control the indicator was 33.4 t/ha (an increase in control – 5 t/ha) as it is shown in the Table 5.

Table 5. The effect of the use of biological preparations on the productivity of potato plants and the nitrate content of tubers (average for 2018-2020).

Experiment options	Yield of crops		Fractional composition, %			Nitrates
	t / ga	% to control.	30-60 мм	>60 мм	<30 мм	mg / kg
1.Control	23,4	-	55,3	39,5	5,2	187
2.BisolbiSan	28,2	116,0	51,7	41,7	6,6	190
3.Kartofin	27,9	114,8	53,8	40,0	6,2	185

4 Discussion and conclusions

Thus, the results of three-year studies showed that the use of biological preparations of Kartofin (*B. subtilis-I5-12/23*), BisolbiSan (*Bacillus subtilis h-13*) in the conditions of the foothill zone of the North Caucasus had a positive effect on the germination of potato tubers, increasing it compared to the control by 6.3; and 8.7%. The use of of biological preparations did not affect the number of main stems significantly, but contributed to an increase in the height of the potato plant by 6.9; and 21.5 cm. The biological effectiveness of Kartofin *(B. subtilis-I5-12/23)* and BisolbiSan (*Bacillus subtilis h-13)* against pathogens

of fungal diseases of potatoes, in particular *Phytophthora infestans Mont. de Bary*, has been proven. Accounting for the total yield in the held trial showed that all the studied biological products on the Udacha variety have a positive effect on productivity indicators compared to the control. The highest yield indicators were noted in the variant using BisolbiSan biological product – 38.4 t/ha, higher than the control variant by 20.5%.

Biostimulants-BisolbiSan, Kartotin are environmentally safe drugs for humans and the environment that have a wide spectrum of action, participate in the regulation of plant growth and development, in adaptation to adverse growing conditions and provide an increase in yield.

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