DOI 10.32900/2312-8402-2025-134-238-250
UDC 635.63:632:631.544

BIOLOGICAL CONTROL OF CUCUMBER DISEASES IN THE CLOSED GROUND

Ganna POSPIELOVA, PhD., associate professor,
http://orcid.org/0000-0002-8030-1166
Ninel KOVALENKO, PhD., associate professor
http://orcid.org/0000-0001-5998-1745
Sergii POSPIELOV, doctor of Agricultural Sciences, professor,
http://orcid.org/0000-0003-0433-2996
Vladislav PELYKH, PhD student,
http://orcid.org/0009-0000-9518-0494
Borislav MUCHA, PhD student,
http://orcid.org/0009-0008-3680-2773
Poltava State Agrarian University, Poltava, Ukraine

The study was conducted in the closed ground conditions of a farm enterprise in the Poltava region. The species composition of pathogens of the culture, which was dominated by fungi of the genera Fusarium and Rhizoctonia, was determined. The proportion of occurrence of Alternaria cucurbitae, Pseudoperonospora cubensis, Erysiphe cichoracearum was insignificant. In order to control the prevailing diseases, the biofungicides Trichoplant, R., Mikohelp, R. and Fitohelp, S. were studied. their effectiveness was compared with the chemical preparation Previkur Energy, RK.

The positive effect of applying cucumber seeds of the Kibria hybrid with biofungicides based on Bacillus subtilis and Trichoderma lignorum on sowing qualities was noted. Germination energy increased with the use of biologics on average over the years of research by 2.0 %, 4.9% and 10.0% compared to the control (82.5 %). Indicators of laboratory germination in the variants with seed treatment Trichoplant, R. and Mikohelp, R. were 95.4% and 96.3%, respectively, while in the control version – 92.5%. The stimulating effect of biologics on growth processes (seedling and Root Length) was revealed. For the use of Trichoplants, P. and Mikohelp, R. The length of the seedling on average exceeded the control by 6.0 mm, and the roots by 3.0 mm and 6.0 mm, respectively. The studied drugs were effective in controlling cucumber root rot. In the version with the fungicide Previkur Energy, RK. the development of the disease was recorded at the level of 1.3% and 1.7 % (respectively, years of study), technical efficiency averaged 85.3 %. Among biofungicides, the highest technical efficiency over the years of research was provided by Mikohelp, R.– 80.5% and 76.9%. When applied, the average yield of commercial fruits per 1 m^2 was 25.2 kg, which exceeded the control by 6.8 kg/m^2 or 36.9 %. A statistically significant increase in yield was observed in the variants using Phytohelp, C. (by 4.0 kg/m^2) and Trichoplant, R. (by 6.5 kg/m^2).

Keywords: phytosanitary monitoring, pathogenic complex, cucumber root rot, closed ground, biofungicides, technical efficiency.

БІОЛОГІЧНИЙ КОНТРОЛЬ ХВОРОБ ОГІРКІВ В ЗАКРИТОМУ ГРУНТІ

Ганна ПОСПЄЛОВА, к. с.-г. н., доцент,
http://orcid.org/0000-0002-8030-1166
Нінель КОВАЛЕНКО, к. с.-г. н., доцент,
http://orcid.org/0000-0001-5998-1745
Сергій ПОСПЄЛОВ, доктор с.-г. наук, професор,
http://orcid.org/0000-0003-0433-2996
Владислав ПЕЛИХ, асп., http://orcid.org/0009-0000-9518-0494
Борислав МУХА, асп., http://orcid.org/0009-0008-3680-2773
Полтавський державний аграрний університет, м. Полтава, Україна

Дослідження проведено в умовах закритого грунту фермерського підприємтва Полтавського району. Визначено видовий склад збудників хвороб культури, в якому домінували гриби родів Fusarium та Rhizoctonia. Частка трапляння Alternaria cucurbitae, Pseudoperonospora cubensis, Erysiphe cichoracearum виявилася незначною. З метою контролю переважаючих хвороб досліджувалися біофунгіциди ТрихоПлант, р., МікоХелп, р. та ФітоХелп, с. Їх ефективність порівнювалася з хімічним препаратом Превікур Енерджі, рк.

Відмічено позитивний вплив аплікації насіння огірка гібриду Кібрія біофунгіцидами на основі Bacillus subtilis і Trichoderma lignorum на посівні якості. Енергію проростання зросла за використання біопрепаратів в середньому за роки досліджень на 2,0 %, 4,9 % та 10,0 % у порівнянні з контролем (82,5 %). Показники лабораторної схожості у варіантах з обробкою насіння ТрихоПлант, р. і МікоХелп, р. становили 95,4 % і 96,3 % відповідно, тоді як у контрольному варіанті – 92,5 %. Виявлено стимулюючий ефект біопрепаратів на ростові процеси (довжину проростку та корінця). За використання ТрихоПлант, р. і МікоХелп, р. довжина проростка в середньому перевищувала контроль на 6,0 мм, а корінців на 3,0 мм і 6,0 мм відповідно препаратів. Досліджувані препарати виявилися ефектвними у контролі кореневих гнилей огірків. У варіанті з фунгіцидом Превікур Енерджі, рк. розвиток захворювання реєструвався на рівні 1,3 % та 1,7 % (відповідно років дослідження), технічна ефективність в середньому становила 85,3 %. Серед біофунгіцидів найвищу технічну ефективність за роками досліджень забезпечив МікоХелп, р.– 80,5% та 76,9%. За його внесення середня врожайність товарних плодів з 1 м^2 становила 25,2 кг, що перевищувало контроль на 6,8 кг/м^2 або 36,9 %. Статистично достовірне збільшення врожайності відмічено у варіантах із застосуванням ФітоХелп, с. (на 4,0 кг/м^2) і ТрихоПлант, р. (на 6,5 кг/м^2).

Ключові слова: фітосанітарний моніторинг, патогенний комплекс, кореневі гнилі огірків, закритий грунт, біофунгіциди, технічна ефективність.

Introduction. The growing demand for fresh vegetable products, especially in the off-season period, which has been observed in recent years in Ukraine, requires an increase in the area of closed ground and contributes to the intensive development of greenhouse vegetable growing. Currently, according to the state statistics service of Ukraine, closed ground areas occupy about 6 thousand hectares. A significant share in the structure of greenhouse agrocenoses, both in terms of area and gross yield, falls on the cucumber crop (Verheles, P. M., 2021; Havii, V. M., & Pryplavko, S. O., 2021; Dudchenko, V. V., et al., 2024).

Modern technologies for growing cucumbers in the off-season period involve the use of various types of cultivation facilities and substrates. Closed ground is a relatively stable ecosystem, favorable for the growth and development of vegetable crops, but small areas of greenhouses, permanent use of substrates, limited species composition of plants and other factors lead to deterioration of the phytosanitary state of artificial agrocenosis, significant crop losses and deterioration of the quality of vegetable products (Yarovyi, H. I. et al., 2018).

When growing vegetable crops in closed ground, an important issue is the phytosanitary condition of plantations and the protection of plants from harmful organisms, including infectious diseases of various etiologies (Bondarenko, S. V., & Stankevych, S. V. 2021; Kovalenko, N. P. et al., 2024; Kyryk M. M. et al., 2012). The results of monitoring observations in cultivation facilities of various types allowed us to identify the dominant complex of pathogens under different growing conditions. Since the vast majority of registered and identified pathogens have a wide range of nutrient plants, they are able to parasitize various types of indoor crops from year to year, which contributes to the accumulation of infectious potential, creating a dangerous phytosanitary situation (Yarovoy G. I. et al. , 2018; Tkalenko G., 2020). In addition, the closed ground regime determines the number of pathogen generation and continuous infectious load in greenhouses. Pathogens respond quickly to changes in environmental factors, as they have a rather short development cycle compared to plants. Fungi are a certain environmental indicator that indicates a violation of the abiotic conditions of the greenhouse. As a result of an increase in their number, conditions are created for the development of a complex of diseases on plants.

An analytical review of publications of domestic and foreign phytopathologists suggests that among diseases of closed ground, Root and basal rot (34.3%), verticillosis and fusarium wilt (6.5% and 4.6%) are the most common (Kovalenko, N. P. et al., 2024; Onyshchenko, O. et al., 2019; Ta Y. et al., 2024).

The results of the analysis of greenhouse substrates and samples of affected plants from greenhouses conducted by employees of the Institute of plant protection of the National Academy of Sciences of Ukraine indicate the same type of species composition of pathogens under various technological factors and conditions (Tkalenko G. et al., 2019). Dominant on cucumber culture in various types of cultivation facilities are root and root rot, which manifests itself throughout the growing season and can cause mass death of plants (Pelykh, V. Yu. et al., 2023). Their pathogens (primarily fungi of the genera *Pythium, Fusarium, Rhisoctonia*) are characterized mainly by a necrotrophic way of feeding (Heflish A. A. et al., 2021; Sharma D. & Shukla A., 2021).

The main causes of root rot are unfavorable conditions for the growth and development of cucumber plants. Delayed development of the root system and local death of the cow root parenchyma creates favorable conditions for microbial damage. Weakened tissues quickly colonize various types of pathogenic fungi, in particular: *Fusarium culmorum* (W. G. Sm.) Sacc., *F. solani* App. et Wr., *F. oxysporum* Schlecht., *Rhizoctonia solani* Kuhn., *Ascochyta cucumis* Fautr.) and so on. Thus, the rotting of root system tissues is a consequence of a combined pathological process involving abiotic and biotic stress factors. The dependence of the depth of the pathological process on the manifestation of root rot (the degree of development of the disease) on the humidity of the substrate, sharp fluctuations in the temperature of the substrate, and the concentration of salts in the soil solution is proved (Kyryk M. M. et al., 2012; Zhang S. et al., 2008).

You should pay attention to the particular danger of developing root rot during the fruiting phase, since during this period it is impossible to influence the course of the infectious process and stop the development of the disease. The reason for this situation

is the latent form of the infectious process before the fruiting period and the manifestation of symptoms during the onset of stressful conditions (Perez-Hernandez A. et al., 2020). According to research by phytopathologists of the Institute of plant protection of the National Academy of Sciences of Ukraine, epiphytotic development of root rot of various etiologies in closed ground during the growing season can lead to the death of 25% to 50% of plants (Tkalenko H. M. et al., 2020).

The defeat of *Pythium de barianum* Hesse and *Rhizoctonia solani* Kuerhn fungi is somewhat less common in closed ground conditions. Waterlogging of the substrate contributes to the development of these pathogens. According to Mahmoud A. F., Abdalla O. A. (2021) of the 56 fungal isolates isolated from root rot-affected cucumber plants, 17.9 % (10 isolates) belonged to *Rhizoctonia solani*. Subsequent studies have shown a high level of pathogenicity of this species for cucumber plants – 76.8 % (Mahmoud A. F. & Abdalla O. A., 2021). In addition, the authors isolated the fungi *Pythium aphanidermatum*, *Fusarium solani*, *Drechslera halodes* and *Macrophomina phaseolina* from the substrate of experimental greenhouses.

To prevent the spread of root rot, it is important to know the sources of infection (affected seeds, soil and plant residues), since infectious structures of pathogens (sclerotia, chlamydospores, etc.) can persist in the soil and other substrates for up to 6-8 years (Balvas-Hremiakova, K. M. & Horal, S. V., 2019).

So, to improve the phytosanitary condition of cucumber crops in closed ground, it is advisable to search for effective and environmentally friendly preparations.

The problems of the modern market of vegetable products dictate an increase in requirements for greening the technology of growing vegetables by reducing the use of pesticides and introducing biologics (Tkalenko H. M. et al., 2020; Amer M. & Osama A., 2021). Currently, an active search is underway for bioagents that can replace chemical fungicides without losing their effectiveness. To date, more than 50 biologics based on fungi and bacteria that have fungistatic properties are known.

The antagonistic properties of fungi of the genus *Trichoderma spp* are best studied. bacteria of the genera *Bacillus* and *Pseudomonas*, which effectively control a wide range of pathogens and exhibit growth-stimulating properties (Igbal S. et al., 2024; Ta Y. et al., 2024). Preparations based on them are recommended both for processing seed and planting material, and for spraying plants during the period of active growth.

Long-term studies of domestic scientists indicate a higher efficiency of bioagents in closed ground than in open ground. This fact is associated with the regular use of certain drugs (for several years in a row) in the technology of growing vegetable crops and the inclusion of active agents in the structure of agrocenosis (Pyliak, N. V., & Bakreu, S. P. et al., 2022; Serhiienko, V. H. et al., 2024).

Thus, the use of biologics in the protection system in combination with preventive, agrotechnical and organizational and economic measures can ensure stable yields of vegetable crops.

The aim of the study is to study the effect of biologics on the sowing qualities of cucumber seeds of the Kibria hybrid in closed ground conditions and their ability to control crop diseases.

Materials and methods of research. The analysis of the phytosanitary condition of cucumbers of the Kibria hybrid was carried out in a film greenhouse against a natural background during the cultivation periods of 2023 and 2024, accounting was carried out in accordance with the phases of crop development according to generally accepted methods (Omeliuta, V. P. et al., 1986).

In order to diagnose diseases, a visual method was used. The percentage and extent of damage were determined by examining ten central plants in non-contiguous

repetitions in ten different greenhouse areas. Accounting for the development of root rot was carried out in accordance with the methodological recommendations (Trybel, S. O. et al., 2001). Plants with symptoms of damage were selected for further analysis in the laboratory to determine the species belonging of pathogens. Based on the results of route surveys, the spread and development of the disease in this location was established.

To control root rot, biological preparations Fitohelp, S., Trichoplant, R., Mycohelp, R. were used, the effectiveness of which was compared with the chemical fungicide Previkur Energy, R. K.

Calculations of the technical effectiveness of drugs were performed according to the formulas proposed in "methods of testing and application of pesticides" (2001).

Research results. Based on the results of phytosanitary monitoring, the species composition of pathogens of cucumbers in closed ground conditions was determined: root rot (*Fusarium spp.* and *Rhizoctonia solani* Kuehn.), *Alternaria cucurbitae* Letendre et Roum.), false powdery mildew (*Pseudoperonospora cubensis* Rostowz.), powdery mildew (*Erysiphe cichoracearum* DC. *f. cucurbitacearum* Pot.) and others.

Evaluating the structure of the pathogenic complex, a significant spread of root rot was noted (fig. 1, 2), the pathogens of which are *Fusarium spp*. and *Rhizoctonia solani* pose a threat to the development and fruiting of cucumber plants. Their share in 2023 was 57.9 %. Leaf – stemmed infections had a much lower level of manifestation: Erysiphe cichoracearum – 19.8 %, *Pseudoperonospora cubensis* – 15.3 %, *Alternaria cucurbitae* – 5.4 %.

The species composition of phytopathogens found on cucumber plants of the Kibria hybrid changed somewhat in 2024. During cultivation, there were no signs of powdery mildew damage.

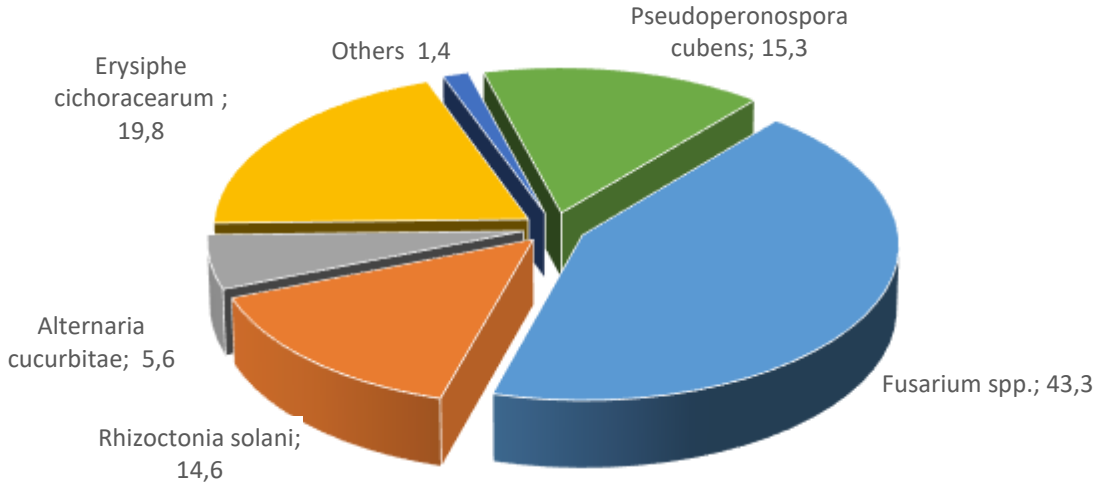

Fig. 1. **Structure of the pathogenic complex of cucumbers of the hybrid Kibria (Closed ground, 2023)**

In general, the level of manifestation of leaf-stem infections increased compared to the previous year: alternariosis by 0.2 % (fig. 2), powdery mildew by 2.3 %. Proportion of *Fusarium spp* fungi. almost unchanged, while the manifestation of *Rhizoctonia solani* increased by 11.7 %.

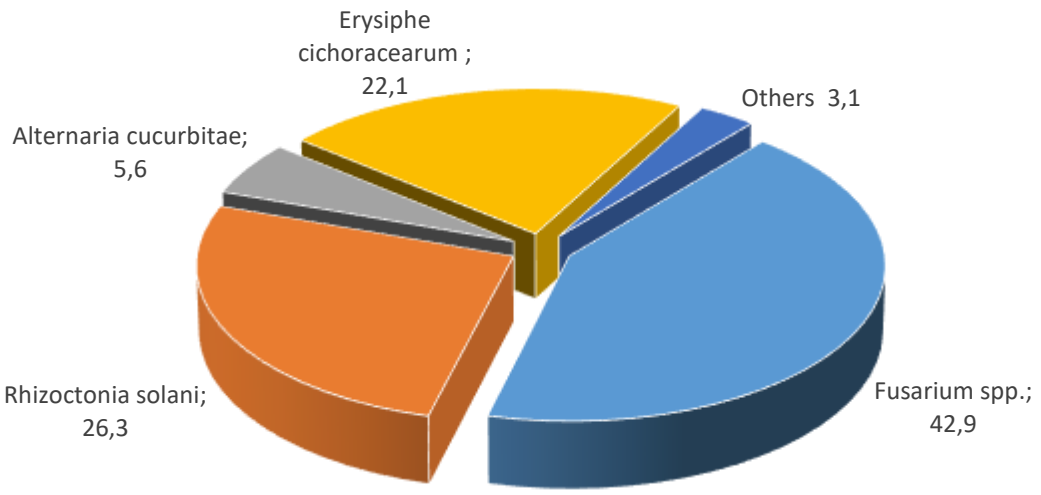

Fig. 2. **Structure of the pathogenic complex of cucumbers of the hybrid Kibria (closed ground in 2024)**

The main sources of primary infection for most identified phytopathogens are seeds and soil substrate. The phytoexpertiza of cucumber seeds of the Kibria hybrid made it possible to determine not only the sowing qualities and level of contamination of seeds with phytopathogens, but also the effect of the studied biopesticides on growth processes (Table. 1).

Table 1.

Influence of microbiological preparations on seed sowing qualities and morphometric parameters of seedlings and roots of the Kibria hybrid (average over the years of research)

Indicator	Experiment option				
	Control (water)	Previkur Energy, RK.	Fitohelp, S.	Trichoplant, R.	Mikohelp, R.
Germination energy, %	82,5	82,7	84,5	87,4	92,5
Laboratory germination rate, %	92,5	93,2	93,1	95,4	96,3
Infection rate, %	3,0	-	1,0	1,2	0,5
Field germination rate, %	83,0	76,5	80,5	83,2	84,3
Seedling height, mm	19,0	18,0	23,0	25,0	25,0
Root Length, mm	13,0	13,0	14,0	16,0	18,0

It is necessary to note the high sowing qualities of cucumber seeds of the Kibria Hybrid during the years of research. The germination energy in the control (seeds treated with fresh boiled water) was 82.5%, when it was treated with the chemical fungicide Previcur Energy, R. K. The Indicator almost did not change and amounted to 82.7%,

while when seeds were treated with biologics based on *Bacillus subtilis* and *Trichoderma lignorum*, it increased by 2.0% and 4.9% compared to the control. The maximum level of germination energy of 92.5% was observed in the variant using the drug Mycochelp, R., The basic bioagents of which are both *Trichoderma lignorum* and *Bacillus subtilis*. This trend was also observed in determining laboratory similarity. High indicators were registered in the variants with seed treatment with biologics Trichoplant, R. and Mikohelp, R. – 95.4% and 96.3%, respectively, which is 2.9% and 3.8% more than in the control version. For the use of Previkur Energy, RK. and Fitohelp, S. (bioagent – Bacillus subtilis) laboratory similarity indicators were observed at almost the same level – 93.2% and 93.1%, respectively. When sowing cucumber seeds in pallets, field germination slightly decreased; the best indicators were noted for the use of preparations based on the fungus Trichoderma lignorum. Micromycete contamination is almost nonexistent.

The stimulating effect of the studied biologics on the length of the seedling and Root was noted. The best effect was obtained with the use of Trichoplant, R. and Mycohelp, R. The Seedling length in both variants was 25.0 mm, while in the control – 19.0 mm. A similar positive effect of biopesticides was observed on the roots (16.0 mm and 18.0 mm, respectively, of these drugs), and in the control – 13.0 mm. Seed treatment with the chemical fungicide Previkur Energy, RK. did not affect the studied indicators.

In order to identify diseases and study the dynamics of their spread and development, phytosanitary monitoring was carried out every 7 days during the growing season. The dominance of root rot was revealed, the first signs of which were observed on plants after planting seedlings in the ground. An increase in infection was observed before the flowering phase, and later the disease led to the death of plants with signs of Fusarium infection. The dynamics of root rot development of cucumbers of the Kibria hybrid in the conditions of a film greenhouse differed over the years. The disease developed more actively in 2024, which can be explained by a violation of the temperature and irrigation regime in the greenhouse. At the beginning of fruiting in the control version, the spread of root rot by year was recorded at the level of 11.3% and 16.5%, while at the end of the growing season, the indicator increased to 19.6% in 2023 and 26.5% in 2024.

During the growing season, in order to improve the phytosanitary condition of cucumber plants with irrigation water, biologics and a chemical fungicide were applied three times (Table 2).

Table 2.

Effectiveness of biologics in protecting cucumbers hybrid Kibria from root rot

Options	Norm consumption, l / ha	development of the disease in the fruiting phase, %		technical efficiency, %	
		2023	2024	2023	2024
Control (water)		8,2	12,6		
Previkur Energy, RK. (Etalon)	3	1,3	1,7	84,1	86,5
Phytohelp, S.	3	3,5	5,2	57,3	58,7
Trichoplant, P.	3	2,0	3,1	75,6	73,6
Mikohelp, R	3	1,6	2,9	80,5	76,9
LSD_{05}		3,2	4,5		

During the fruiting phase, the control variant recorded the highest level of root rot development – 8.2% and 12.6%, respectively, of the study years. Soil fungicide Previcur Energy, R. K. well controlled the disease, the intensity of which was noted at the level of 1.3% (2023) and 1.7% (2024). Biopesticide Fitohelp, C. based on Bacillus subtilis almost halved the manifestation of root rot in the years of research, but the technical effectiveness of the drug did not exceed 60%. For the introduction of a chemical fungicide, this indicator in 2023 was 81.4%, and in 2024 – 86.5%, which was higher by 26.8% and 27.8% than for the use of a one-component bacterial preparation. Biologics whose bioagent is the fungus Trichoderma lignorum have proven to be more effective in curbing the development of root rot. The use of Trichoplant, R. allowed to reduce the development of the disease in 2023 to an economically imperceptible level of 2.0%, while the following year the indicator increased to 3.1%. Technical efficiency of Trichoplant, P. it was quite high in 75.6% and 73.6%, respectively, of the study years. The best development of root rot among biologics was controlled by Mikohelp, R. The intensity of the disease manifestation in the variant with its introduction in 2023 was almost equal to the indicator in the variant with Previkur Energy, RK. – 1.6%. The technical efficiency with the introduction of Mycohelp, R. was the highest in the years of research 80.5% and 76.9% compared to other biopesticides.

The studied biologics not only effectively protected plants from root rot, but also contributed to better development of plants with high vital potential. In the variants using biopesticides, the average number of flowers per plant significantly increased. Thus, due to the introduction of the bacterial preparation Fitohelp, S. There was an increase in the formation of flowers by 9.2 PCs., fungal fungicide Trichoplant, R. – 12.3 PCs., and the combined drug Mikohelp, R. na – 12,0 PCs. compared to control. The reference preparation almost did not affect the formation of generative organs of cucumbers, the average number of flowers in the variant was almost equal to the control – 27.2 PCs. (Table. 3).

Table 3.

Effect of drugs on the growth and fruiting of cucumber hybrid Kibria plants (average over the years of study)

Option	average amount per plant, PCs		Weight of collected fruits from one plant, kg	yield of commercial fruits kg / m^2	yield increase	
	flowers	fruit			kg / m^2	%
Control (water)	26,4	19,5	6,5	18,4	-	-
Previkur Energy, RK (Etalon)	27,2	22,1	7,0	20,6	2,2	111,9
Phytohelp, S	35,6	27,9	7,8	22,4	4,0	121,7
Trichoplant, P.	38,7	30,4	8,3	24,9	6,5	135,3
Mikohelp, R	38,4	31,8	8,4	25,2	6,8	136,9
LSD_{05}					1,19	

The productivity of one plant with the use of Mycohelp, R. increased by 12.3 pieces of fruit compared to the control. Biologics Fitohelp, S. and Trichoplant, R. also stimulated fruit formation; the number of fruits in variants with their introduction increased to 27.9 and 30.4 PCs./ plants that are 8.4 and 10.9 PCs. more than in control.

Thus, the use of biologics not only helped to reduce the manifestation of root rot, but also stimulated fruit formation, which provided an increase in crop yield.

Crop growth was observed in all variants with the use of biologics. The best result was provided by the combined preparation Mikohelp, R. The average yield of commercial fruits in this variant with 1 m2 was 25.2 kg, which exceeded the control by 6.8 kg/m^2 or 36.9%. The yield also increased statistically significantly in the variants with the introduction of Phytochelp, C. (by 4.0 kg/m^2) and Trichoplant, R. (by 6.5 kg/m^2).

Cucumber plants grown on soil substrates using the studied biologics remained green longer, and the flowering period was extended, which made it possible to collect an additional crop of greens.

Discussion. Most modern publications cited in the introductory part of the article indicate that the productivity of cucumbers in closed ground depends on the phytosanitary state of coenoses. Analysis of samples of affected plants from greenhouses conducted by employees of the Institute of plant protection of the National Academy of Sciences of Ukraine indicates the same type of species composition of pathogens under various technological factors and conditions, which is consistent with the data of our research.

The most dangerous, according to S. V. Bondarenko and S. V. Stankevich, for the development and fruiting of cucumbers are root and basal rot, the harmfulness of which is manifested in a decrease in crop productivity and deterioration of the quality of commercial fruits. This is fully confirmed by the results of our research.

Tkalenko G. M., Borzykh O. I., Ignat V. V. note the relevance of the use of biological plant protection products in agrocenoses of Ukraine. Especially important according to Tkalenko G. M., Balvas-Gremyakova K. M. is the greening of the protection of indoor vegetable crops, since these products are consumed mainly in fresh form. That is why the goal of our research is to find effective biologics to protect cucumbers from dominant diseases.

The results of our own observations confirm the data of foreign phytopathologists Amer M., Osama A., Heflish A. A. and Al-Askar A. A. relatively high efficiency of control of pathogenic fungi with biofungicides.

Most often, preparations based on bacterial (Bacillus subtilis) and fungal (Trichoderma lignorum) bioagents are used to protect vegetable crops. Domestic scientists Borzykh A. I., Sergienko V. G., Tkalenko G. M. and others pay attention to this in their scientific works.

Application of seeds with biologics based on these microorganisms contributed to an increase in germination energy and laboratory germination by an average of 2.0-5.0 %, which is consistent with the data of Onishchenko O., Chayuk O., Morgun O. V. In addition, their positive effect on the growth and development of roots and seedlings was observed, which contributed to an increase in the total length of the STEM by an average of 33.0% and the root by 18.5% compared to untreated plants, which is consistent with our research. Despite the rather high technical efficiency of the chemical fungicide Previcur Energy, RK. (84.1% and 86.5%, respectively, of the study years), it is also advisable to introduce biologics based on Trichoderma lignorum, the effectiveness of which is on average lower than indicated (78.1% and 75.3%) (Amer M. & Osama A., 2021).

Conclusions.

1. Changes in the species composition of pathogens of cucumbers in closed ground conditions over the years of research are determined. So, the distribution of *Fusarium spp.* in 2023, it was 43.3%, while in 2024 there was a decrease to 42.9 %; *Rhizoctonia solani* progressed from 14.6% to 26.3 %; the level of *Alternaria cucurbitae* increased by only 0.2 %; *Pseudoperonospora cubensis* was registered only in 2023 (the share was 15.3 %); the level of spread of *Erysiphe cichoracearum* in in 2024, it reached 22.1%, which exceeded the previous year's figure by 0.3%.

2. The effect of biofungicides on the sowing qualities of cucumber seeds of the Kibria hybrid was studied. Application of seeds with biologics based on *Bacillus subtilis* and *Trichoderma lignorum* contributed to an increase in germination energy by 2.0% and 4.9% (on average over the study years) compared to the control (82.5%). The highest rates were observed in the variant using the combined drug Mycohelp, R. – 92.5%. A similar trend was observed when determining laboratory germination in variants with seed treatment with biologics Trichoplant, R. and Mikohelp, R., The Indicator was 95.4% and 96.3%.

3. The stimulating effect of the studied biologics on growth processes (seedling and Root Length) is elucidated. The best effect was observed with the use of Trichoplant, R. and Mycohelp, R. The Seedling length in both variants averaged 25.0 mm, exceeding the control by 6.0 mm. Similar results were obtained when studying their effect on root development (16.0 mm and 18.0 mm, respectively, drugs, the indicator in the control is 13.0 mm).

4. The technical effectiveness of the studied drugs in the control of root rot was studied. Soil fungicide Previcur Energy, RK. well controlled the disease, the development of which was recorded at the level of 1.3% and 1.7% (respectively, years of research), technical efficiency averaged 85.3%, which exceeded this indicator for the use of biologics. However, the introduction of the two – component preparation Mycohelp, R. provided the highest technical efficiency among the studied biologics-80.5% and 76.9%.

5. The use of the combined preparation Mikohelp, R. contributed to the maximum increase in the yield of commercial fruits from 1 m2 (25.2 kg). Crop growth was observed in all variants with the use of biologics. The yield also increased statistically significantly in the variants with the introduction of Phytohelp, C. (by 4.0 kg/m^2) and Trichoplant, R. (by 6.5 kg/m^2).

References

Amer, M., & Osama, A. (2021). Biological control of fungi associated with damping-off and root rot disease of cucumber (*Cucumis sativus* L.). *Archives of Phytopathology and Plant Protection*, 54(13/14), 870-885. http://dx.doi.org/10.1080/03235408.2020.1860412

Balvas-Hremiakova, K. M., & Horal, S. V. (2019). Riststymuliuiucha aktyvnist metabolitiv hryba Trichoderma [Stimulating activity of metabolites fungi of the genus Trichoderma on plant growth]. *Young Scientist*, 7(71), 165-168. https://doi.org/10.32839/2304-5809/2019-7-71-34 (in Ukrainian).

Bondarenko, S. V., & Stankevych, S. V. (2021). Poshyrenist i shkidlyvist osnovnykh zakhvoriuvan ohirkiv ta imunitet kultury [Influence of liquid organ-mineral and microfertilizers on the structure of the chickpea crop in the conditions of the Black Sea Steppe]. *Taurida Scientific Herald*, 118, 21-38. https://doi.org/10.32851/2226-0099.2021.118.5 (in Ukrainian).

Dudchenko, V. V., Markovska, O. Ye., & Mrynskyi, I. M. (2024). Efektyvnist biolohichnoi systemy zakhystu ohirkiv zakrytoho gruntu dlia kontroliu chyselnosti klishcha pavutynnoho zvychainoho [The impact of pre-sowing seed treatment with pesticides of various actions on the productivity of common millet is studied]. *Taurida Scientific Herald*, 135(1), 56-63. https://doi.org/10.32782/2226-0099.2024.135.1.8 (in Ukrainian).

Havii, V. M., & Pryplavko, S. O. (2021). Porivnialna diia syntetychnykh rehuliatoriv rostu roslyn na asymiliatsiini protsesy ta produktyvnist ohirka posivnoho

(Cucumis sativus L.). sortotypu Nizhynskyi [Comparative effect of synthetic plant growth regulators for assimilation processes and productivity of cucumber (Cucumis sativus l.). cultivar Nizhynsky]. In O. O. Nepochatenko (Red.), *Zbirnyk naukovykh prats Umanskoho natsionalnoho universytetu sadivnytstva. Ch. 1: Silskohospodarski ta tekhnichni nauky [Collection of scientific works of the Uman National University of Horticulture. Part 1: Agricultural and technical sciences]* (Issue. 98(1), pp. 142-150). Uman: Redaktsiino-vydavnychyi viddil Umanskoho NUS. http://dx.doi.org/10.31395/2415-8240-2021-98-1-142-150 (in Ukrainian).

Heflish, A. A., Abdelkhalek, A., Al-Askar, A. A., & Behiry, S. I. (2021). Protective and Curative Effects of *Trichoderma asperelloides* Ta41 on Tomato Root Rot Caused by *Rhizoctonia solani* Rs33. *Agronomy*, 11, 1162. https://doi.org/10.3390/agronomy11061162

Iqbal, S., Ashfaq, M., Rao, M. J., Khan, K. S., Malik, A. H., Mehmood, M. A., Fawaz, M. S., Abbas, A., Shakeel, M. T., Naqvi, S. A. H., Alrefaei, A. F., & Duan, M. (2024). *Trichoderma viride*: An Eco-Friendly Biocontrol Solution Against Soil-Borne Pathogens in Vegetables Under Different Soil Conditions. ***Horticulturae***, 10(12), 1277. https://doi.org/10.3390/horticulturae10121277

Kovalenko, N. P., Pospielova, H. D., Pelykh, V. Yu., & Mukha, B. H. (2024). Vplyv infektsiinykh khvorob na produktyvnist ohirka v zakrytomu grunti [Influence of infectious diseases on productivity of cucumber in closed grounds]. *Grail of Science*, 46, 575-580. https://doi.org/10.36074/grail-of-science.17.03.2023.024 (in Ukrainian).

Kyryk, M. M., Pikovskyi, M. Y., & Azaiki, S. (2012). *Diagnostic signs of diseases of vegetable crops and potato.* Kyiv.

Mahmoud, A. F., & Abdalla, O. A. (2021). Biological Control of Fungi Associated with Damping-off and Root Rot Disease of Cucumber (*Cucumis sativus* L.). *Archives of Phytopathology and Plant Protection*, 54(13/14), 870-885. http://dx.doi.org/10.1080/03235408.2020.1860412

Omeliuta, V. P., Hryhorovych, I. V., Chaban, V. S. Pidoplichko, V. N., Kalenych, F. S., Petrukha, O. Y., Antoniuk, S. I., Pozhar, 3. A., Tyshchenko, Ye. I., Hryhorenko, V. H., Koval, M. K., & Chernenko, O. O. (1986). *Oblik shkidnykiv i khvorob silskohospodarskykh kultur [Accounting for pests and diseases of agricultural crops]*. Kyiv: Urozhai. https://shron3.chtyvo.org.ua/Zbirka/Oblik_shkidnykiv_i_khvorob_silskohospodarskykh_kultur.pdf (in Ukrainian).

Onyshchenko, O., Chaiuk, O., Morhun, O. (2019). Rehuliatory rostu roslyn yak mozhlyvyi chynnyk zakhystu ohirka vid hrybnykh infektsii [Adjusters of growth of plants as a possible factor of protection of a cucumber against fungous disease]. *Bulletin of Agricultural Science*, 97(8), 28-33. https://doi.org/10.31073/agrovisnyk201908-05 (in Ukrainian).

Pelykh, V. Yu., Pospielova, H. D., Nechyporenko, N. I., & Kovalenko, N. P. (2023). Biopreparaty v tekhnolohiiakh zakhystu ohirka vid korenevykh hnylei u zakrytomu grunti [Biopreparations in cucumber protection technologies against root rot in closed soil]. *Grail of Science*, 25, 155-159. https://doi.org/10.36074/grail-of-science.17.03.2023.024 (in Ukrainian).

Pérez-Hernández, A., Rocha, L., Porcel-Rodríguez, E., Summerell, B. A., Liew, E. C., & Gómez Vázquez, J. M. (2020). Phylogenetic Characterization of Fusarium solani f. sp. cucurbi tae Isolates From Cucurbits in Almeria Province, Spain. *Plant disease*, 104(5), 1465-1476.

Pyliak, N. V., & Bakreu, S. P. (2022). Perspektyvni mikroorhanizmy dlia stvorennia na yikh osnovi kompleksnykh preparativ dlia biolohichnoho zakhystu roslyn vid shkidnykiv ta khvorob [Promising microorganisms for the creation of complex preparations for biological protection of plants against pests and diseases based on them]. In *Zakhyst roslyn: naukovi zdobutky ta perspektyvy doslidzhen : Mizhnarodna naukovo-praktychnoi konferentsii, prysviachenoi 75-richchiu vid dnia zasnuvannia Instytutu zakhystu roslyn NAAN, 150-richchiu vid dnia narodzhennia Pospielova Volodymyra Petrovycha, 100-richchiu vid dnia narodzhennia Arieshnikova Borysa Andriiovycha, 90-richchiu vid dnia narodzhennia Dolina Volodymyra Hdalicha (24-25 travnia 2022 roku)* [*Plant Protection: Scientific Achievements and Research Prospects: International Scientific and Practical Conference Dedicated to the 75th Anniversary of the Founding of the Institute of Plant Protection of the NAAS, the 150th Anniversary of the Birth of Pospelov Volodymyr Petrovych, the 100th Anniversary of the Birth of Areshnikov Boris Andriyovych, the 90th Anniversary of the Birth of Dolin Volodymyr Gdalich (May 24-25, 2022)]* (pp. 176-178). Kyiv. https://ipp.gov.ua/wp-content/uploads/tezi_konferentsiya-do-75-richchya-izr_07_06_2022.pdf (in Ukrainian).

Serhiienko, V. H., Tkalenko, H. M., Borzykh, O. I., & Shyta, O. V. (2024). Biokontrol khvorob ovochevykh kultur za vykorystannia preparativ na osnovi Bacillus subtilis [Biocontrol of vegetable crop diseases using bacillus subtilis-based preparations]. *International Science Journal of Engineering & Agriculture*, 3(3), 61-72. https://doi.org/10.46299/j.isjea.20240303.06 (in Ukrainian).

Sharma, D., & Shukla, A. (2021). Fusarium Wilt of Cucumber. *International Journal of Economic Plants*, 8(4), 193-200. https://ojs.pphouse.org/index.php/IJEP/article/view/4694

Ta, Y., Fu, S., Liu, H., Zhang, C., He, M., Yu, H., Ren, Y., Han, Y., Hu, W., Yan, Z., & Wang, Y. (2024). Evaluation of *Bacillus velezensis* F9 for Cucumber Growth Promotion and Suppression of *Fusarium wilt* Disease. ***Microorganisms***, ***12***(9), 1882. https://doi.org/10.3390/microorganisms12091882

Tkalenko, G., Balvas-Hremiakova, K., & Goral, S. (2019). Influence of nutrition elements on life and differentiation Trichoderma lignorum CK. *Magyar Tudományos Journal*, 26, 3-5.

Tkalenko, H. (2020). Fitosanitarna sytuatsiia na ohirkakh u zakrytomu grunti [Phytosanitary situation on cucumbers in closed ground]. *Ovochivnytstvo [Vegetable growing]*, 3, 140-144 (in Ukrainian).

Tkalenko, H. M., Borzykh, O. I., & Ihnat, V. V. (2020). Suchasnyi stan zastosuvannia biolohichnykh zasobiv zakhystu roslyn v ahrotsenozakh Ukrainy [The current state of application of biological plantprotection agents in agrocnosis of Ukraine]. *Bulletin of Agricultural Science*, 12, 18-25. https://doi.org/10.31073/agrovisnyk202012-03 (in Ukrainian).

Trybel, S. O., Siharova, D. D., Sekun, M. P. & Ivashchenko, O. O. (2001). *Metodyky vyprobuvannia i zastosuvannia pestytsydiv [Pesticide testing and application methods]*. Kyiv: Svit (in Ukrainian).

Verheles, P. M. (2021). Otsinka systemy zakhystu ohirka v umovakh zakrytoho gruntu [Assessment of the cucumber protection system in the conditions of the closed soil]. *Agriculture and Forestry*, 21, 206-219. https://doi.org/10.37128/2707-5826-2021-2-17 (in Ukrainian).

Yarovyi, H. I., Lebedynskyi, I. V., Serhiienko, O. V., Sevidov, V. P. & Valkov, R. T. (2018). Tekhnolohii vyroshchuvannia ohirka [*Cucumber growing technologies*]. Kharkiv: KhNAU. https://repo.btu.kharkov.ua/bitstream/123456789/7930/1/M_Ohirok_2018.pdf (in Ukrainian).

Zhang, S., Raza, W., Yang, X., Hu, J., & Huang, Q. (2008). Control of Fusarium wilt disease of cucumber plants with the application of a bioorganic fertilizer. *Biology and Fertility of Soils*, 44(8), 1073-1080. https://doi.org/10.1007/s00374-008-0296-0