Advances in Social Science, Education and Humanities Research, volume 393
The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector (TFTS 2019)

Effect of Antiviral Drugs on the *Phytoseiulus persimilis* Ath.-H. Acariphagus

Sergey Pashkovsky
Laboratory of Enzyme Analysis and DNA Technologies
Novosibirsk State Agrarian University
Novosibirsk, Russia
ORCID: 0000-0003-4215-7279

Darya Gerne
Entomophage Breeding Laboratory
Novosibirsk State Agrarian University
Novosibirsk, Russia
ORCID: 0000-0002-0212-1821

Aleksandra Zenkova
Entomophage Breeding Laboratory
Novosibirsk State Agrarian University
Novosibirsk, Russia
ORCID: 0000-0002-9604-2824

Valeria Kurochkina
Laboratory of Enzyme Analysis and DNA Technologies
Novosibirsk State Agrarian University
Novosibirsk, Russia
ORCID: 0000-0003-4673-2365

***Abstract*—The article considers the possibility of sharing the most common Russian plant protection products against viruses jointly with the acarifagus – *Phytoseiulus persimilis* Ath.-H. The necessity of their complex application is substantiated; studies of other authors on this topic are noted. The data on the market of vegetables grown on protected ground and biological products of the Russian Federation are analyzed. The effect of the "Viron", "Farmaiod" and "Enzyme-FITO" preparations with antiviral effect on the laboratory population of predatory mites was studied. The mechanism of their interaction is determined. The "Farmaiod" drug almost halved the population of *Phytoseiulus persimilis* on the seventh day; the "Viron" drug inhibited the growth of the acariphagus papulation in the first 5 days after treatment; and "Enzyme-FITO" did not show a significant negative effect. Recommendations on the safest way to use antiviral agents in combination with acariphagus are given.**

Keywords—acariphages, entomophages, Phytoseiulus persimilis, antiviral drugs, biological preparations, plant protection.

I. Introduction

According to the Federal State Statistics Service, the volume of vegetable production in the Russian Federation reached 13685 thousand tons in 2018. For examplethis indicator amounted to 12792 thousand tons, in 2012, thus, the increase was 6,9% after 6 years. According to Institute of Agricultural Market Studies the total market for greenhouse vegetables amounted to 1,9 million tons in 2018, while the share of domestic production of the Russian Federation in the same year approached 1.1 million tons. For the market of vegetables grown indoors, the leader in harvesting is cucumber – its share is at 70% [1-2].

Protected ground conditions include human control of agrobiocenosis. If a phytopathogenic organism enters a human-controlled agrobiocenosis, chemical or biological plant protection products must be used in order to destroy it. In connection with the annual increase in the production of cucumbers in greenhouses, the need for their protection against various pathogens increases, which inevitably leads to an increase in demand for these drugs. Currently, a tendency has been established for the transition from chemical plant protection products to biological ones [3-4]. The volume of biological products production increased by 205% from 2012 to 2018. So, in 2012, the market for biological products amounted to 0,5 billion rubles, and in 2018 exceeded 1,5 billion rubles [5]. There are many biological plant protection products: biological preparations (antiviral, fungicides, insecticides, acaricides, etc.); entomophages and acariphages (natural mites' antagonists); phytophages (weed's antagonists), etc. In the conditions of a protected ground, the need for the comprehensive protection of plants often arises, due to their failure by several pathogens.

In this regard, the objective is to assess the effect of the most common Russian plant protection products against viruses on the acarifagus *P. persimilis*.

II. Literature review

Cucumbers are affected by a wide range of diseases (viral, bacterial and fungal infections) and pests. Viruses, sucking pests and arthropods (thrips, aphids, whiteflies, spider mites) are the most harmful, since they are difficult to control under conditions of agrobiocenosis of greenhouses [6]. At the same time, some of them play a role in disseminating the others. It has been proven that aphids and thrips carry the cucumber green mottle mosaic virus [7-8].

CGMMV – the cucumber green mottle mosaic virus, entering the plant cells, causes a systemic infection, disrupting the normal vital activity of plants. Symptoms of CGMMV are shortened internodes, elongated edges of the leaf, growth retardation, a mosaic in the form of yellow blotches on the leaves and deformed fruits. This leads to deterioration of salable condition of the products and a reduction in overall productivity. The virus is transmitted during plant care, and is often already present in the seeds [8].

The spider mite – *Tetranychus urticae* Koch, is a dangerous pest and its appearance in a greenhouse is almost impossible to prevent. Mites penetrate everywhere by the cobweb with air currents, and passively carried by humans. Symptoms of their damage are silver or yellowish dots on the leaves, which turn into general chlorosis. The pest feeds on the leaves and not moving at the very beginning of their colony. Later, mites move to the upper leaves, where they begin to feed on the top leaves. Due to the leaves' drying, the yield of a cucumber decreases sharply. With a high number of pests, plants can die. The cobweb, tightly covering the leaves, protects aphid, whitefly and thrips colonies, contributing to their greater survival, since treatment solution drops do not fall on pests when spraying plants [9].

One of the means to significantly suppress or completely destroy phytopathogenic insects, mites, etc., are entomophages and acariphages. They are widely used for

protection of vegetable, berry, and flower cultivars in protected ground against aphids, thrips, whiteflies, spider mites, etc. [10-11]. Entomophages and acariphages must survive on the leaves for 7-14 days for their effective use. Therefore, using predatory mites and insects in a protected ground, it is impractical to simultaneously use drugs that can affect them. In this regard, information on the effect of plant protection products on entomophages and acariphages is necessary for planning and organizing plant protection in the greenhouse facilities.

The world is actively exploring the impact of new biological and chemical preparations on the life of entomophages and acariphages. In this case, the influence of chemicals, in the vast majority of studies, is negative.

So, SYP-9625 acaricide was tested not only on phytopathogenic *Tetranychus cinnabarinus* Boisdul mites, but also on its natural predators *Neoseiulus californicus* McGregor. The authors concluded that SYP-9625 significantly reduces the number of offspring in females of *N. californicus* [12], which complicates the joint use of acaricides and acariphages.

A study of the Abamectin insecticide effect on *Phytoseiulus* confirmed the decrease in predatory activity of this acariphagus, with sub-lethal doses of the active substance up to 44,99% [13].

Employees of the entomophagus breeding laboratory of the Novosibirsk State Agrarian University conducted a study on the microbiological insectoacaricide Biovert effect on *Phytoseiulus*. When releasing the acariphagus 1 day after spraying the plants with Biovert, the negative effect of the drug was not manifested. The number of predatory mites, taking into account the new generation of individuals that appeared during the experiment, did not significantly differ from the control version, and on the 7th day after its release, it increased in the version with Biovert – by 3,9 times, in the control – by 3,8 times. It was concluded that, given the relatively low acaricidal effect of Biovert, the combined use of a biological product with *Phytoseiulus* is advisable in case of simultaneous population of plants with different types of pests. In particular, treatment with the drug, combined with the release of *Phytoseiulus* at reduced consumption rates, leads to complete suppression of the spider mite and a decrease in the number of *Aphis gossypii* by 7 times (compared with the control version) on the 7th and 14th day of the experiment [14].

Since insect pests are carriers of viral diseases, there is a need to assess the possibility of the simultaneous use of acariphages and antiviral drugs. Due to the lack of information, the study of the integrated use of these plant protection products is relevant.

The most commonly used antiviral drugs in greenhouse facilities are fungicide Viron and Farmaiod. Furthermore, in order to protect plants from viruses, a new agent – Enzyme-FITO, developed on the basis of NSAU, is being increasingly applied.

"Enzyme-FITO" is a multi-enzyme complex based on endonucleases, when penetrated into the tissues of an infected plant, destroy most of the viral RNA, thereby reducing the viral load on the plant and leveling the effect of the virus on it [15].

"Viron" is an antiviral agent of a Turkish manufacturer. There is no official information on the principle of action and composition of this product in the public domain. According to the statements of the "Association of Producers of Fruits, Berries and Planting Material", it suppresses the virus by affecting its vital functions in an infected plant, promotes the crystallization of viruses, and has an anti-stress effect. This returns the plant to its normal state and maintains it [16].

Farmaiod is a broad-spectrum disinfectant and antiseptic. Farmaiod acts on non-spore-forming microorganisms (excluding mycobacteria), viruses, fungi. This drug is used both for bacterial, fungal and viral infections at various stages of development, and for prophylactic disinfection and disinfestation of any premises, equipment, vehicles, soil [17].

III. METHODS

The studies were conducted on the basis of the entomophagus breeding laboratory of the Novosibirsk State Agrarian University. The effect of antiviral agents on the predatory mite of *Phytoseiulus* was evaluated in laboratory experiments in accordance with the "Methodological guidelines on methods for assessing the environmental safety of pesticides when used in integrated plant protection". The experiment was carried out in compliance with the following rules: concentration of solution of recommended doses; evenly distributed drug solutions on plants' surface; we used mite species *Phytoseiulus persimilis* from a laboratory culture; the exposure period of 7 days; we used water as a control version.

Solutions of the studied antiviral agents were prepared based on the active substance per 1 liter of water. Thus, to prepare the required volume: Viron 1,5 ml; Farmaiod 0,3 ml; EnzymeFito 0,1 g. The preparations were applied by aerosol spraying using a finely dispersed atomizer.

Assessment of drugs' toxic effect on laboratory populations of *Phytoseiulus* was carried out on separated pest-infected leaves of a cucumber using the cup method (Fig. 1)

Fig. 1. Evaluation of the drugs effect (cup method)

An ordinary spider mite *Tetranychus urticae* was used as food for the predator. Planting of females of acariphagus on the processed leaves of the fodder plant was carried out immediately after the preparation was dried up.

Accounting for the predatory tick's mortality was carried out on the 3rd, 5th and 7th days after treatment. We used 20 samples and repeated the experiments is 5 times. To account

the number of acariphages, a MBS-10 brand binocular was used.

Student's t-test was used for statistical processing of the material.

IV. Results

The criterion for assessing the toxic effect of drugs was the number of entomophagus populations in the experimental and control groups. The obtained results confirmed the tendency of application of biological products as the safer, than the chemical ones. The data on the change of *Phytoseiulus* population in the experiment are presented in the Table I.

TABLE I. THE DRUGS' ACTION AGAINST IMAGO OF *P. PERSIMILIS*

Option	**Population change of *P. persimilis* relative to initial, in % by days after treatment**			
	1	***3***	***5***	***7***
Control	100	132±13,1	229,8±10	322,5±31,8
Viron	100	99,5±4,8	104,5±2,6	287±18,6
EnzymeFito	100	110±2,5	214±18,9	312,5±24,4
Farmaiod	100	77,5±10	68,5±5,6	53,8±8,1

After 3 days after the treatment, the entomophagus population of the control group increased by 32% of the initial data. The Viron drug showed an ambiguous result, since the acariphagus population decreased by 0,5%. The mite species population increased by 10% on the 3rd day of treating with "Enzyme-FITO". Farmaiod, suppressed the *Phytoseiulus* population by 22,5% over the same period of time.

The acariphagus population of the control group increased by 129,8% on the 5th day after treatment. A positive trend was observed in the group treated with Viron – the *Phytoseiulus* population increased by 4,5% compared with the 1st day. At the same time, the amount of acariphages has increased by 114% after processing "Enzyme-FITO". Farmaiod reduced the acariphagus population by 31,5% by the end of 5 days.

At the end of the experiment, the total number of mites in the control group increased by 222,5%. The group treated with Viron showed a growth result of 187% on the 7th day. The entomophagus population grew by 212,5% in the group treated with Enzyme-PHYTO. Farmaiod retained the tendency to suppress the *Phytoseiulus* population; its number over the 7 days of the experiment decreased by 46,2%.

The change in the population size of the predatory mites by groups is clearly reflected in the graph (Fig. 2).

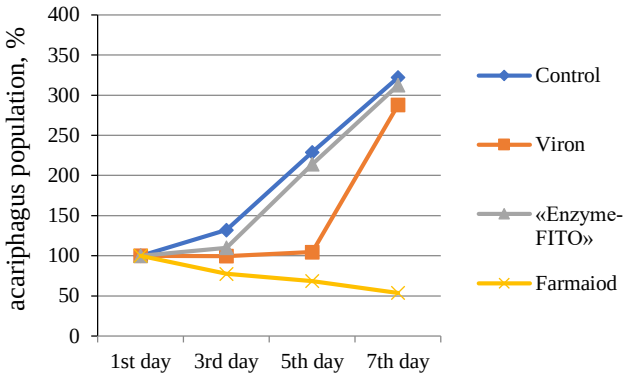

Fig. 2. Population dynamics of the *P. persimilis* acariphagus after treatment

A growth suppression of the acariphagus population after Viron treatment and a further rise in the number of mites are clearly visible for 5 days. The "Enzyme-FITO" drug shows an insignificant increase in the acariphagus population in the first 3 days after treatment; further growth does not deviate from the control group. The antiviral drug Farmaiod caused a clear reduction in the population of *P. persimilis* throughout the experiment.

V. Conclusion

Based on the results of our study, we can draw the following conclusions about the combined use of *Phytoseiulus persimilis* with the tested agents. When using the Viron preparation during the first 5 days, the population of predatory mites practically did not change, however, in the next two days there was a leap of that indicator by 182,9%. It can be concluded that the use of the Viron + *Phytoseiulus* complex is possible, however, the acariphages should be released 4-5 days after the treatment.

The Farmaiod drug significantly reduced the *Phytoseiulus* population. At the end of the experiment, only 53,8% of viable predatory mites remained. Thus, the toxic effect of Pharmaiod on mites can be considered proven, which makes their complex application inappropriate.

The antiviral agent "Enzyme-FITO" does not significantly affect the vital activity of the acariphagus *Phytoseiulus*. Throughout the experiment, the population dynamics in the experimental group was comparable with the control group. 7 days after the treatment, the *Phytoseiulus* population increased by 312,5%, which almost corresponds to the control indices – 322,5%. Thus, the combined use of Enzyme-FITO and *Phytoseiulus* is the safest and most effective.

References

[1] E. Maximova, Vegetables crossed the millionth line. Harvest in closed soil showed a new record. Agrovestor. https://www.agroinvestor.ru/analytics/article/31004-ovoshchi-pereshli-millionnyy-rubezh/

[2] R.V. Gnutova, "The current state of viruses studying in vegetable crops of the Far East," Izvestiya Timiryazevskoj selskohozyajstvennoj akademii (Izvestiya Timiryazev Agricultural Academy), No. 5, pp. 32-49, 2013. (in russ.)

[3] S.A. Dobrokhotov, A.I. Anisimov, N.A. Belyakova, L.G. Maximova and O.G. Orlova, "Towards the ecological agriculture," Zashchita i karantin rastenij (Plant Protection and Quarantine), No. 12, pp. 19-22, 2011. (in russ.)

[4] S.I. Nekrasov, O.F. Kalyeva and P.F. Rulev, "The biologization of agricultural production as the way to solve environmental problems of agriculture," Tavricheskij nauchnyj obozrevatel (Taurida Scientific Reviewer), No. 3(8), pp. 195-202, 2016. (in russ.)

[5] A. Labykin, Agrarians are moving away from chemistry to bio-farming. Experttonline. https://expert.ru/expert/2019/12/agrarii-uhodyat-ot-himii-v-biozemledelie/

[6] A.K. Akhatov, "Cucumbers and tomatoes in greenhouses," Zashchita i karantin rastenij (Plant protection and quarantine), No. 2, pp. 70-125, 2011. (in russ.)

[7] A.K. Akhatov and E.A. Akhatov, "The most damnific diseases of vegetable crops in modern greenhouse complexes," Gavrish, No. 3, pp. 16-23, 2014. (in russ.)

[8] Results of the year 2018. Hothouse vegetables. Institute for Agricultural Market Studies. http://ikar.ru/lenta/677.html

[9] A.K. Akhatov, F.B. Hannibal, Yu.I. Meshkov, F.S. Jalilov, V.N. Chizhov, A.N. Ignatov, V.P. Polishchuk, T.P. Shevchenko, B.A. Borisov, Yu.M. Stroykov and O.O. Beloshapkina, Diseases and pests of vegetable crops and potatoes. Moscow: KMK scientific publications, 2004. (in russ.)

[10] N.A. Belyakova and I.M. Pazyuk, "Overview of Entomophages for Greenhouses," Zashchita i karantin rastenij (Plant Protection and Quarantine), No. 7, pp. 28-30, 2007. (in russ.)

[11] E.Yu. Shipilova, "Biomethod in the system of integrated protection of vegetable and ornamental crops in greenhouses," Gavrish, No. 6, pp. 25-27, 2010. (in russ.)

[12] J. Ouyang, Y. Tian, C. Jiang, Q. Yang, H. Wang and Q. Li, "Laboratory assays on the effects of a novel acaricide, SYP-9625 on Tetranychus cinnabarinus (Boisduval) and its natural enemy, Neoseiulus californicus (McGregor)," PlosOne, 2018. https://doi.org/10.1371/journal.pone.0199269

[13] J.I. Monjarás-Barreraa, J.C. Chacón-Hernándezb, E. Cerna-Cháveza, Y.M. Ochoa-Fuentesa, L.A. Aguirre-Uribea and J. Landeros-Floresa, "Sublethal effect of Abamectin in the functional response of the predator Phytoseiulus persimilis (Athias-Henriot) on Tetranychus urticae (Koch) (Acari: Phytoseiidae, Tetranychidae)," Brazilian Journal of Biology, Vol. 79, No. 2, pp. 273-277, 2019. https://doi.org/10.1590/1519-6984.180184

[14] I.V. Andreeva, A.A. Zenkova, E.I. Shatalova and D.Yu. Gerne, "Effectiveness of the new biopreparation biovert against pests in greenhouses end evaluation of its impact on acariphage phytoseiulus," Granat, No. 10, pp. 146-148, 2018. (in russ.) [Biological plant protection is the basis of agroecosystems stabilization. Formation and prospects of the development of organic agriculture in the Russian Federation, 2018].

[15] Enzyme-Fito. Technological Park of the NSAU. https://www.park-nsau.com/enzyme

[16] Preparations for plant protection against bacterial, phytoplasmic, mycoplasma and viral diseases from the company PKF Polimerprom LLC. Association of Producers of Fruits, Berries and Planting Material (Uppapm). http://asprus.ru/blog/preparaty-dlya-zashhity -rastenij-ot-gribkovyx-organizmov-virusov-bakterij-ooo-pkf-polimerprom/

[17] Farmaiod. SPC Farmbiomed. https://pharmbiomed.ru/product/farmajod-10