СЕЛЬСКОХОЗЯЙСТВЕННЫЕ ИССЛЕДОВАНИЯ

AGRICULTURAL SCIENCES

DOI: 10.12731/2658-6649-2022-14-2-312-325
UDC 632.9

BIOLOGICAL EFFECTIVENESS OF BIOFUNGICIDE METABACTERIN, WP IN THE PROTECTION OF *GLYCINE HISPIDA MAXIM.*, AND *PISUM SATIVUM L.* FROM ASCOCHITOSIS AND *SOLANUM TUBEROSUM L.* FROM LATE BLIGHT IN THE CONDITIONS OF THE ALTAI OB REGION

O.V. Manylova, S.V. Zharkova, L.V. Sokolova

Continuous application of chemical crop protection products resulted in an agrocenosis imbalance. The number of pathogenic organisms does not decrease. Thus, one needs to search for newer and more effective active ingredients. New disease-resistant varieties quickly lose their resistance due to the high mutation activity of pathogenic organisms. In agriculture, the following fungal diseases are predominant: (1) Septoria blight, (2) Alternaria blight, (3) powdery mildew, (4) late blight, (5) rust, and others. Introducing biofungicides into plant protection systems can help reduce fungal infections in crops. For the first time in the conditions of the forest-steppe of the Ob region, the prospects of using the biofungicide Metabacterin, WP on soybean, pea, and potato crops are shown. The active ingredient in the product is a strain of the bacteria Methylobacterium extorquens Bousfieldand Green (1985), Streptomyces hygroscopicus Yüntsenetal. (19560, Bacillus subtilis Cohn (1872) and Validomycin. The paper aims to evaluate the effectiveness of the biofungicide Metabacterin, WP against Ascochyta blight on soybeans and peas, and late blight on potatoes in the forest-steppe of the Ob region of Altai. We evaluated

the spreading, development, and biological effectiveness of the tested product and chemical fungicides according to the registration tests of fungicides in agriculture. We tested the product in an area of sufficient moisture. Weather conditions favored the growth and development of plants and the development of pathogens (particularly Ascochyta blight on legume crops and late blight on potatoes). Before the symptom expression of diseases, preventive spraying had greater biological effectiveness on peas and potatoes than treatment on soybeans (where the spraying of crops coincided with the appearance of the first symptoms of diseases). There is a high prevalence of Ascochyta blight (89.3%–90.7%). However, the intensity of development in the variants with biofungicide treatment was 10% lower than in the control variant. The potatoes showed high biological effectiveness of the product Metabacterin, WP, relative to the variant without protective treatment, and 5% higher than the variant with the use of chemical fungicides. The biofungicide Metabacterin, WP on potatoes, and peas had a long-lasting effect up to the ripening of the crop.

Keywords: *soybean; peas; potato; biofungicide Metabacterin; WP; biological effectiveness*

For citation. *Manylova O.V., Zharkova S.V., Sokolova L.V. Biological Effectiveness of Biofungicide Metabacterin, WP in the Protection of Glycine Hispida Maxim., and Pisum Sativum L. from Ascochitosis and Solanum Tuberosum L. from Late Blight in the Conditions of the Altai Ob Region. Siberian Journal of Life Sciences and Agriculture, 2022, vol. 14, no. 2, pp. 312-325. DOI: 10.12731/2658-6649-2022-14-2-312-325*

БИОЛОГИЧЕСКАЯ ЭФФЕКТИВНОСТЬ БИОФУНГИЦИДА МЕТАБАКТЕРИН, СП В ЗАЩИТЕ *GLYCINE HISPIDA MAXIM.* И *PISUM SATIVUM L.* ОТ АСКОХИТОЗА И *SOLANUM TUBEROSUM L.* ОТ ФИТОФТОРОЗА В УСЛОВИЯХ АЛТАЙСКОГО ПРИОБЬЯ

О.В. Манылова, С.В. Жаркова, Л.В. Соколова

Постоянное применение химических средств защиты растений привело к дисбалансу агроценоза. Количество патогенных организмов не снижается. Таким образом, необходимо искать более новые и эффективные активные

ингредиенты. Новые устойчивые к болезням сорта быстро теряют устойчивость из-за высокой мутационной активности патогенных организмов. В сельском хозяйстве преобладают такие грибковые болезни, как септориоз, альтернариоз, мучнистая роса, фитофтороз, ржавчина и другие. Внедрение биофунгицидов в системы защиты растений может способствовать снижению грибковых инфекций сельскохозяйственных культур. Впервые в условиях лесостепи Приобья показана перспективность применения биофунгицида Метабактерин, СП на посевах сои, гороха и картофеля. Действующим веществом препарата является штамм бактерий Methylobacterium extorquens Bousfield and Green (1985), Streptomyces hygroscopicus Yüntsenetal. (19560, Bacillus subtilis Cohn (1872) и валидомицин. Цель работы заключается в оценке эффективности биофунгицида Метабактерин, СП против аскохитоза сои и гороха и фитофтороза картофеля в условиях лесостепи Приобья Алтая. Мы оценили распространение, развитие и биологическую эффективность испытуемого препарата и химических фунгицидов по данным регистрационных испытаний фунгицидов в сельском хозяйстве. Мы протестировали продукт в помещении с достаточной влажностью. Погодные условия благоприятствовали росту и развитию растений и развитию патогенов, в частности аскохитоза на бобовых культурах и фитофтороза на картофеле. Профилактические опрыскивания до проявления симптомов болезней имели большую биологическую эффективность на горохе и картофеле, чем обработка на сое, где опрыскивание посевов совпадало с появлением первых признаков болезней. Отмечается высокая распространенность аскохитоза (89,3–90,7%). Однако интенсивность развития в вариантах с обработкой биофунгицидом была на 10 % ниже, чем в контроле. Картофель показал высокую биологическую эффективность препарата Метабактерин, СП, по сравнению с вариантом без применения защитной обработки и на 5 % выше, чем вариант с применением химических фунгицидов. Биофунгицид Метабактерин, СП оказывал пролонгированное действие на картофеле и горохе вплоть до созревания урожая.

Ключевые слова: *соя; горох; картофель; биофунгицид Метабактерин; СП; биологическая эффективность*

Для цитирования. *Манылова О.В., Жаркова С.В., Соколова Л.В. Биологическая эффективность биофунгицида Метабактерин, СП в защите Glycine Hispida Maxim. и Pisum Sativum L. от аскохитоза и Solanum Tuberosum L. от фитофтороза в условиях Алтайского Приобья // Siberian Journal of Life Sciences and Agriculture. 2022. Т. 14, № 2. С. 312-325. DOI: 10.12731/2658-6649-2022-14-2-312-325*

Introduction

The high concentration of crops and the long-term and intensive use of various chemical means of protecting plants from pathogens and pests did not decrease their number. However, they led current agriculture to problems associated with environmental pollution and the frequent occurrence of epiphytotics. There was a decrease in species diversity and quantitative indicators of beneficial organisms. The level of self-regulation of agrocenoses decreases leads to phytosanitary destabilization, increasing the innocuousness of populations of phytopathogens and pests [10; 18].

Crop losses from developing diseases in different years can be up to 30% and more. Currently, one does not grow the crop on an industrial scale without using protection products. One of the ways to reduce the pesticide load in agricultural production is to replace synthetic products with biological ones. The leader in the production of biopesticides is the United States. The market value of these products is $125 million per year [17]. In Russia, the index numbers were much lower. Biological products accounted for only 2% of the total amount of protection products used. At the same time, more than 80% are biofungicides. According to experts in Russia, there will be rapid growth in this area in the coming years [17].

Soybean is one of the three most common crops in agriculture. The high demand is due to the diversity of its use. The seeds of this crop are characterized by a high content of protein and fat. According to the Food and Agriculture Organization of the United Nations, the area occupied by the crop in 2019 in the world production is 120.5 million hectares [14]. Russia is not among the leaders in terms of soybean seed production. Nevertheless, the sown area is about 3 million hectares [15].

Potatoes are valuable food and technical culture. The consumption of this product in Russia is approximately 130 kg per person per year [1].

Crop capacity is often reduced due to the development of pathogenic microbial flora. The most common diseases on soybeans and peas include (1) Ascochyta blight, (2) downy mildew, (3) Alternaria blight, (4) anthracnose, (5) Septoria blight, and (6) Fusarium blight. Late blight and Alternaria blight are the most common diseases of the aboveground part of potatoes.

The selection of biofungicides with high efficiency to curb the development of fungal pathogenic microbial flora on plants would reduce crop yields and prevent environmental pollution with synthetic pesticides [11; 19; 20; 21; 22].

For the first time, we presented generalized material on the study of the biological efficacy of the biofungicide Metabacterin, WP on three field cultures: Glycine Hispida Maxim., Pisum Sativum L., Solanum Tuberosum L. Some of the results of these studies were presented in our earlier papers [5; 8].

Materials and methods

We evaluated biofungicide Metabacterin and WP on soybean and potato crops under the conditions of the forest-steppe of the Altai Ob region. In the leached chernozem zone, the climate of the research area is continental. The amount of precipitation was 477 mm per year. Summers were moderately hot.

This study aims to evaluate the effectiveness of the biofungicide Metabacterin, WP against Ascochytablight on soybeans and peas and late blight on potatoes under conditions of the forest-steppe of the Altai Ob region.

The tasks were (1) to assess the effect of Ascochyta blight on soybeans and peas and late blight on potatoes when using the biofungicide Metabacterin, WP; (2) to assess the intensity of the spread of these diseases on the studied crops; and (3) to calculate the biological effectiveness of the tested biofungicide.

The research object is a variety of soybeans, the variety of *Varyag* peas, and the variety of *Lyubava* potatoes. The research subject is the biological effectiveness of biofungicide Metabacterin, WP.

During the tests, soybean became the second crop after soybean. Peas were sown according to the fore crop spring wheat, and potatoes were sown according to the fore crop buckwheat.

During the growing season, background treatment of pea crops was carried out with Fastak insecticide, EC – 0.1 l/ha, pre-seeding treatment of tubers was carried out on potatoes with Prestige, SC – 1l/t, before seedling potatoes were cured with Boxer herbicide, EC– 4 l/ha, during the growing season Titus, DF - 40 g/ha, Fusilade Forte, EC–1l/ha, Agritox, SL- 0.7l/ha were used.

Biofungicide Metabacterin, WP is a multicomponent bacterial preparation consisting of spores *Methylobacterium extorquens Bousfield and Green, 1985* NVD VKM B-2879D, *Streptomyces hygroscopicus* subsp. "*limoneus*" *Yüntsen et al., 1956*VKPMAS-1966 with validamycin, *Bacillus subtilis Cohn, 1872* КПМВ-2918.

The plot areas in the farm-scale trial were (1) 5.04 ha – in the trial with soybean; (2) 2.43 ha – in the trial with peas; (3) 1.44 ha – in the trial with potatoes.

Records and observations in the trial were performed according to the methodological recommendations for registration tests of fungicides [4].

Results

The weather conditions during the year were favorable for crop development. The indicators of the average air temperatures for the decade were 2–3 degrees higher than the long-run annual average. Precipitation amounts also exceeded the long-run annual average.

We noted the first symptoms of Ascochyta blight on soybeans and peas in the first decade of July. For soybeans, this moment coincided with the treatment of crops with biofungicide by spraying (July 12). During the first tracking (immediately before planting of crops), the spread of Ascochyta blight was 55%. However, the intensity of the disease development was only 1%. As the plants grew, the intensity and prevalence of Ascochyta blight also increased. By the end of August (the third tracking), the spread of soybeans was 89.3%–90.7%, with a development intensity of 30.7%–40.4% (Table 1). Since the soybean crops were treated during the period when the plants already had signs of Ascochyta blight on the lamina, the biological effectiveness of the tested product was small. It amounted to only 21.8% at the norm of 15g/ha of Metabacterin, WP use, and 24% at the norm of 12 g/ha.

The picture looked different for pea crops. At the first tracking (immediately before the sowing of crops), the symptoms of Ascochyta blight on the plants were absent. However, they appeared later. At the second tracking (in 10 days after the spraying of crops), the P, % index was 16%–24%, while the values ranged from 0.3%–3% with the maximum value in control (untreated area), by the third and fourth tracking Ascochyta blight made progress. The number of damaged plants was 56%–96% at the third tracking and 74.3%–97.1% at the fourth track. We observed the greatest prevalence of symptoms of Ascochyta blight in the control variant. However, the indicator of the biological effectiveness of the tested product, calculated from the intensity of the disease development relative to the control variant, showed high values of 74.6%–77.7%. A consortium of bacteria in the biofungicide Metabacterin, WP had a long-lasting protective effect on pea plants. Its preventive function in protecting the samples from the disease since the product was used before the symptoms of Ascochyta blight appeared.

One of the most common potato diseases in the forest-steppe of the Ob region is a late blight which is evident as a form of brown spots on the leaves at the initial stages of development and as browning and top necrosis with severe plant damage.

Table 1 shows the trial results comparing the effectiveness of the biofungicide Metabacterin, WP applied once during the bud-formation period, and the scheme of application of fungicides according to the farm unit. The scheme of chemical protection on potatoes was sequential spraying of plants during the growing season starting from the bud-formation period with an interval of 10–14 days: Bravo, SC, Ridomil Gold MZ, WDG, Kurzat R, WP, Bravo, SC, Shirlan, SL.

Table 1.

Prevalence and development of the diseases on field crops and the biological effectiveness of the biofungicide Metabacterin, WP.

A trial variant	Trackings								
	second			third			fourth		
	P*,%	D**,%	E***, %	P,%	R,%	E, %	P,%	R,%	E, %
Soybeans									
Metabacterin, WP-12g/ha	62.7	5.6	65.4	89.3	22.3	39.3	89.3	30.7	24
Metabacterin, WP-15g/ha	58.7	6.2	61.7	90.7	21.5	41.4	90.7	31.6	21.8
Control (untreated)	88	16.2	-	88	36.7	-	89.3	40.4	-
Peas									
Metabacterin, WP-12g/ha	24	2.6	13.3	56	8.3	70.6	77.1	11.4	74.6
Metabacterin, WP-15g/ha	16	0.3	90	68	7.1	74.8	74.3	10	77.7
Control (untreated)	16	3	-	96	28.2	-	97.1	44.8	-
Potatoes									
Metabacterin, WP-15g/ha	22.2	3.9	72.5	52.2	22	69.3	22.2	3.9	72.5
Chemical fungicides	24.4	4.6	67.6	51.1	18.9	73.7	24.4	4.6	67.6
Control (untreated)	64.4	14.2	-	100	71.2	-	64.4	14.2	-

Note: P* – disease prevalence, D** – disease development, E*** – biological effectiveness of the product relative to control.

The biological effectiveness of the treatment options was 67.6%–72.5% in the second tracking and 69.3%–73.7% in the third tracking relative to the control variant (untreated). High values of this indicator for biofungicide prove its effectiveness. Timely preventive treatment explains these results. The bacteria that make up the product settled on the surface of the leaves and in the natural pores on their surface (lenticels and stomata). This situation created barriers to the entry of zoospores of the late blight invader.

The obtained results suggest the possibility of wider use of the biofungicide Metabacterin, WP, to protect field crops from fungal pathogens.

Discussion

Currently, the crucial factor in the production of agricultural products is the biologisation and ecologization of the process. Anthropogenic impacts on the agroecosystems negatively affect the environment, increasing the number of phytophages and disease excitants [12]. Hence, many scientists note the need to improve plant protection products based on biological ingredients with an environmental focus when using them [2; 3; 6; 12]. The use of a new genera-

tion of plant protection products, such as biological fungicides, allows one to reduce negative impacts on the environment and the plants themselves and obtain cleaner and safer products.

Research on the creation and further use of the biological product Metabacterin, WP started more than ten years ago and showed that the bacterium Methylobacterium extorquens *Bousfield and Green, 1985* has great prospects for use as a part of both biopesticides and growth stimulators [7; 16].

O.N. Gostev noted that the use of the biofungicide Metabacterin, WP in the protection system of spring wheat resulted in a yield increase of 30% in comparison with the untreated area and 16% in comparison with the use of the fungicide Kolosal, EC [13]. Previous studies [9] reported the biological effectiveness of the biofungicide Metabacterin, WP against Septoria blight on winter wheat at a rate of application 9 g/ha for seed treatment and twice during the growing season.

The analysis of the scientific research available on the results of the use of the biofungicide Metabacterin, WP, and the results of our research show its potential for use in crop protection systems.

Conclusion

We obtained the results of using the biofungicide Metabacterin, WP. Thus, we can recommend this product to agricultural producers as effective against diseases such as Ascochyta blight on soybean and pea crops and late blight on potatoes.

The biological effectiveness of the product was 21.8%–24% on soybeans and 74.6%–77.7% on peas. This fact suggests the possibility of using this biofungicide in the protection systems of other leguminous crops. The effectiveness of the biofungicide Metabacterin, WP on potatoes against late blight in our studies was 72.5 % compared to the control (untreated). This result will allow potato producers to significantly reduce the cost of plant protection and increase output production. Further studies on biofungicide should be conducted on crops of the Solanaceae family, where potatoes, tomatoes and eggplant are also affected by late blight. One should carry out the preventative application of the product before the onset of symptoms of diseases, which will reduce the intensity of the effect.

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DATA ABOUT THE AUTHORS

Olga V. Manylova

Altai State Agricultural University
98, Krasnoarmeyskiy Ave., Barnaul, 656049, Russian Federation
manylova@asau.ru
ORCID: https://orcid.org/0000-0002-9967-3242

Stalina V. Zharkova

Altai State Agricultural University
98, Krasnoarmeyskiy Ave., Barnaul, 656049, Russian Federation
stalina_zharkova@mail.ru
ORCID: https://orcid.org/0000-0001-8410-6715

Liudmila V. Sokolova
Altai State University
61, Lenin Ave., Barnaul, 656049, Russian Federation
l.v.sokol@mail.ru
ORCID: https://orcid.org/0000-0001-5171-3965

ДАННЫЕ ОБ АВТОРАХ

Манылова Ольга В.
Алтайский Государственный Аграрный Университет
просп. Красноармейский, 98, г. Барнаул, 656049, Российская Федерация
manylova@asau.ru

Жаркова Сталина В.
Алтайский Государственный Аграрный Университет
просп. Красноармейский, 98, г. Барнаул, 656049, Российская Федерация
stalina_zharkova@mail.ru

Соколова Людмила В.
Алтайский Государственный Университет
просп. Ленина, 61, г. Барнаул, 656049, Российская Федерация
l.v.sokol@mail.ru

Поступила 26.01.2022 Received 26.01.2022
После рецензирования 14.02.2022 Revised 14.02.2022
Принята 04.03.2022 Accepted 04.03.2022