

# Influence of multistrain biological preparations with protective functions on the productivity and quality of potatoes

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**Abstract.** The article deals with potato protection systems, the use of multi-strain biopreparations with protective functions and chemical pesticides. Preparations were analyzed and selected, as well as a mycological analysis of the soil was carried out to determine the ecological and trophic groups of microscopic fungi, which in turn made it possible to select biological preparations and develop regulations for their use. Techniques aimed at reducing the use of chemical protection agents when growing potatoes in conditions on irrigated light chestnut soils have also been studied, and schemes for applying biological preparations that reduce the pesticide load on agricultural landscapes have been presented. Long-term studies on the use of biological products make it possible, in unstable natural and climatic conditions, not only to reduce the infectious background of pathogenic microflora, but also to increase the productivity of the culture.

## 1 Introduction

Today, the potato is the fourth food crop widely cultivated throughout the world. A large number of food products from potatoes do not reach consumers due to large losses [1-2].

It is no coincidence that in recent years there has been an increased demand for most plant protection products used in the agricultural sector. This is dictated by the need to reduce the pesticide load on agricultural landscapes and the rational use of means of protection against harmful organisms [3].

The production of environmentally friendly products and the rational use of pesticides are dictated by world politics, which in turn poses practical tasks for agricultural producers to replace chemical plant protection products with biological ones, which, in a number of ways, turn out to be more effective due to the resistance of fungi, bacteria and pests to the active substances of chemicals, therefore, in the current situation, it is necessary to ensure control over the amount of mycotoxins in products and soil due to biologization. Minimizing the negative impact on the environment and caring for the health of the nation will ensure sustainable agricultural production.

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A wide range of pesticides is represented by a variety of components of active substances, but due to the use of excessive doses of chemicals, addiction and inefficiency of their use are very often observed, and as a result, the pesticide load on agricultural landscapes increases with environmental damage to the environment.

Of the available phytopathogenic groups, fungi of the genus *Fusarium* are the most harmful and widespread. The defeat of potatoes by *Fusarium infestans* oomycete creates a high degree of infection, causing the leaf apparatus to dry out with the death of the stems, which subsequently negatively affects the storage of tubers. The quantity and quality of products also directly depend on other types of microscopic fungi from the class of pathogenic plant parasitic [4].

Late blight seriously affects the yield of potatoes, and the use of biofungicides according to the studies of G. Puopolo et al [5] can ultimately increase their productivity and commercial value. An effective fight against potato late blight was observed using bacterial preparations both in closed and open ground [6].

According to V. Mishra, the biofungicide Taegro (*Bacillus subtilis* var. *Amyloliquefaciens* strain FZB24) demonstrates an effective result in reducing the degree and severity of the incidence of late blight in potatoes [7].

Also, much attention is paid to the fungus *Trichoderma* spp. as a means of deterring pathogens, since, according to numerous studies, it can effectively control pathogens such as *Botrytis* spp., *Sclerotinia sclerotiorum*, *Cladosporium Colletotricum acutatum* and *Fusarium oxysporum* [8-10].

Potato cultivation is impossible without plant protection products, and it is very important to choose preparations that ensure high-quality treatments during the growing season. However, the effectiveness of protective measures should follow environmental safety and economic feasibility, aimed at preserving and reproducing soil fertility, as well as obtaining high-quality products.

## 2 Materials and methods

The purpose of the research was to select a protection system that would reduce the pesticide load on agricultural landscapes and increase soil suppression.

**Table 1.** Doses of drugs used by vegetation phases on the chemical protection system, l/ha.

Chemical protection system									
A drug	Active substance	Tubers	Sheet processing						
		Landing	Seedlings	Active growth	Closing rows	Budding	Bloom	Tuber accumulation	
Emesto Quantum	Clothianidin (207 g/l) + Penflufen (66.5 g/l)	0.35							
Revus Top	Difenoconazole (250 g/l) + Mandipropamide (250 g/l)		0.6						0.6
Biscay	Thiacloprid 240 g/l		0.25				0.25		0.25
Fortuna Extra	Mancozeb 640 g/kg + Mefenoxam 40 g/kg			2.5			2.5		
Belt	Flubendiamide 480 g/l			0.15					0.15
Kurzat	Copper oxychloride 689.5 g/kg + Cymoxanil 42 g/kg				2.0				
Boreas Neo	Alpha-cypermethrin 125 g/l + Imidacloprid 100 g/l + Clothianidin 50 g/l				0.15				0.15
Consento	Propamocarb hydrochloride 375 g/l + Fenamidon 75 g/l					2.0	2.0		
Proteus	Deltamethrin 10 g/l + Thiacloprid 100 g/l					0.75	0.75		
Luna Tranquility	Pyrimethanil 375 g/l + Fluopyram 125 g/l								0.6

Biological defense system									
A drug	Microorganisms in the composition of drugs	Tubers	Sheet processing						
		Landing	Seedlings	Active growth	Closing rows	Budding	Bloom	Tuber accumulation	
Geostim Fit A	Chaetomium globosum not less than 1x10 <sup>9</sup> CFU/cm <sup>3</sup> , Trichoderma viride not less than 1.5g/dm <sup>3</sup>	3.0							
Geostim Fit J	Bacillus subtilis not less than 1x10 <sup>9</sup> cfu/cm <sup>3</sup>	2.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
BSka-3	Trichoderma viride 256 not less than 1.5 g/dm <sup>3</sup> ; Pseudomonas koreensis Ap33, Bacillus subtilis 17, Bradyrhizobium japonicum 614a not less than 2.5x10 <sup>8</sup> CFU/cm <sup>3</sup>		4.0						
BFTIM KS-2, Zh	Bacillus amyloliquefaciens not less than 1x10 <sup>9</sup> cfu/cm <sup>3</sup>			4.0	4.0	4.0	4.0	4.0	4.0
Insetim	Bacillus thuringiensis, not less than 2x10 <sup>9</sup> CFU/cm <sup>3</sup>				5.0	5.0	5.0	5.0	5.0
Gumel Lux			1.0			1.0			

Tests were carried out with the variety Vineta (1st reproduction) on an area of 2.4 ha. The repetition is three times, the placement is systematic. The territory of the experimental plot is represented by light chestnut soils. The humus content is about 1.6%. The forerunner is perennial herbs. The experiment scheme included the following options:

- Chemical protection system (Control).
- Biological protection system (Table 1).

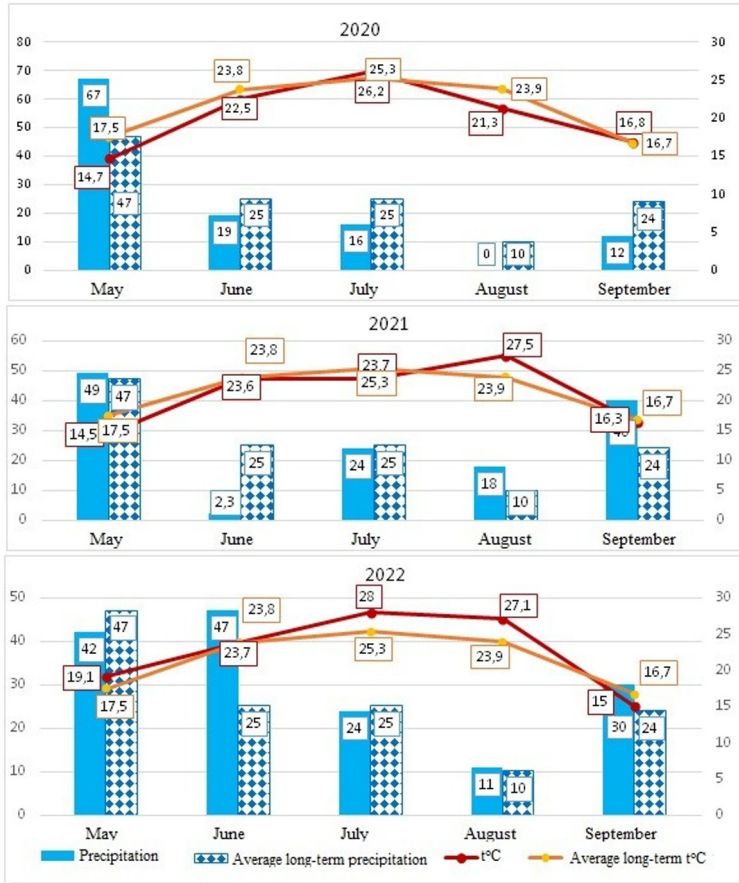
### 3 Results

The weather conditions during the years of the research were different and had significant differences in temperature and moisture levels. The year 2020 was most favorable in terms of average daily temperatures, where the numerical values were at the multi-year level and did not have a negative impact on growth and development.

Similar dynamics was observed during the growing season of 2021, where temperatures critical for the crop were observed at the end of the growing season, did not adversely affect the accumulation of the productive part of the crop and did not contribute to the development of viral, fungal and bacterial diseases. 2022 is not entirely favorable for potato cultivation, especially the period from July to August, when the temperature was at the level of 28 °C, its maximum values reached 30 and more degrees. During this period, minimal growth of the vegetative and productive parts of the culture was observed and turned out to be the most difficult in terms of the infectious background. In terms of the amount of precipitation, the years had significant differences and significantly differed from long-term indicators.

In the course of soil analysis, 2 groups of micromycetes were isolated and identified. The pathogenic group is represented by fungi *Verticillium* spp., *Fusarium* spp., *Alternaria* spp. and etc.

At the same time, it should be noted that by the end of the growing season, the quantitative and species composition of pathogenic microflora changes upwards, but against the background of the biological protection system, the quantitative indicators are lower compared to the chemical protection of plants.

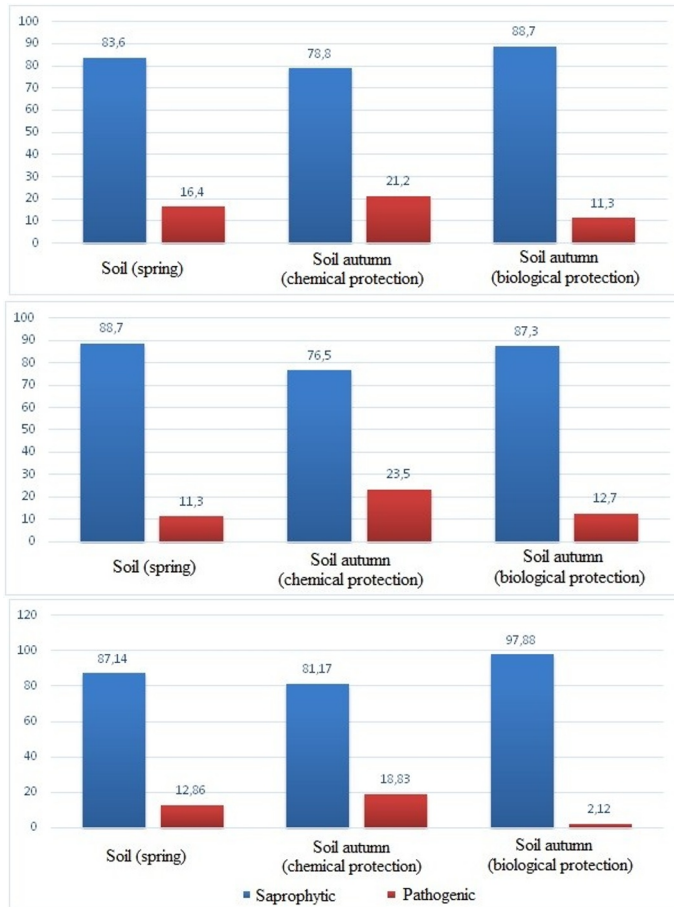


**Fig. 1.** Weather conditions for 2020-2022.

**Table 2.** Results of mycological analysis of soil samples 2020-2022.

Options	CFU of mushrooms, thousand pieces in one gram of absolutely dry soil									
	Penicillium spp.	Aspergillus spp.	Trichoderma spp.	Rizopus spp	Cladosporium spp	Paecilomyces spp.	Pythium spp.	Verticillium spp.	Fusarium spp	Alternaria spp.
2020										
Soil of the experimental plot (spring)	1.1	3.4	-	-	-	1.1	-	-	-	1.1
Soil of the experimental site (chemical protection)	60.4	13.2	3.6	1.2	1.2	-	-	8.3	13.0	-
Soil of the experimental site (bio.protection)	103.0	9.7	6.1	2.4	1.2	1.2	-	3.6	12.1	-
2021										
Soil of the experimental plot (spring)	103.0	9.7	6.1	2.4	1.2	1.2	-	3.6	12.1	-
Soil of the experimental site (chemical protection)	146.0	1.2	2.3	2.3	12.5	-	1.2	6.2	25.6	1.2
Soil of the experimental site (bio.protection)	170.6	3.5	3.7	2.5	9.2	-	1.2	3.5	8.7	3.7
2022										
Soil of the experimental plot (spring)	45.5	14.3-	1.3	9.1	9.1	-	-	-	11.7	-
Soil of the experimental site (chemical protection)	52.1	1.2	1.2	1.2	1.2	-	-	3.6	8.4	1.2
Soil of the experimental site (bio.protection)	93.6	3.7	8.7	5.0	-	-	-	-	1.2	1.2

According to the ratio of ecological and trophic groups in all samples, the predominance of saprophytic microflora was revealed. At the beginning of the growing season, before planting potatoes, a high suppressiveness of the soils of the experimental plot was noted (Figure 2). By harvesting potatoes in the variant with chemical protection, an increase in pathogenic microflora by 4.8% was noted, while against the background of the use of biological preparations, a decrease in harmful microflora by 5.1% was noted. In 2021, a similar trend has emerged.



**Fig. 2.** The ratio of ecological and trophic groups of microscopic fungi, % 2020-2022.

Mycological analysis of tubers for infection with pathogens was carried out before planting and after the growing season during storage. The results of the microbiological laboratory made it possible to determine the presence of harmful pathogens on imported planting material, which were also observed during harvesting. A particularly high percentage of infestation was with fungi of the genus *Fusarium* and bacteria. The use of a biological protection system showed little effectiveness in the fight against *Fusarium*, but it worked much better for other harmful organisms compared to chemical protection.

The technologies used to protect potatoes from diseases and pests make it possible to obtain fairly high yields of more than 40 t/ha on light chestnut soils, but the system using biological preparations deserves special attention. With such a protection system with the selection of multi-strain preparations and their application according to the designated

growth phases, it provides an increase in yield at the level of 5.4 t/ha, and also increases the yield of marketable products by 14.5%. The marketability of tubers is quite high and is in the same range.

**Table 3.** Results of mycological analysis of planting material.

Culture	Name of detected microorganisms										
	Fusarium	Nematode	Pythium	Rizotonia	Rizopus	Oospora pustulans	Alternaria	Poma	Verticillium	Cladosporium	Bacteria
2020											
Potato tubers (before planting)	+++						+	+			+
Potato tubers (chemical protection)	+++	++	++			+					+++
Potato tubers (bio. protection)	++				++						+++
2021											
Potato tubers (before planting)	+++								+	+	+++
Potato tubers (chemical protection)	+++	+++	++	+				+	+	++	+++
Potato tubers (bio. protection)	+++	+++	+								+++
2022											
Potato tubers (before planting)	+++								+	+	+++
Potato tubers (chemical protection)	+++				+			++	++	++	+++
Potato tubers (bio. protection)	+++				+			+			++

+++ high infestation ++ moderate infestation + low infestation

**Table 4.** Potato productivity depending on the plant protection system, 2020-2022.

Option	Productivity, t/ha								Marketability, %			
	Gross collection				Commodity part				2020	2021	2022	Average
	2020	2021	2022	Average	2020	2021	2022	Average				
Chemical protection	30.9	45.1	44.7	40.2	28.4	41.6	39.9	36.6	91.9	92.2	95.9	93.3
Biological protection	37.9	49.9	49.0	45.6	33.8	46.1	45.9	41.9	89.2	92.4	93.8	91.8
NSR <sub>05</sub> t/ha	0.68	0.71	0.82	-	-	-	-	-	-	-	-	-

## 4 Conclusion

In conclusion, it should be noted that the proposed potato protection system with the selection of biological multi-strain preparations made it possible to increase soil suppression and potato productivity. The biologized element in the cultivation technology contributed to a significant reduction in the pesticide load on agricultural landscapes and ensures the production of environmentally friendly products.

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