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Improving the methods of breeding, storing, and using beaked mites for biological pest control

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ABSTRACT

The methods of mass breeding the Phytoseiidae beaked mites, including breeding flour mites on sterilized and moistened bran and infestation by the predators, have been improved. A series of experiments have been performed for assessing the possibility of long-term storage of the *N. barkeri*, *N. cucumeris*, and *A. swirskii* genera. As a result of the experiments, a positive effect of using beaked mites has been found, but only in the mobile stages; no predatory activity to eggs has been observed, the eggs have remained viable, and after 5-7 days, the hatching of mites has started; therefore, the beaked mites have been released for the second time. Thus, to prevent the development of spider mites, it is necessary to repeatedly release beaked mites.

Key words *: Breeding phytoseiidae beaked mites, Storage, Biological protection, Spider mites.*

Introduction

Due to the progressive development of organic crop production in many countries of the world, including Kazakhstan and Russia, the widespread use of entomophages and acariphages for biological control of some open-field pests becomes relevant.

In modern programs of biological pest control, an important role is played by the target use of the relationships between phytophages and their parasites and predators existing in nature (Agasieva, Ismailov, 2017).

The methods and effectiveness of using the Phytoseiidae beaked mites against several pests in the crops cultivated in the protected ground have been widely covered (Ilnitskaya, 2015; Bolckmans *et al.*, 2005; Delisle *et al.*, 2015; Meshkov, Salobukina 2013; Messelink *et al.*, 2006). The widespread use of the Phytoseiidae beaked mites of the *Neoseiulus* and *Ambliseius* genera is due to their polyphagy. They can be used against tobacco (*Bemisia tabaci* Gennadius) and greenhouse (*Trialeurodes vaporariorum* Westwood) whiteflies, against ordinary western flower thrips (*Frankliniella occidentalis* Pergande), and Tetranychoidea mites (*Tetranychus)* (Nomikou *et al.*, 2001; Bolckmans *et al.*, 2005).

Available feed objects and technological methods of breeding them in the laboratory were searched for. In particular, artificial diets consisting of honey, sucrose, pollen, ambrosia, tryptone, egg yolk, black soldier fly hemolymph (*Hermetia illucens* Linnaeus), mill moth eggs (*Ephestia kuehniella* Zeller), and eggs of the Artemia genus crustaceans were assessed (Nguyen *et al.,* 2014; Delisle *et al.,* 2015). However, feed mites remain the main type of feed for the Phytoseiidae.

This work was aimed at improving the methods of breeding, storing, and using beaked mites against common *T. urticae* spider mites.

Materials and Methods

The beaked mites (*Neoseiulus barkeri* Hughes, *N. cucumeris* Oud, *Amblyseius andersoni* Chant, *A.* and *swirskii* A. – H.) were bred using flour mites as the feed. Breeding the predators required optimum conditions, which corresponded to a temperature of +23 – +27 °C and a relative humidity of 80 %. The substrate with 250 – 270 predators per 1 cm^3 was placed in a desiccator in a 1 – 2 cm layer, and the substrate with flour mites was placed on top. The substrate was not stirred; after 7 – 10 days, the population of the bred biological agent could multiply to the size required for use.

The quality was assessed with the use of the biological indicators of the mites development: the time of obtaining the biological material, the number of flour and beaked mites in 1 cm^3. To account for the number of ordinary spider mites, samples of 30 leaf plates were taken in three repetitions from the experimental plots with protected soy plants. At the laboratory, all stages of pest development were counted using the MBS-1 microscope. The studies were performed using the material and technical base of the Technological Line for Mass Breeding of Entomophagous Insects USI, and the facilities of the State Collection of Entomoacariphages and Microorganisms of the Federal State Budget Scientific Institution VNIIBZR and the Collection of Entomoacariphages of the Laboratory for Plant Biological Protection of LLP Kazakh Research Institute of Agriculture and Plant Growing. The tables show the mean (*M*) and standard deviations (±SD). The calculations were performed using the Statistica 12.6 application (StatSoft, Inc., USA).

Results and Discussion

As a result of the studies, the key stages of the mass cultivation of the *A. farus* flour mites were improved, which could significantly accelerate achieving a high density of the feed mites population for breeding flour mites, the stock culture of flour mites was poured on the bottom of the tank in a 3 – 4 cm layer, cooked wheat bran was put on top in a 3.5 – 4 cm layer. The substrate was then covered loosely with a lid. The bran was not stirred for 7 days. During this period, the population density of the feed mites reached 7,000 thousand bions in 1 cm^3. The optimal development temperature was 25 °C, the humidity was 75 – 80 %, and the height of the feed layer was 4 cm.

It was found that for normal reproduction of predatory mites of the Neoseiulus and Ambliseius genera, the degree of aeration in the bran layer was of great importance. It should be emphasized that substrate aeration depended on its mechanical composition, i.e., on the size of its constituent particles and the coarse to fine fractions ratio.

As the data in Table 1 show, adding soy meal as a filler significantly improved the quality of the substrate on which the predator mites were bred, since aeration increased and they fully consumed the entire feed base in the substrate. With the substrate layer thickness of 8 – 9 cm, the density of the population of *A. andersoni* in 1 cm^3 was 263.0 ± 11.1 bions in 1 cm^3.

Since in laboratory conditions it was not always possible to produce the required number of entomoacariphages in a short period, it became necessary to develop the methods for short-term and long-term storage of the biomaterial (Table 2).

The materials in Table 2 show that the duration of the effective biomaterial storage depended on the mites species and the duration of storage. For instance, after 20 days, the survival rate of *N. barkeri* was 93 %, that of *N. cucumeris* — 89 %, and that of *A. swirskii* — 45 %, after 30 days, these survival rates were 88 %, 89 %, and 18 %, and after 45 days, these survival rates were 78 %, 10 %, and 0 %, respectively. Thus, effective durations of storage at 4 °C were the following: for *N. barkeri* — 30 to 45 days, for *N. cucumeris* — 30 days, and for *A. swirskii* — no more than 10 days.

To date, many populations of Tetranychoidea mites have been showing high resistance to acaricides, which significantly reduces the effectiveness of protective measures and increases the pesticide load on agroecosystems, which predetermines the need for finding alternative methods of their suppression.

A field assessment of the biological effectiveness of Phytoseiidae beaked mites was made in 2018 – 2019 on the experimental plots of the Vilana soy cultivar with the area of one hectare. In 2018, the first spider mites appeared in the second ten days of July. The population of spider mites on soy was nonuniform, and the maximum pest population density of 23.1 bions per leaf was observed in the second ten days of August.

To combat the common spider mites (*T. urticae)* on soy in the open soil, a mixture of the *N. cucumeris* and *A. andersoni* beaked mites was used through the method of introducing predator mites into the natural foci of the target as they were found, which predetermined the possibility to early create reproducible reserves of bioagents. For this purpose, wheat bran with beaked mites in various phases of development in it was evenly scattered on the leaves of the upper tier of soy in the foci of spider mites with the release rate of 160 – 170 bions per plant. Ten days later, the beaked mites were released again at the rate of 180 – 200 bions per plant. As a result of the experiment, a positive effect of using beaked mites was found against mobile stages; no predatory activity to eggs was observed, the eggs remained viable, and after 5 – 7 days, the hatching of mites started, therefore, the beaked mites were released for the second time (Table 3).

The dynamics of the number of spider mites in 2019 show that the first individuals of the pest appeared in early July, the maximum density of the mites population (25 bions/leaf) was observed in the second ten days of August. In the second ten days of July, the beaked mites were released in the experimental plots at the rate of 150 – 200 bions per plant.

In the first ten days of August, the beaked mites

Table 1. The efficiency of feeding the *A. andersoni* beaked mites, depending on the composition and the height of the feed substrate layer

The height of the substrate layer, cm		The population density of flour mites*, bions in 1 cm^3		The population density of Amblyseius**, bions in 1 cm^3	
without soy meal	with soy meal	without soy meal	with soy meal	without soy meal	with soy meal
5 – 6	5 – 6	3,997.3 ± 164.1 ^{a}	5,507.7 ± 167.5 ^{b}	165.0 ± 11.8 ^{bc}	202.3 ± 13.7 ^{a}
8 – 9	8 – 9	5,329.0 ± 317.3 ^{b}	6,853.0 ± 235.7 ^{d}	204.3 ± 14.6 ^{a}	263.0 ± 11.1 ^{d}
10 – 12	10 – 12	3,879.3 ± 210.5 ^{a}	4,535.3 ± 195.1 ^{c}	153.0 ± 11.4 ^{b}	188.3 ± 17.6 ^{ac}

Table 2. Reductions in the population density of beaked mites, depending on the duration of storage at 4 °C

Duration of storage, days	The population density of *N. barkeri*, bions in 1 cm^3	The population density of *N. cucumeris*, bions in 1 cm^3	The population density of *A. swirskii*, bions in 1 cm^3
0	143.0 ^{i}	130.3 ^{gh}	83.0 ^{e}
10	134.3 ^{h}	125.0 ^{g}	65.3 ^{d}
20	130.0 ^{gh}	116.3 ^{f}	37.3 ^{c}
30	126.0 ^{gh}	115.7 ^{f}	9.3 ^{b}
45	110.7 ^{f}	13.0 ^{b}	0 ^{a}
60	13.7 ^{b}	0 ^{a}	0 ^{a}

Table 3. The results of using the *N. cucumeris* and *A. andersoni* beaked mites against spider mites on soy in 2018

The initial number of spider mites (bions/leaf)		The number of spider mites, bions/leaf					
		5 days		10 days		15 days	
Mobile phases	eggs	Mobile phases	eggs	Mobile phases	eggs	Mobile phases	eggs
20.2 ^{c}	15.6 ^{d}	12.4 ^{b}	10.4 ^{c}	6.8 ^{a}	4.6 ^{b}	4.0 ^{a}	0 ^{a}

were released for the second time. As a result, a positive effect was observed after using the Phytoseiidae beaked mites; in the experimental plots, the number of mites decreased significantly, and by mid-August, it was 1.4 bions/leaf, compared to 17.8 bions/leaf in the reference. In addition to reducing the number of spider mites during the accountings, a significant decrease in the density of the populations of *Trips tabasi* Lind and *Frankliniella intosa* Tryb was noted.

Conclusion

Therefore, the joint study performed by the members of the FSBSI VNIIBZR (the research performed within State assignment No. 075-00376-19-00 of the Ministry of Science and Higher Education of the Russian Federation in the framework of research studies on topic No. 0686-2019-0009) and the Kazakh Research Institute for Plant Protection and Quarantine under the SF (No. AP 05134585) has shown the optimal storage periods for beaked mites at 4 °C, being 30 – 45 days for *N. barkeri*, 30 days for *N. cucumeris*, and no more than 10 days for *A. swirskii*.

The field assessment of the effectiveness of a mixture of the *N. cucumeris* and *A. andersoni* beaked mites has shown sufficient efficacy of the bioagents against spider mites and the related pests — *T. tabasi* and *F. intosa*.

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