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Effectiveness of biological products for control of the most significant mycoses on potato crops

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Abstract. Experiments on comparative assessment of effectiveness of bioagents to control the most significant fungal diseases were carried out on crops of potato breeding line in the Zernograd district, Rostov region. Biofungicide Metabakterin, WP based on *Methylobacterium extorquens* NVD VKM B-2879D + Validamycin *Streptomyces hygroscopicus* subsp. *limoneus* VKPM AC-1966 + *Bacillus subtilis* VKPM B-2918 IPM 215 and biofungicide Vitaplan based on *Bacillus subtilis*, strain VKM-B-2604D + *Bacillus subtilis*, strain VKM-B-2605D were studied in the research. The results showed that Metabakterin, WP at the rate of 80 g/ha was the most effective for control of early blight, late blight, fusarium dry rot and rhizoctonia canker on potatoes, while protection period of the biofungicide against these fungal diseases ranged from 19 to 27 days. It was noted that application rate of 80 g/ha of Metabakterin, WP provided the maximum increase in potato yield.

Key words: early blight, late blight, fusarium dry rot, rhizoctonia canker, Metabakterin, Vitaplan

Conflicts of interest: The authors declared no conflicts of interest. The biofungicide was submitted for scientific research to conduct further registration trials.

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Introduction

Potato occupies one of the first places among crops in dry matter production per unit area, while its tubers are a universal product and the main source of vitamin C. The importance of potatoes as one of the main food crops of the Russian Federation can hardly be overestimated; the average annual consumption of this crop only for food is estimated at 15 million tons. However, a large share of the market today is represented by foreign cultivars, especially for seed planting material, which is a serious challenge to the country's food security. Therefore, according to the plan of the Ministry of Agriculture of the Russian Federation, half of seed potatoes should be produced in Russia by 2025. Among the tasks of modern potato breeding, in addition to creating highly productive varieties with high taste qualities, the seed production program indicates the mandatory adaptability of varieties to biotic and abiotic factors when cultivated in various climatic conditions [1, 2].

The problem of adapting planting material obtained *in vitro* to open ground conditions is not only in successful survival of plants, but also in their ability to withstand stress caused by a complex of secondary phytopathogens, among which the most harmful to potatoes are early blight, late blight, fusarium dry rot and rhizoctonia canker¹ [3–6]. Chemical fungicides, conventionally used to control pathogenic microbiota, often create additional stress for young plants [7, 8], while in order to preserve agronomic traits of crop, especially in selective crops, it is preferable to use non-chemical methods for controlling phytopathogens to reduce the pesticide load on plants and improve physiological and biochemical parameters of the final product [2, 9, 10].

The purpose of the study was to evaluate the effectiveness of Metabakterin, WP and Vitaplan for biological control of early blight, late blight, fusarium dry rot and rhizoctonia canker on potato breeding lines and their influence on crop yield formation.

Materials and methods

In controlling mycoses on potatoes, the most commonly used non-chemical product is Vitaplan based on *Bacillus subtilis*, strain VKM-B-2604D + *Bacillus subtilis*, strain VKM-B-2605D at a recommended application rate of 20 g/ha. Vitaplan and Metabakterin, WP based on *Methylobacterium extorquens* NVD VKM B-2879D + Validamycin *Streptomyces hygroscopicus* subsp. *limoneus* VKPM AC-1966 + *Bacillus subtilis* VKPM V-2918 IPM 215 were used when developing a system for controlling the most significant diseases on potatoes in open ground conditions.

To evaluate the effectiveness of bioagents Metabakterin, WP and Vitaplan, the studies were carried out on crops of potato breeding line in the Zernograd district of the Rostov region. The experiment consisted of four replications of four experimental plots (25 m²) with a sequential arrangement in accordance with the Guidelines for Registration Testing of Fungicides in Agriculture².

¹ Gannibal F.B. *Monitoring al'ternariozov sel'skokhozyaistvennykh kul'tur i identifikatsiya gribov roda Alternaria* [Monitoring of Alternaria diseases of agricultural crops and identification of fungi of the genus *Alternaria*]. Saint-Petersburg; 2011. (In Russ.).

² Dolzhenko V.I. *Metodicheskie ukazaniya po registratsionnym ispytaniyam fungitsidov v sel'skom khozyaistve: metodicheskoe posobie* [Guidelines for registration testing of fungicides in agriculture]. Saint-Petersburg; 2011. (In Russ.).

Pre-planting treatment of tubers was carried out with Metabakterin, WP based on active ingredient *Methylobacterium extorquens* NVD VKM B-2879D + Validamycin *Streptomyces hygroscopicus* subsp. *limoneus* VKPM AC-1966 + *Bacillus subtilis* VKPM V-2918 IPM 215 with a titer concentration of at least 10^{10} CFU/g + 0.5 g/kg + titer of at least 10^{10} CFU/g at the rate of 15 g/t and 20 g/t. Subsequent treatments of vegetative plants were carried out by spraying three times during the growing season after the appearance of 2–4 true leaves and then with an interval of 12–14 days at the rate of 40+40+40 g/ha and 80+80+80 g/ha. Pre-planting treatment of tubers with Vitaplan titer 10^{10} + 10^{10} CFU/g *Bacillus subtilis*, strain VKM–V-2604D + *Bacillus subtilis*, strain VKM–V-2605D was carried out at a rate of 20 g/t, followed by three treatments of vegetative plants after the appearance of 2–4 true leaves and then with an interval of 12–14 days at the rate of 20+20+20 g/ha. Treatments with the biofungicides were carried out using a backpack pump sprayer “Zhuk Optima” with a spray mix volume rate of 300 L/ha (Table 1).

Table 1

Scheme of the experiment to evaluate effectiveness of Metabakterin, WP

Variant	Treatment	Application rate
1	Metabakterin, WP	15 g/t + (40 + 40 + 40 g/ha)
2	Metabakterin, WP	20 g/t + (80 + 80 + 80 g/ha)
3	Vitaplan, titer 10^{10} + 10^{10} CFU/g <i>Bacillus subtilis</i> , strain VKM-B-2604D + <i>Bacillus subtilis</i> , strain VKM-B-2605D	20 g/t + (20 + 20 g/ha)
4	Control (no treatment)	–

Potato harvesting was carried out manually from 10 plants, 3 rows of each plot. The results of field experiments, as well as harvest data, were statistically analyzed using the MS Excel.

Results and discussion

The following fungal diseases were found on potato crops: early blight (*Alternaria* sp.), late blight (*Phytophthora* sp.), fusarium dry rot (*Fusarium* sp.) and rhizoctonia canker (*Rhizoctonia* sp.), which are typical mycosis for the crop [2, 4, 5, 8, 11–14]. Biological efficiency of Metabakterin, WP at the rate of 40 g/ha against *Alternaria* was 78.1 %. At the same time, increase in the application rate to 80 g/ha increased efficiency to 81.2 %. Vitaplan at the rate of 20 g/ha controlled the development of *Alternaria* blight at 77.5 %. In addition to the bacterium *Bacillus subtilis*, which is the main active component of Vitaplan, Metabakterin, WP also includes *Methylobacterium extorquens* and *Streptomyces hygroscopicus* subsp., which ensures a higher effectiveness of the biofungicide. A complex of two bacterial genera and an actinomycete is capable of suppressing phytopathogenic microbiota to a greater extent than monocomponent biological products.

To control late blight, Metabakterin, WP at the rate of 40 g/ha showed 73.2 % efficiency, increase in the application rate to 80 g/ha led to increase in efficiency to 80.3 %. At the same time, efficiency of Vitaplan at the rate of 20 g/ha was at the level of 71.8 %.

Efficiency of Metabakterin, WP against *Fusarium* at a consumption rate of 40 g/ha was 69.3 %. Thus, it was close to Vitaplan application at the rate of 20 g/ha, which efficiency was 68.2 %. Further increasing the application rate to 80 g/ha did not lead to a significant increase in efficiency, amounting to 70.2 %.

In controlling rhizoctonia canker, Metabakterin, WP at the rate of 40 g/ha showed 67.3...68.2 % efficiency, which was lower compared to Vitaplan 20 g/ha with 68.4...69.38 % efficiency. When application rate was increased to 80 g/ha, effectiveness of Metabakterin, WP increased to 71.4...73.2 %. (Tables 2 and 3).

The yield increase obtained in the variant with Metabakterin, WP at the rate of 40 g/ha was 10.9 %, increasing the application rate to 80 g/ha provided 13.9 % yield increase, using Vitaplan increased yield by 11.7 % compared to the control (Table 4).

Table 2

Efficacy of Metabakterin, WP against early blight, late blight, fusarium dry rot canker on potato breeding line, Rostov region, 2023

Variant	Application rate, L/ha	Number of treatments	Dates of treatments: 5 and 27 May, 10 and 24 June													
			Early blight						Late blight				Fusarium dry rot			
			05.06		15.06.		25.06.		15.06.		25.06.		25.06.	05.07		
			Progression, %	Efficacy, %	Progression, %	Efficacy, %	Progression, %	Efficacy, %	Progression, %	Efficacy, %	Progression, %	Efficacy, %	Progression, %	Efficacy, %		
Metabakterin, WP (15 g/t + (40+40+40 g/ha))	40 g/ha	4	6.8	63.8	9.4	62.8	7.6	78.1	4.2	66.9	5.6	73.2	6.2	70.9	9.3	69.3
Metabakterin, WP (20 g/t + (80+80+80 g/ha))	80 g/ha	4	5.6	70.2	8.0	68.4	6.5	81.2	2.4	81.1	4.1	80.3	5.5	74.2	9.0	70.2
Vitaplan, titer 10 ¹⁰ +10 ¹⁰ CFU/g <i>Bacillus subtilis</i> , strain VKM-B-2604D + + <i>Bacillus subtilis</i> , strain VKM-B-2605D	20 g/ha	4	5.8	69.1	8.3	67.2	7.8	77.5	3.6	71.6	5.9	71.8	6.1	71.4	9.6	68.2
Control (without treatment)	—	—	18.8	—	25.3	—	34.6	—	12.7	—	20.9	—	21.3	—	30.2	—

Table 3

Efficacy of Metabakterin, WP against rhizoctonia canker on potato breeding line, Rostov region, 2023

Variant	Application rate, L/ha	Number of treatments	Dates of treatments: 5 and 27 May; 10 and 24 June			
			Rhizoctonia canker			
			25.06		05.07	
			Progression, %	Efficacy, %	Progression, %	Efficacy, %
Metabakterin, WP (15 g/t + (40+40+40 g/ha))	40 g/ha	4	6.4	67.3	10.7	68.2
Metabakterin, WP (20 g/t + (80+80+80 g/ha))	80 g/ha	4	5.6	71.4	9.0	73.2
Vitaplan, titer 1010 +1010 CFU/g <i>Bacillus subtilis</i> , strain VKM-B-2604D + <i>Bacillus subtilis</i> , strain VKM-B-2605D	20 g/ha	4	6.2	68.4	10.3	69.3
Control (without treatment)	–	–	19.6	–	33.6	–

Table 4

Productivity of potato breeding line after application of Metabakterin, WP (Rostov region, 2023)

Variants	Productivity by replications, t/ha				Average productivity	
	1	2	3	4	t/ha	% to control
Metabakterin, WP (15 g/t + (40+40+40 g/ha))	25.0	25.8	25.8	25.9	25.6	110.9
Metabakterin, WP (20 g/t + (80+80+80 g/ha))	23.9	27.2	28.4	25.8	26.3	113.9
Vitaplan, titer 1010 +1010 CFU/g <i>Bacillus subtilis</i> , strain VKM-B-2604D + <i>Bacillus subtilis</i> , strain VKM-B-2605D	23.8	25.5	27.8	26.1	25.8	111.7
Control (without treatment)	20.0	23.1	24.5	24.8	23.1	100
LSD(05) % = 2.59						

Conclusions

Results of the experimental comparison of Metabakterin, WP and Vitaplan effectiveness for control of early blight, late blight, fusarium dry rot, rhizoctonia canker on crops of potato breeding line and their influence on productivity led to the following conclusions:

- 1) use of Metabakterin, WP biofungicide at the rate of 80 g/ha provides the maximum increase in potato yield;
- 2) protection period of Metabakterin, WP against early blight, late blight, fusarium dry rot and rhizoctonia canker amounts 19, 22, 21 and 27 days;

3) due to multicomponent composition, Metabakterin, WP at the rate of 80 g/ha is most effective for controlling early blight, late blight, fusarium dry rot and rhizoctonia canker on potatoes.

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Оценка эффективности биопрепаратов для контроля наиболее значимых микозов на посадках картофеля

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Аннотация. Опыты по сравнительной оценке эффективности биологических препаратов Метабактерин, СП на основе действующего вещества *Methylobacterium extorquens* NVD ВКМ В-2879D + Валидамицина *Streptomyces hygrosopicus* subsp. “limoneus” ВКПМ АС-1966 + *Bacillus subtilis* ВКПМ В-2918 ИПМ 215 и Витаплан на основе *Bacillus subtilis*, штамм ВКМ-В-2604D+ *Bacillus subtilis*, штамм ВКМ-В-2605D для контроля наиболее значимых грибных болезней проводились на посадках селекционной линии картофеля в Зерноградском районе Ростовской области. Установлено, что препарат Метабактерин, СП в норме расхода 80 г/га оказался наиболее эффективным для контроля альтернариоза, фитофтороза, фузариоза и ризоктониоза на картофеле, при этом период защитного действия препарата против этих грибных болезней составил от 19 до 27 дней. Отмечено, что данная норма расхода Метабактерина, СП обеспечила максимальную прибавку урожайности картофеля.

Ключевые слова: альтернариоз, фитофтороз, фузариоз, ризоктониоз, Метабактерин, Витаплан

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