Chapter 19

INTEGRATED PROTECTION SYSTEMS FOR CUCUMBER AGAINST THE TWO-SPOTTED SPIDER MITE (*TETRANYCHUS URTICAE* KOCH) IN GREENHOUSE CULTIVATION

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DOI https://doi.org/10.30525/978-9934-26-588-4-19

INTRODUCTION

Protected vegetable cultivation represents a strategically important and rapidly developing segment of the agricultural sector, which, under the implementation of innovative technologies, holds significant potential for meeting domestic food demand, reducing dependence on imported produce in specific commodity groups, enhancing export capacity, and promoting employment in rural and peri-urban areas. According to global expert assessments, the area under greenhouse cultivation has recently reached approximately 0.5-0.7 million hectares, demonstrating a consistent upward trend in recent years. In Ukraine, prior to the onset of military conflict, protected vegetable production accounted for around 1.3% of the total area sown with vegetable crops. In particular, the total greenhouse area across all categories of agricultural enterprises amounted to 6,286.2 hectares in 2019 and increased to 7,069.8 hectares in 2020, enabling the production of approximately 0.5 million tonnes of vegetables, which represented 5% of the national vegetable output[1, 2].

Cucumber (Cucumis sativus L.) remains the leading vegetable crop under protected cultivation in Ukraine, accounting for 60-70% of the total greenhouse cropping area. This is primarily due to its comparatively high productivity, with yields reaching up to 200 tonnes per hectare[3]. It is well recognized that greenhouse conditions, characterized by elevated temperatures and high relative humidity, create an optimal environment not only for the growth and development of vegetable crops but also for the rapid propagation of various harmful organisms capable of infesting or damaging

[1] Ефективне овочівництво, 2020. URL: https://numl.org/Psz

[2] Агроіндустрія закритого ґрунту: інновації та продуктивність, 2021. URL: https://numl.org/Psy

[3] Вергелес П. М. Оцінка системи захисту огірка в умовах закритого ґрунту. *Сільське господарство та лісівництво.* 2021. № 21. С. 206–219. DOI: https://doi.org/10.37128/2707-5826-2021-2-17.

plants throughout the entire vegetative period[4]. Therefore, the effective management of pests, particularly phytophagous species, represents a fundamental element of the technological framework for greenhouse vegetable production technologies.

The species composition of harmful organisms, including phytophagous pests, under protected cultivation conditions is less diverse compared to open-field agrocenoses. However, year-round greenhouse use, elevated humidity and air temperature regimes, and the absence of natural regulatory factors create highly favorable conditions for the mass reproduction of phytophagous pests and significantly increase their harmful impact. To control pest populations and limit their damage under protected conditions, it is essential to implement modern integrated plant protection systems. These systems should combine organizational and managerial measures, preventive strategies, agronomic techniques, biological and chemical methods, as well as quarantine actions into a unified, synergistic framework [5, 6].

The most widespread polyphagous pest affecting vegetable crops under protected cultivation is the two-spotted spider mite (*Tetranychus urticae* Koch.). The initial symptom of plant infestation is the appearance of isolated light-colored spots on the upper surface of the leaves, which subsequently develop into a light marbled pattern, followed by leaf yellowing, desiccation, and premature abscission. Crop yield losses due to mite infestation can reach 35-40%, and in severe cases, total crop failure may occur[7, 8]. The exceptional harmfulness of *T. urticae* Koch. is attributed not only to its polyphagous feeding behavior but also to its high reproductive potential, short life cycle, and, consequently, its ability to rapidly develop populations resistant to chemical acaricides. Therefore, the development of effective systems for controlling the population density and harmful impact of the two-spotted spider mite remains a critical task in addressing the challenges of ensuring a

[4] Піковський М. Й., Марковська О. Є., Дудченко В. В., Мельник В. І., Соломійчук М. П., Крюковський Р. Д. Вплив поживних середовищ і температури на ріст та розвиток гриба *Fusarium oxysporum* f. sp. Cucumerinum Owen – збудника фузаріозного в'янення огірка. *Науковоі доповіді НУБіП України*. 2023. №6/106. DOI: https://doi.org/10.31548/dopovidi6(106).2023.001.

[5] Гіль Л. С. Сучасні технології овочівництва закритого і відкритого ґрунту. / Л. С. Гіль, А. І. Пашковський, Л. Т. Суліма // Ч.1. Закритий ґрунт: навчальний посібник. Вінниця : Нова Книга, 2008. 368 с.

[6] Технології вирощування огірка: монографія / Г.І. Яровий, І.В. Лебединський, О.В. Сергієнко та ін. Харків: ХНАУ, 2018. 190 с.

[7] Морфологія, біологія багатоїдних шкідників та заходи боротьби з ними в адаптивних технологіях вирощування: навчальний посібник / І. М. Мринський, В.В. Урсал, Н.М. Лавренко; за ред. І.М. Мринського. Херсон : ОЛДІ-ПЛЮС, 2018. 92 с.

[8] Основні хвороби та шкідники огірків в теплицях. 2019. URL: https://numl.org/PsB

stable supply of fresh vegetable products to the population and enhancing the productivity of greenhouse farming systems[9].

1. Biological Control Methods for Managing the Two-Spotted Spider Mite (*Tetranychus urticae* Koch) on Cucumber in Greenhouse Production

The two-spotted spider mite (*T. urticae* Koch) has more than 900 host plants, including 150 species of economically important agricultural and ornamental crops[10, 11].

Considering that the use of chemical control methods under protected cultivation conditions is restricted and permitted only when pest populations exceed the economic threshold during periods of mass outbreaks, the development of an effective biological control system for cucumber cultivation is a highly relevant and pressing task[12].

In global greenhouse production practices, the biological method for controlling *T. urticae* Koch. consists of a series of measures that combine the application of biological products with acaricidal properties and the use of natural enemies – acariphagous predators. During the cucumber seedling stage and throughout the vegetative period, the predatory mite *Phytoseiulus persimilis* Athias-Henriot is employed against the pest. If infestation is detected at the seedling stage, the predator is released at an initial pest-to-predator ratio of 1:30-40; in cases of mass infestation, multiple releases are carried out at a ratio of 1:100. Upon the appearance of the first pest hotspots on mature plants, *P. persimilis* is introduced at a ratio of 1:20-40, and in cases of heavy infestation, the recommended release rate is 500,000 individuals per hectare. Additionally, before the appearance of the two-spotted spider mite, preventive releases of the predatory bug *Macrolophus pygmaeus* Rambur are recommended. Following the detection of pest infestation foci, *M. pygmaeus* is evenly released at a density of 1 individual per square meter (once per ten-day period). Colonization with *M. pygmaeus* can be combined with the use of other beneficial entomophagous species[13].

Among microbiological preparations based on the metabolic products of fungi – representatives of soil microflora – and bacteria, the most widely used

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[10] Kavitha J., Bhaskaran E.V., Gunasekaran K., Ramaraju K. Evaluation of new acaricides against two spotted spider mite, Tetranychus urticae Koch on bhendi. *International Journal of Acarology*. 2007. № 17. P. 77–78. DOI: 10.5958/0974-4576.2018.00098.1.

[11] Xie L., Miao H., Xiao-Yue Hong XY. The two spotted spider mite *Tetranychus urticae* Koch and the carmine spider mite *Tetranychus cinnabarinus* their Wolbachia phylogenetic tree. *Zoolaxa*. 2006. № 1166. P. 33–46. DOI: https://dx.doi.org/10.11646/zootaxa.1165.1.2.

[12] Ткаленко Г. М. Шкідники овочевих культур у закритому ґрунті і заходи боротьби з ними. *Агробізнес сьогодні.* 2012. № 18 (241). С. 28–34.

[13] Біологічний захист у закритому ґрунті, 2014. URL: https://numl.org/PsC.

in practice include Fitoverm (Aversectin), Actofit (Aversectin-C), Bitoxibacillin, and Bicol, among others[14].

To assess the effectiveness of biological insectoacaricides and complexes of entomophagous organisms in cucumber cultivation, research was conducted at the production facilities of the greenhouse complex of PJSC "Myronivka Cereal and Feed Mill" (Kyiv region, Bila Tserkva district, Myronivka) in accordance with standard methodologies for testing microbiological preparations under protected cultivation conditions[15, 16].

Cucumber cultivation in the summer–autumn crop rotation was carried out in a block-type greenhouse with a total area of 345.6 m² using conventional production technology. For the experiment, the universal ultra-early parthenocarpic hybrid Kibria F1 RZ was used. The total number of plants in the trial was 500. Sowing for seedling production was performed on July 7, 2023, and transplanting of the seedlings took place on August 3, 2023. Prior to transplanting, the soil was disinfected, and the greenhouse premises were subjected to disinsection in accordance with the technological protocol, which included fumigation, greenhouse washing, scorching of metal structures, soil steaming, soil flushing, and application of Trichodermin.

At the age of 25-26 days, the cucumber seedlings were transplanted to a permanent growing site. The plant density in the greenhouse ranged from 2.4 to 2.8 plants per square meter. The area of the accounting plot was 4 m², with 10 plants per plot designated for data collection. The experiment was established using a randomized block design with four replications. The experimental layout is presented in Table 1.

Observations on the population dynamics of the two-spotted spider mite and the infestation levels of plants in the greenhouse revealed that, beginning from the fruit development phase, the plant infestation rate exceeded the economic threshold of harmfulness (5% of plants infested). The number of pest individuals per leaf on sampled plants increased from 1.5 mites per leaf during the seedling rooting stage to 7.6 mites per leaf at the onset of the fruiting phase. Further monitoring confirmed that, in the absence of control measures aimed at regulating the population of this species, the infestation rate continued to rise steadily, reaching 32.5% by the end of the fruiting period (Fig. 1).

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Table 1

Efficacy of Bioinsectoacaricides and Complexes of Entomophagous Organisms Against T. urticae Koch in Greenhouse Cucumber Cultivation

No.	Name of Preparation	Active Ingredient	Application Rate (mL/10 L or units/m²)
1	Control (untreated)	-	- -
2	Actofit + Liposan	Fermentation products of the fungus *Streptomyces avermitilis*	150 ± 30
3	Bitoxibacillin + Liposan	Spore-forming bacteria of the genus Bacillus and toxins of two types: β-exotoxin and δ-endotoxin	300 ± 30
4	Boverin + Liposan	Toxic metabolites and conidia of fungi from the genus Beauveria	300 ± 30
5	*Macrolophus pygmaeus* Rambur *Chrysoperla carnea* Stephens *Aphidoletes aphidimyza* Rondani		1 bug per m^2 100 larvae per m^2 3200 cocoons per block

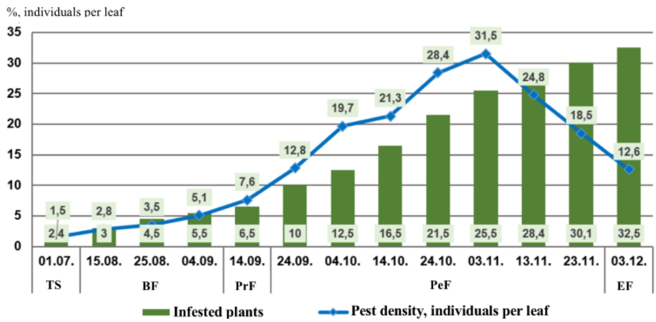

Fig. 1. Dynamics of *T. urticae* Koch Population in 2023: TS – transplanting stage; BF – beginning of fruiting; PrF – progressive fruiting; PeF – peak fruiting; EF – end of fruiting

The peak values of *T. urticae* Koch population density (ranging from 28.4 to 24.8 and down to 1.5 individuals per plant) were recorded on October 24, November 3, and November 13, 2023, corresponding to the mid-to-late stage of the peak fruiting phase. These values gradually declined toward the end of the fruiting period, reaching 12.6 individuals per plant. This decrease is likely attributed to the physiological aging of the plants and a consequent reduction in their attractiveness as a food source.

Based on the results of the study on the technical efficacy of biological insectoacaricides and entomophagous complexes against *T. urticae* Koch for cucumber protection under greenhouse conditions, it was established that their application effectively suppressed the increase in the number of adult mites and larvae of the two-spotted spider mite starting from the flowering phase through to the fruiting stage.

The application of the preparations Actofit BT + Liposan, Boverin BT + Liposan, and Bitoxibacillin BT + Liposan reduced plant infestation rates by 4.1, 4.8, and 5.4 times, respectively, at the beginning of the flowering phase, and by 3.7, 3.5, and 4.3 times at the onset of fruiting. The technical efficacy of these preparations was 75.7%, 79.3%, and 81.6% at the first assessment, and 74.1%, 72.2%, and 76.8% at the second, respectively.

The effectiveness of the entomophagous complex was slightly lower compared to that of the biological insectoacaricides, amounting to 61.5% and 69.7% depending on the timing of application (Table 2).

Table 2

Technical Efficacy of Biological Insectoacaricides and Entomophagous Organisms Against *Tetranychus urticae* Koch on Cucumber Plants

Treatment Variant	**Beginning of Flowering**		**Beginning of Fruiting**	
	Infested plants, %	**Technical efficacy, %**	**Infested plants, %**	**Technical efficacy, %**
Control (untreated)	16.9	–	36.7	–
Actofit BT + Liposan	4.1	75.7	9.5	74.1
Bitoxibacillin BT + Liposan	3.1	81.6	8.5	76.8
Boverin BT + Liposan	3.5	79.3	10.2	72.2
Macrolophus pygmaeus Rambur *Chrysoperla carnea* Stephens *Aphidoletes aphidimyza* Rondani	6,5	61,5	11,1	69,7

Analysis of the impact of biological insectoacaricides and entomophagous complexes on the biometric indicators of plant productivity revealed that, in the absence of control measures against *T. urticae*, significant reductions were observed in plant mass, main stem length, number of lateral shoots, and total leaf area. In the untreated control variant, the average plant mass was 812 g, whereas the application of biopreparations and entomophagous complexes contributed to an increase in this indicator by 96-156 g per plant, depending on the treatment. As a result, the plant mass ranged from 908 to 968 g, with the highest value recorded in the variant treated with Boverin BT + Liposan (968 g/plant).

The highest number of lateral shoots per cucumber plant was also observed in the variant treated with Boverin BT + Liposan, amounting to 30 shoots per plant, which exceeded the corresponding value in the control by 67%, or 12 shoots per plant. The formation of additional shoots resulting from the use of biological insectoacaricides and entomophagous complexes contributed to an increase in the total leaf area, which ranged from 1395 to 1721 dm² per plant – exceeding the control by 74 to 400 dm² per plant, depending on the treatment variant (Table 3).

Table 3

Biometric Parameters of Cucumber Hybrid Kibria During the Peak Fruiting Stage Depending on the Applied Biopreparations and Entomophagous Organisms

Treatment Variant	**Plant Mass, g**	**Main Stem Length, cm**	**Number of Lateral Shoots, pcs**	**Leaf Area, dm²/plant**
Control (untreated)	812 ± 24	212 ± 12	18 ± 3	1321 ± 87
Actofit BT + Liposan	908 ± 25	245 ± 14	24 ± 4	1395 ± 98
Bitoxibacillin BT + Liposan	924 ± 23	252 ± 15	29 ± 4	1564 ± 101
Boverin BT + Liposan	968 ± 26	281 ± 16	30 ± 5	1721 ± 112
Macrolophus pygmaeus Chrysoperla carnea Aphidoletes aphidimyza	918±21	258±15	27±3	1643±108

The highest amount of preserved yield under the application of biological preparations and entomophagous complexes was recorded in the variant treated with Boverin BT + Liposan, where it reached 6.6 kg/m², with a total yield of 18.9 kg/m². The use of Actofit BT + Liposan and Bitoxibacillin BT + Liposan also contributed to the preservation of a substantial portion of the yield – ranging from 4.2 to 5.1 kg/m² – with total yields of 16.5 and 17.4 kg/m², respectively (Fig. 2).

The application of the entomophagous complex also contributed to a higher productivity level compared to the control. Specifically, under its use, the fruit yield per 1 m² amounted to 16.1 kg, which exceeded the corresponding value in the control variant by 3.8 kg/m².

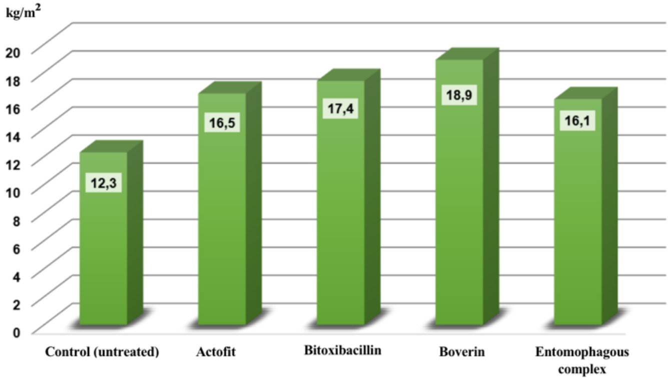

Fig. 2. Effect of Biological Insectoacaricides and Entomophagous Complexes on the Productivity of Cucumber Hybrid Kibria ($LSD_{0.5}$ = 0.24 kg/m², 2023)

2. Chemical Methods for Protecting Cucumber Crops in Greenhouses Against the Two-Spotted Spider Mite (*Tetranychus urticae* Koch)

As noted above, the primary tool for regulating the development and spread of phytophagous pests to economically insignificant levels is integrated plant protection, which combines organizational and operational, quarantine, preventive, and agronomic measures, along with the use of genetic, physical-mechanical, biological, and chemical methods for pest population control. The decision to apply preparations of various origins is made in each specific case based on the results of plant health monitoring and forecasting, economic thresholds of harmfulness, and with consideration for the conservation, enhancement, and increased effectiveness of beneficial organisms within agroecosystems[17, 18, 19].

In cases where the economic threshold of harmfulness (ETH) is exceeded or during mass outbreaks of pest populations in greenhouses, the application of acaricides from various groups of chemical compounds is permitted, including organophosphates, carbazinates, pyrethroids, quinolines, carbamates, diphenyl oxazolines, tetrazines, quinazolines, phenoxypyrroles,

[17] Стратегія і тактика захисту рослин. т. 1 Стратегія: монографія / під редакцією академіка НААН України, д. б. н., професора В.П.Федоренка. К.: Альфа-стевія, 2012. С. 473.

[18] Інтегрований захист рослин / Писаренко В.М. та ін. Полтава, 2020. С. 155.

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thiazolidines, pyridazinones, macrocyclic lactones, and pyrazoles, with strict adherence to the pre-harvest interval regulations[20]. The positive characteristics of many chemical acaricides include their rapid action, high efficacy, and prolonged protective effect. However, failure to comply with application requirements may lead to the development of resistance in Tetranychus urticae Koch populations and negatively affect the quality of the harvested produce. According to reports by various researchers, the development of resistance in mite populations to acaricides can be prevented through the use of compounds such as ketoenols, carbazate-bifenazate, acetyl-CoA carboxylase inhibitors, complex II inhibitors, mitochondrial complex III inhibitors, and mite growth inhibitors such as hexythiazox, clofentezine, and etoxazole, which interact with chitin synthase [21, 22, 23] Additional effective strategies include studying cross-resistance, applying products with different modes of action and types of resistance, considering genetic polymorphism in their target molecules, as well as employing synergistic combinations or alternation of acaricides [24, 25, 26, 27].

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[20] Чайка Т.О., Піщаленко М.А., Рубан Є.Р., Саєнко А.О., Скляр С.С., Кріпак А.В., Голтвяниця Т.О. Особливості використання акарицидів від звичайного павутинного кліща (*Tetranychus urticae* Koch) для захисту огірка в умовах захищеного ґрунту. *Scientific Progress & Innovations*. 2023. № 26 (3). С. 58–62. DOI: https://doi.org/10.31210/spi2023.26.03.11.

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[27] Андрейчин М.А., Климнюк С.І., Романюк Л.Б. Акарициди та їх застосування (Частина 2). 2023. Інфекційні хвороби. № 3(113). С. 65–76. DOI: https://doi.org/10.11603/1681-2727.2023.3.14209.

To evaluate the efficacy of chemical insectoacaricides in controlling Tetranychus urticae populations during cucumber cultivation under protected conditions, a study was conducted at the production facilities of the greenhouse complex of PJSC "Myronivka Cereal and Feed Mill" in accordance with established methodologies for testing acaricides under greenhouse conditions.

The experiment (Table 4) was established using a randomized block design with four replications. Acaricide treatments were applied using a handheld aerosol sprayer at the beginning of the plant vegetation period and up to the peak fruiting phase.

Table 4

Efficacy of Insectoacaricides Against *Tetranychus urticae* Koch.

Name of Preparation	Active Ingredient	Application Rate, kg or L/ha	Application Timing*
Control (untreated)	–	–	A; B
Mospilan	Acetamiprid, 200 g/kg	0.3	A; B
Talstar 10%, EC	Bifenthrin, 100 g/L	0.6	A; B
Vertimec 018 EC, EC	Abamectin, 18 g/L	0.7	A; B
Movento 100 SC, SC	Spirotetramat, 100 g/L	0.75	A; B

***** A – 15 days after transplanting, B – 40 days after transplanting

The number of *T. urticae* Koch individuals per leaf on sampled cucumber plants during the seedling rooting stage was 1.5 individuals per leaf. By the beginning of the progressive fruiting phase, this number had increased to 7.6 individuals per leaf, exceeding the economic threshold of harmfulness (5% of plants infested). In the control variant (untreated), the infestation rate by the two-spotted spider mite continued to increase dynamically, reaching 32.5% by the end of the fruiting phase (Fig. 3).

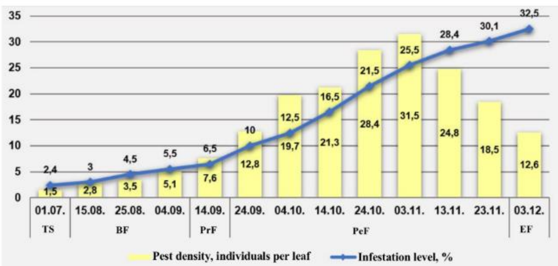

Fig. 3. Dynamics of *T. urticae* Koch Population in 2023: TS – transplanting stage; BF – beginning of fruiting; PrF – progressive fruiting; PeF – peak fruiting; EF – end of fruiting

The highest pest density values (28.4-31.5-24.8 individuals per plant) were recorded on the following monitoring dates: October 24, November 3, and November 13, 2023, corresponding to the mid-to-late stage of the peak fruiting phase. These values gradually declined toward the end of the fruiting phase, reaching 12.6 individuals per plant. This reduction is likely attributed to the physiological aging of the plants and the resulting decrease in their attractiveness as a food source for phytophagous pests.

The technical efficacy of the preparations Talstar 10% EC (0.6 l/ha), Vertimec 018 EC (0.7 l/ha), and Movento 100 SC (0.75 l/ha), when applied at the early stages of cucumber plant vegetation, was high (83.4-91.2%), with pest population density decreasing by 6 to 11 times. At the beginning of the fruiting phase, the technical efficacy of the tested insectoacaricides was slightly higher, reaching 90.5-94.6%, while plant infestation levels ranged from 2.0% to 3.5%, depending on the treatment variant (Table 5).

The insecticide Mospilan had no effect on the population density of *T. urticae* Koch in the cucumber agrocenosis due to its chemical properties. Therefore, in the presence of this phytophagous pest and the intention to use Mospilan as the primary insecticide, it should be supplemented with one of the approved acaricides.

Biometric parameters of the plants also differed significantly between the variant without plant protection measures and those with the use of plant protection products.

Table 5

Technical Efficacy of Insectoacaricides Against *T. urticae* Koch

Treatment Variant	Beginning of Flowering		Beginning of Fruiting	
	Infested Plants,%	Technical Efficacy,%	Infested Plants,%	Technical Efficacy, %
Control (untreated)	16.9	–	36.7	–
Mospilan, 0.3 kg/ha	16.1	4.4	36.0	1.9
Talstar 10% EC, 0.6 l/ha	2.8	83.4	3.5	90.5
Vertimec 018 EC, 0.7 l/ha	2.5	85.2	2.7	92.6
Movento 100 SC, 0.75 l/ha	1.5	91.2	2.0	94.6

The implementation of two treatments prior to the onset of cucumber fruiting contributed to a significantly greater accumulation of vegetative mass, increased main stem length, higher number of lateral shoots, and larger leaf area compared to the control. The best biometric parameters were observed in the treatment variant with the application of the insectoacaricide Movento 100 SC, SC (0.75 l/ha). In this variant, the average plant mass reached 998 g, exceeding the values obtained with other treatments by 2.8-6.4% and surpassing the untreated control by 22.9%. The main stem length was also the greatest in this treatment, measuring 290 cm, which contributed to the formation of the highest number of lateral shoots (32 pcs) and the largest leaf area (1768 dm² per plant) (Table 6).

Table 6

Biometric Parameters of Cucumber Plants During the Peak Fruiting Phase

Treatment Variant	Plant Mass, g	Main Stem Length, cm	Number of Lateral Shoots, pcs	Leaf Area, dm²/plant
Control (untreated)	812 ± 24	212 ± 12	18 ± 3	1321 ± 87
Mospilan, 0.3 kg/ha	938 ± 24	267 ± 15	28 ± 4	1697 ± 99
Talstar 10% EC, 0.6 L/ha	956 ± 26	282 ± 15	28 ± 4	1731 ± 100
Vertimec 018 EC, 0.7 l/ha	970 ± 26	288 ± 16	31 ± 5	1745 ± 115
Movento 100 SC, 0.75 l/ha	998 ± 27	290 ± 17	32 ± 5	1768 ± 112

Regarding plant productivity, consistent with the results of the biometric analysis, the highest fruit yield of cucumber was obtained in the treatment variant with the insectoacaricide Movento 100 SC, SC, where it reached 20.4 kg/m² (Fig. 4).

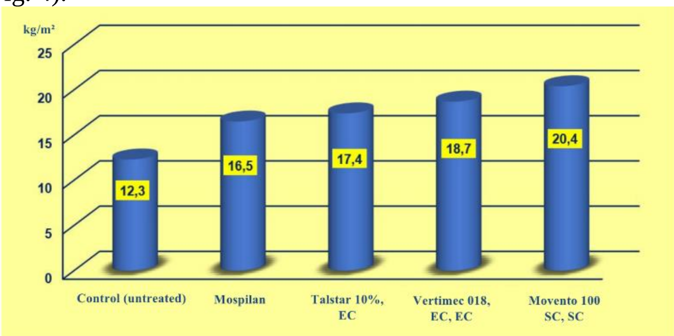

Fig. 4. Yield of Cucumber Hybrid Kibria Under the Application of Insectoacaricides ($LSD_{0.5}$ = 0.96 kg/m², 2023)

This value significantly exceeded the yields recorded for other treatments by 1.7-3.9 kg/m² and surpassed the untreated control by 8.1 kg/m²

The amount of preserved yield under the application of Talstar 10% EC (0.6 L/ha) and Vertimec 018 EC (0.7 L/ha) was 5.1 and 6.4 kg/m², respectively.

CONCLUSION

Analysis of the phytophagous pest complex in greenhouse-grown cucumbers revealed significant infestation by the two-spotted spider mite (Tetranychus urticae Koch). In the absence of protective measures, the pest population substantially exceeded the economic threshold of harmfulness, resulting in a 23.6-34.9% decrease in cucumber yield compared to biological control treatments, and a 25.5-39.7% reduction compared to chemical control treatments.

When the goal is to produce environmentally friendly cucumbers under greenhouse conditions, effective protection against T. urticae can be achieved through the use of biological insectoacaricides or their integration with natural enemies (entomoacariphagous organisms) as part of a comprehensive plant protection system. This approach provided a high level of pest control (70-81%) and allowed cucumber plants to achieve yields ranging from 16.1 to 18.9 kg/m².

In cases where *T.* urticae exceeds the economic threshold of harmfulness and there are no restrictions on chemical control methods, a twofold application – prior to the onset of fruiting – of an insectoacaricide containing the innovative active substance spirotetramat from the new ketoenol chemical class (Movento 100 SC, SC at 0.75 L/ha) is recommended. This product demonstrated high technical efficacy (94.6%), with preserved yield reaching 8.1 kg/m². Under this protection system, the yield of the universal ultra-early parthenocarpic cucumber hybrid Kibria F1 RZ grown in a summer–autumn rotation in a block-type greenhouse reached 20.4 kg/m².

Thus, depending on the production goals and quality requirements (e.g., organic or conventional cultivation), the appropriate method of *T.* urticae control should be selected based on a sound understanding of the pest's biological and ecological characteristics and with a focus on ensuring high efficacy of the applied control strategies.

SUMMARY

In greenhouse conditions in Ukraine, various species of phytophagous pests cause significant damage to crops, including cucumbers. The most widespread and harmful among them are representatives of the classes Insecta and Arachnida. Mites of the class Arachnida are represented by two species from the family Tetranychidae, with the two-spotted spider mite (*Tetranychus urticae* Koch) being the most common polyphagous pest of vegetable crops. This pest has over 900 host plants, including 150 economically important agricultural and ornamental species. Effective pest population control and mitigation of their harmfulness in greenhouses requires the implementation of modern integrated plant protection systems that include organizational, preventive, agronomic, biological, chemical, and quarantine measures combined into a unified strategy. The application of biological preparations such as Actofit BT + Liposan, Boverin BT + Liposan, and Bitoxibacillin BT + Liposan reduced plant infestation rates by 4.1, 4.8, and 5.4 times during the flowering initiation phase, and by 3.7, 3.5, and 4.3 times, respectively, during

the beginning of fruiting. The technical efficacy of these products was 75.7%, 79.3%, and 81.6% at the first assessment and 74.1%, 72.2%, and 76.8% at the second. The efficacy of the entomoacariphagous complex was slightly lower compared to biological insectoacaricides, amounting to 61.5% and 69.7%, depending on the timing of application.

In the case of exceeding the economic threshold of harmfulness (ETH) by the two-spotted spider mite during the cultivation of the universal ultra-early parthenocarpic cucumber hybrid Kibria F1 RZ in a summer–autumn rotation within a block-type greenhouse, the application of chemical control is recommended. Specifically, a twofold treatment before the onset of fruiting using an insectoacaricide based on the innovative active ingredient spirotetramat from the new ketoenol chemical class (Movento 100 SC, SC at 0.75 L/ha) provided high technical efficacy (94.6%), with the amount of preserved yield reaching 8.1 kg/m².

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