The effect of biofungicides used to protect cucumber from major diseases in unheated spring greenhouses on the yield of marketable products

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Abstract. Currently, in protected ground, preparations are widely used that promote the prolonged action of their components, and provide an integrated technology for growing vegetable plants. However, due to economic problems, the use of biologicals in vegetable production has declined. In this regard, in 2019-2020, in the conditions of unheated greenhouses in the Oktyabrsky District of the Rostov Region, an experiment was laid with the aim of studying the use of drugs with fungicidal methods in the fight against diseases common on the Ataman hybrid cucumber culture. It has been established that powdery mildew is most widespread on greenhouse cucumbers. The drugs Gaimair, Strekar and the mixture Gaimair + Alirin restrain the average score of the spread of diseases most strongly. Thus, a mixture of Gaimair and Alirin is almost 1.6-1.7 times more effective at restraining the distribution point in comparison with Strekar and 4.0-4.5 times more effective than the chemical Topaz. Among the studied methods of using medicinal preparations, a greater effect is observed when watering plants at the root, with the exception of the fight against powdery mildew, where spraying of vegetative plants is more effective. Therefore, it is possible to reveal the positive effect of preparations of biological nature, Gaimair, Strekar, or a mixture of Gaimair and Alirin, used mainly for watering under the root with an interval of 10 days. Reducing the development of major diseases has a positive effect on the size of the crop. The use of a mixture of drugs allows you to increase the early harvest by 0.6-0.65 and the total by 1.35-1.40 kg/m².

1. Introduction
Modern greenhouse vegetable growing is a complex component, which, despite its extreme importance for providing the population with fresh vegetable products in the off-season, experiences many difficulties. One of these difficulties is the increased demand for products with high quality characteristics, including environmental friendliness of products. This problem is directly related to both the need to modernize protected soil and the development of environmentally friendly technologies. In many countries, this is reflected in the active development of the spectrum of biological products produced to protect against harmful organisms.

The intensive use of inorganic fertilizers and pesticides in the agricultural sector has led to the global destruction of soil fertility, the destruction of beneficial microorganisms, as well as a decrease in the natural resistance of crops, which made them more vulnerable to diseases, in addition to the impact on human health and the environment. To overcome these problems, it is very important to turn our attention to environmentally friendly alternatives that can not only increase the growth and
productivity of crops, suppress diseases and pests sustainably, but can also protect human health and the environment [1].

Biological research is being carried out in many countries and on a variety of crops. The basis of the action of biological products are the features of the biology of antagonist species. This includes the rate of soil colonization in different regions and conditions, the rate of reproduction of microorganisms, their competitiveness with local types of microorganisms. Studies have shown the presence of these qualities in some antagonist species, which manifested themselves in a decrease in the growth of phytopathogenic fungi, as well as in a decrease in their prevalence [2-3].

The use of microbial preparations Alirin-B, Gaimair showed that their effectiveness is comparable to that of agrochemicals. Microbial preparations based on genetically modified microorganisms are able to effectively compete with agrochemicals in the fight against phytopathogenic microorganisms [4].

The quality of the developed preparations directly affects the efficiency of plant protection against phytopathogenic microorganisms, which ultimately manifests itself in the indicators of crop productivity. All these developments and studies were carried out on the basis of the known rhizosphere – microorganism relations [3]. Microbial biopesticides derived from bacteria have the potential to produce a wide variety of antifungal metabolites with remarkable biocidal effects [5]. The results indicate that biofungicides may be the preferred option when trying to prevent side effects for susceptible groups among the species-rich community of soil detritus feeders [6].

Since powdery mildew grows mainly on the leaf surface, where contact fungicides are effective, biofungicides can be effective prophylactic agents for treating powdery mildew [7].

Many studies related to the study of the action of biofungicides are aimed at identifying the optimal methods of application, concentrations and timing. The authors agree that the use of biofungicides has a positive, including a prolonged effect on the state of the soil, productivity and quality, and also affects the environment and directly to humans [8-13].

Thus, the analysis of the literature on the use of biological preparations for protection against the main diseases of cucumber in protected ground indicates the need for research work related to the determination of drugs and methods of their use that have the maximum effect in the Oktyabrsky district of the Rostov region.

2. Materials and methods
The studies were carried out in 2019-2020 in spring unheated greenhouses under the conditions of the 5th light zone of the Oktyabrsky district of the Rostov region on alluvial meadow medium loamy soils with pH = 7.1-7.2.

The aim of the research was to study the effectiveness of biological preparations with a fungicidal effect in protecting cucumbers from major diseases. A two-factor laboratory-field experiment, a fourfold repetition of the experiment on a cucumber hybrid Ataman F1, according to the experimental scheme: 1. Control - no treatment; 2. Topaz 0.2%; 3. Agate 25 K; 4. Alirin B; 5. Gaimair; 6. Strekar; 7. Gaimair + Alirin. Treatment with drugs was carried out in two ways: 1. spraying plants; 2. Watering at the root, with an interval between each treatment of 10 days.

The predecessor is tomatoes. Agricultural technology is common for the zone. Plot area: sowing area - 5 m², registration area - 2 m², placement - systematic. The object of research is drugs of biological and chemical nature used to protect against fungal diseases, permitted for use on cucumber and methods of their application. The experiments, records and observations were carried out according to the method of S.S. Litvinov. The mean score for the disease was assessed on a 5-point scale.

3. Results and Discussion
The use of biological products is an alternative to chemicals and an undoubted way to significantly improve the environmental situation in the production of products. In this regard, the assessment of
drugs of biological origin, the study of their effect on the spread of fungal infection during the production of cucumber in spring unheated greenhouses can be considered a priority task.

Additional protection of plants with both chemical and especially biological preparations (biofungicides) provides a sharp decrease in the score of damage to plants by major diseases that were noted during the growing season (table 1).

**Table 1.** The average score of plant damage by major diseases and the yield of cucumber hybrid Ataman when processing vegetative plants in spring greenhouses with biofungicides (average 2019-2020).

| Drugs       | Mode of application | Major diseases of cucumber, score | Productivity, kg / m² | Experience Average | Average for biologics | Average increase from biological products, kg / m² / % |
|-------------|---------------------|----------------------------------|-----------------------|-------------------|----------------------|-----------------------------------------------------|
|             |                     | Blackleg | Powdery mildew | Tracheomycotic wilting | early | general | +0.12 / 3.2 | +0.25 / 2.8 | HCP₉₅ kg / m² / % |
| Control     | Spraying            | 2.2      | 4.0            | 2.5                  | 3.35  | 8.30    |
|             | Watering            | 1.8      | 4.1            | 1.8                  | 3.35  | 8.30    |
| Topaz 0.2%  | Spraying            | 2.3      | 1.9            | 0.8                  | 3.50  | 8.60    |
|             | Watering            | 1.8      | 1.9            | 0.7                  | 3.50  | 8.60    |
| Agate 25 K  | Spraying            | 1.6      | 1.2            | 0.5                  | 3.70  | 8.90    |
|             | Watering            | 1.4      | 1.3            | 0.5                  | 3.75  | 8.95    |
| Alirin B    | Spraying            | 1.4      | 1.2            | 0.4                  | 3.80  | 9.10    |
|             | Watering            | 1.2      | 1.3            | 0.1                  | 3.90  | 9.20    |
| Gamair      | Spraying            | 0.9      | 1.1            | 0.4                  | 3.85  | 9.45    |
|             | Watering            | 0.7      | 1.3            | 0.1                  | 3.85  | 9.45    |
| Strekar     | Spraying            | 0.5      | 1.0            | 0.4                  | 3.85  | 9.45    |
|             | Watering            | 0.4      | 1.3            | 0.1                  | 3.85  | 9.45    |
| Gamair + Alirin | Spraying     | 0.1      | 0.7            | 0.3                  | 3.95  | 9.65    |
|             | Watering            | 0.1      | 0.9            | 0.1                  | 4.00  | 9.70    |
| Average for illness |         | 1.17     | 1.66          | 0.62                 | 3.73  | 9.08    |
|             |                     |          |                |                      | 3.85  | 9.33    |

As the analysis of table 1 shows, powdery mildew is most common in spring unheated greenhouses of the Rostov region, which, in our opinion, is due to the impossibility of good regulation of both temperature and especially humidity in simple unheated ground greenhouses, which are widespread in our region on farms, various forms of ownership. The maximum lesion score is noted by us in the control and during treatment with the chemical Topaz, although, of course, its effect is, which is expressed in a decrease in the average spread score by 1.23-1.10 in comparison with the control. The drugs Gamair, Strekar and especially the mixture of Gamair and Alirin inhibit the average score of the spread of diseases most strongly. Thus, a mixture of drugs Gamair and Alirin is almost 1.6-1.7 times more effective at restraining the distribution point in comparison with Strekar and 4.0-4.5 times more effective than the chemical Topaz.

Among the studied methods of using drug solutions, a greater effect is observed when watering plants at the root. So, even when using Topaz, root watering is more effective than spraying plants by 0.2 points. For biological agents, the effectiveness of root irrigation is also higher than spraying, but to a lesser extent. And, only in the variant with a mixture of drugs, the effect of both spraying and watering under the root is absolutely the same, although watering under the root less effectively suppresses powdery mildew, but more effectively fights tracheomycotic wilting.
Despite the general tendency for a greater average protective effect from watering under the root, the indicators of the spread of powdery mildew for this method of using drugs are lower than when spraying plants.

The genetic stability of the assortment plays an important role in the protection of cucumbers. So, our data are characteristic of the Ataman hybrid and may be similar to hybrids with similar genetic characteristics or origin.

The lowest efficacy against blackleg was observed in the variant with the use of the chemical Topaz and the biostimulant with fungicidal properties Agate 25 K, in which the percentage of diseased plants was 7.1-7.7 and 6.8-7.0, respectively, which is 5% lower than the control 5.3-5.8 and 5.6-6.5% (figure 1).

![Figure 1. Influence of drugs and methods of their use on the percentage of patients with black leg, tracheomycotic wilting and powdery mildew of cucumber plants (average 2019-2020).](image)

As can be seen from the data in figure 1, the greatest damage to plants by powdery mildew was noted in the control (64.6-65.0%), and the economic threshold of the disease severity was up to 40%. Obviously, in the absence of protective measures, significant crop losses are likely. In the variants of the experiment with the use of chemical and biological means of protection, a significant decrease in the damage to plants by powdery mildew was noted, namely by 3.9-4.5 times.

Figure 2 shows the signs of powdery mildew.
Figure 2. Signs of the onset of powdery mildew damage to cucumber plants.

We also note that a decrease in the percentage of diseased plants has a positive effect on increasing yields. So, in the absence of protective measures, the early harvest was 3.35 kg / m², then in the variant with a chemical preparation it is higher by 0.15 kg / m², for biological products it is already significantly higher, reaching a maximum excess over the control by 0.6-0.65 kg / m² in the variant with a mixture of Gamair + Alirin preparations.

In terms of the total yield, the indicators for the same options are even higher - 0.3 kg / m² for the Topaz preparation, up to 1.35-1.4 kg / m² for the mixture of preparations. The option of watering rather than spraying continues, albeit slightly to stand out.

4. Conclusion
Based on the results of the studies carried out, it can be concluded that a decrease in the distribution score and the percentage of diseased cucumber plants, which can be achieved by using biological preparations and their mixtures for protection, and a greater effect of watering at the root will allow to minimize the significant total costs incurred by the producer on plant protection, as well as thereby improve the ecological situation and have a positive effect on the quality of products.

Based on the results of studies conducted in 2019-2020. It was found that powdery mildew develops most strongly in the spring greenhouses of the Rostov region and has a negative effect on the phytosanitary state of the greenhouse agrophytocenosis, the distribution point of which, in the absence of effective protection, reaches 4.0-4.1. It was found that the maximum effect in protection against the main diseases on the Ataman hybrid is achieved from the use of a mixture of Gamair and Alirin preparations, both when watering under the root and when spraying plants. An exception is the greater effect of spraying in protection against powdery mildew. It is noted that a reduction in the development of major diseases has a positive effect on the size of the crop. The use of a mixture of drugs allows you to increase the early harvest by 0.6-0.65 and the total by 1.35-1.40 kg / m².
Producers of commercial products of protected ground cucumber were given recommendations on the use of a set of biological preparations in the cultivation technology for protection against the most harmful diseases, the most productive way of their use was selected for the conditions of the Oktyabrsky District of the Rostov Region, which additionally contributes to an increase in both early and general yield.

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