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Application of biological insecticide Pecilomicine-B for greenhouse pest control

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The estimation of influence of some technological parameters (terms and number of treatments, the interval between them) on biological efficiency of bioinsecticide Pecilomicine-B on greenhouse whitefly (*Trialeurodes vaporariorum* West.) and cucumber midge (*Bradysia brunnipes* Mg.), and also its influence on entomophages encarsia (*Encarsia formosa* Gahan.) and phytoseiulus (*Phytoseiulus persimilis* Ath.) was carried out under greenhouse conditions. It was determined that the most expedient method of Pecilomicine-B application is at the stage of primary settling of greenhouse crop plantings by phytophage: in case with greenhouse whitefly – by the first imago appearance on plant leaves carrying out 2 treatments at 7–14 days interval. Later on, Pecilomicine-B (1 % concentration) is applied up to 4 times considering greenhouse whitefly population dynamics (in case its stable increase). It allows keeping the phytophage population during 1.5–2 months at economically imperceptible level without chemical means of plant protection. Against cucumber midge one should apply the preparation (4 % concentration up to 2 times at 23–27 days interval) at the beginning of pest imago mass flight. In case of combined Pecilomicine-B application under greenhouse conditions (at 7–14 days interval) with phytoseiulus and encarsia it does not render the negative influence on survival, reproduction, parasitic and predatory activity of entomophages and does not decrease the efficiency of their action. Pecilomicine-B application, according to the above mentioned technological parameters, allows to constrain the phytophage populations at economic-imperceptible level.

Key words: bioinsecticide efficiency, bioinsecticide influence on entomophages, *Bradysia brunnipes*, *Cucumis sativus*, *Encarsia formosa*, *Lycopersicon esculentum*, *Paecilomyces fumosoroseus*, Pecilomicine-B, *Phytoseiulus persimilis*, *Trialeurodes vaporariorum*.

Introduction. One of the most rational approaches in greenhouse crop protection against pests is a combination of different means of action on phytophages with a maximum proportion of ecologically safe biological preparations. In this connection it is actual to extend the spectrum of biological insecticides recommended for application. The analysis of literary data shows that the entomopathogenic fungus *Paecilomyces fumosoroseus* (Wize) Brown et Smith (*Deuteromycota: Moniliaceae*) is a perspective agent for biological control of greenhouse pests (Ижевский et al., 1999; Poprawski, Jones, 2000; Wraight et al., 2000; Faria et al., 2001; Lacey et al., 2001;

Nigroho, Ibrahim, 2004; Ахатов et al., 2004; Thungrabeab et al., 2006; Shi, Feng, 2009). As a result of done screening by insecticidal activity level of *P. fumosoroseus* strains from the collection of the Institute of Plant Protection, there was selected *P. fumosoroseus* 3/1 strain possessing high virulence in relation to the most noxious greenhouse phytophages in Belarus: greenhouse whitefly *Trialeurodes vaporariorum* Westw. and cucumber midge *Bradysia brunnipes* Mg. (Прищепа, Янковская, 2008). This strain is a basis of mycoinsecticidal preparation Pecilomicine-B (a paste with the spore titer $1.8 \cdot 10^{10}$/g, manufacturer RUC "Novopolotsk Plant of Protein and Vitamin Concentrates") (Прищепа, 2005; Янковская, 2006; Янковская, Прищепа, 2008). To develop the optimum technological techniques of preparation application we evaluated the influence of different factors (time and number of treatments, the intervals between them) on Pecilomicine-B biological efficiency and also the character of interrelation with other elements of biological protection and especially with the most frequently applied in the greenhouses of Belarus entomophages encarsia (*Encarsia formosa* Gahan.) and phytoseiulus (*Phytoseiulus persimilis* Ath.).

Object, methods and conditions. The researches were carried out in greenhouses of Minsk region greenhouse farm "DorOrs", "Zhdanovichy", "Oziorny" and in greenhouses of the Republican Ecological Educational Center on tomato ('Raissa' F_1, 'Barcelona' F_1, 'Blagovest' F_1), cucumber (TSHA 14-27 F_1, 'Mystica' F_1, 'Turnir' F_1) and soybean crops. The preparation was applied by the method of spraying (preparation concentration – 1 %) against greenhouse whitefly and by the method of watering in the collar zone of cucumber (from the calculation of 50 ml/plant with preparation concentration 4 %) against cucumber midge. Time and number of treatments were determined in the course of experiments considering pest number changes. Pest number was registered every week and the biological efficiency of preparation action was evaluated according to the general methods (Прищепа et al., 2008). The record of parasitized whitefly larvae and flying out encarsia imago was done in the lab under binocular.

Results. The efficiency of Pecilomicine-B application against greenhouse whitefly was evaluated under greenhouse conditions in 2002–2006. In each separate case a scheme of preparation application considering the dynamics of phytosanitary condition of greenhouse crop plantings was developed.

The efficiency of Pecilomicine-B preparation application against greenhouse whitefly was evaluated under greenhouse conditions in 2002 in the greenhouse farm "DorORS" on tomato crop 'Raissa' F_1, (small-volume technology of cultivation on rock wool). In total for the registration period there were 3 treatments. The control plot was without any treatment. The first treatment was done when the primary whitefly focus was detected: the presence of individual imago was noted on registration plants, larvae – not revealed. In Fig. 1 the dynamics of pest number is presented.

The pest larvae occurrence on a control plot was noted 2 weeks earlier than in a variant with biological product application. Within the next four weeks the average whitefly number in both variants was at identical level. Later on in a control variant there was a sharp increase within a month (from 1 to 17 larvae per one leaf). In the experimental variant on 42 and 68 day from the experiment beginning there were repeated

treatments using the biological preparation. The maximum pest number value did not exceeded 3 indiv./leaf (what was 6 times lower in comparison with the control). At the moment of researches termination (in 11 weeks after the experiment started) the larvae number has made, on the average, 10 indiv./leaf, in the experiment – 2 indiv./leaf.

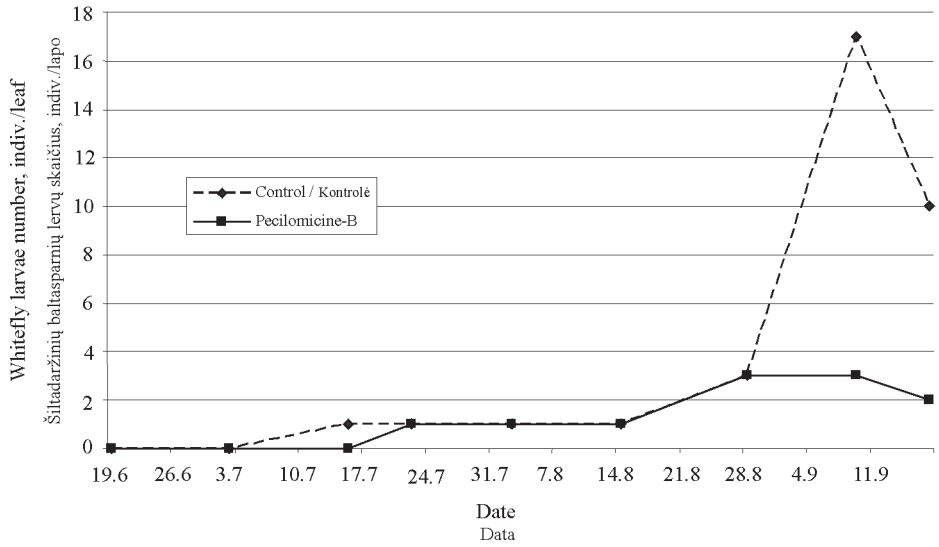

Fig. 1. Influence of Pecilomicine-B application on greenhouse whitefly *Trialeurodes vaporariorum* West. larvae number (greenhouse farm "DorOrs", 2002 m., tomato 'Raissa' F_1, small-volume technology)
1 pav. Pecilomicine-B įtaka šiltadaržinių baltasparnių (*Trialeurodes vaporariorum* West.) lervų skaičiui (šiltnamių ūkis "DorOrs", 2002 m., pomidorai 'Raissa' F_1, mažagabaritė technologija)

Researches in the greenhouse farm "DorOrs" were continued in 2003 on tomato crop 'Barcelona' F_1. For the first time Pecilomicine-B was applied on June 21 at pest larvae number 20 indiv./25 registration leaves. The subsequent treatments were done on June 30, August 4, September 11. The biological efficiency of a preparation has made from 60 to 88.0 %. In the control variant during the experiment whitefly larvae number has increased from 10 to 228 indiv./25 registration leaves.

While carrying out the researches in 2003 in the greenhouse plant "Oziorny" on tomato crop ('Blagovest' F_1, soil ground) the first treatment was done when the pest number in the colonization focuses has made 23–27 larvae/25 leaves. On the whole, there were 4 treatments with 7 days interval. Pecilomicine–B biological efficiency is presented in Table 1.

Table 1. Pecilomicine-B influence on greenhouse whitefly number (tomato 'Blagovest' F_1, soil ground, greenhouse farm "Oziorny", 2003)
1 lentelė. Pecilomicine-B įtaka šiltadaržinių baltasparnių gausumui (pomidorai 'Blagovest' F_1, dirvožemis, šiltnamių ūkis „Oziorny", 2003 m.)

Variant Variantas	Whitefly larvae number on 25 leaves before treatment Šiltadaržinių baltasparnių lervų skaičius ant 25 lapų prieš apdorojimą	Greenhouse whitefly larvae number on 25 leaves / Biological efficiency Šiltadaržinių baltasparnių lervų skaičius ant 25 lapų / Biologinis efektyvumas (%)			
		days from the start of the experiment dienos nuo bandymo pradžios			
		5	12	19	26
Pecilomicine-B, PS	27	90/42.4	145/68.5	198/77.1	356/63.7
Control (without treatment) Kontrolė (be apdorojimo)	23	133	391	736	835
LSD_{05} / R_{05}		2.6	6.7	12.2	14.5

In 2003 in greenhouses of the Republican Ecological Educational Center there was an estimation of efficiency of Pecilomicine-B against greenhouse whitefly on cucumber, TSHA 14-27 F_1 (soil ground). The initial pest number has made 82 larvae per 25 registration leaves. There were 4 treatments by a preparation in the course of 24 days. Control variant – without treatment. Data on the biological efficiency of a preparation are presented in Table 2.

Table 2. Biological efficiency of Pecilomicine-B against greenhouse whitefly, (cucumber, TSHA 14-27 F_1, soil ground, Republican Ecological Educational Center, 2003)
2 lentelė. Pecilomicine-B biologinis efektyvumas nuo šiltadaržinių baltasparnių (agurkai, TSHA 14-27 F_1, dirvožemis, Respublikinis ekologijos švietimo centras, 2003 m.)

	Days from the start of the experiment Dienos nuo bandymo pradžios					
	3	6	9	13	16	24
Pecilomicine-B, PS biological efficiency Pecilomicine-B biologinis efektyvumas (%)	31.9	27.4	45.0	34.9	68.0	69.4

In 2004 there were trials on the evaluation of the efficiency of the preparation Pecilomicine-B application against cucumber midge. Researches were carried out in greenhouse farm "Zhdanovichy" by cucumber growing using small-volume hydroponics on rockwool ('Mystica' F_1) and in the greenhouse farm "Oziorny" under soil ground conditions ('Turnir' F_1). According to the results of records concerning cucumber midge number within 3–4 weeks after treatment, there was its stabilization (farm "Oziorny") or a decrease (farm "Zhdanovichy") (Table 3). Afterwards, there was an increase in imago number what was connected with the flight of a new phytophage generation. In control variant, the pest number on 14th day after treatment increased 2.5 times, on 21st day – 8 times.

Table 3. Biological efficiency of Pecilomicine-B against cucumber midge (*Bradysia brunnipes* Mg.)
3 lentelė. Pecilomicine-B biologinis efektyvumas nuo uodelių (*Bradysia brunnipes* Mg.)

Variant Variantas	Pest number before treatment, imago Kenkėjų skaičius prieš apdorojimą, suaugėliai (cm^2)	Imago number Suaugėlių skaičius (cm^2) Biological efficiency Biologinis efektyvumas (%) days after treatment dienos po apdorojimo			
		7	14	21	28
Cucumber 'Mystica' F_1, rock wool, greenhouse farm "Zhdanovichy", 2004 Agurkai 'Mystica' F_1, akmens vata, šiltnamių ūkis "Zhdanovichy", 2004 m.					
Pecilomicine-B, PS (40 kg/ha)	0.12	0.06 50.0	0.02 83.3	0.04 66.6	0.03 75.0
Cucumber 'Turnir' F_1, soil ground, greenhouse farm "Oziorny", 2004 Agurkai 'Turnir F1', dirvožemis, šiltnamių ūkis "Oziorny", 2004					
Pecilomicine-B, PS (40 kg/ha)	0.22	0.21 35.8	0.31 40.0	0.37 71.5	-
Control (water irrigation) Kontrolė (drėkinimas vandeniu)	0.21	0.28	0.53	1.72	-
LSD_{05} / R_{05}	-	-	-	0.48	-

To study the influence of Pecilomicine-B application on encarsia there were the researches done under greenhouse conditions (greenhouse farm "DorOrs") on tomato 'Raissa' F_1. In all the area of greenhouse in the focuses of whitefly occurrence encarsia was released at the rate predator: victim = 1 : 10. In 12 days after the entomophage release, greenhouse whiteflies (110–130 indiv./leaf) were treated with Pecilomicine-B (1 %). Pecilomicine-B action on encarsia was estimated by a quantity of whitefly infected larvae and flying out encarsia imago, presented in Table 4.

Table 4. Influence of Pecilomicine-B on encarsia (*Encarsia formosa* Gahan.) survival (tomato 'Raissa' F_1, greenhouse farm "DorOrs", 2005)
4 lentelė. Pecilomicine-B įtaka enkarzijų (*Encarsia formosa* Gahan.) išlikimui (pomidorai 'Raissa' F_1 , šiltnamių ūkis "DorOrs", 2005)

Variant Variantas	Average number of the infected larvae in the sample (indiv.) Vidutinis užkrėstų lervų skaičius pavyzdyje, individai	Average number of flying out encarsia imago (indiv.) Vidutinis išskridusių enkarzijų suaugėlių skaičius, individai	Survival of encarsia imago Enkarzijų suaugėlių išlikimo (%)
Pecilomicine-B, PS	157	142.7	91.7
Control (without treatment) Kontrolė (be apdorojimo)	167	152.5	87.4
LSD_{05} / R_{05}		7.8	

The next experiment was carried out for studying the influence of Pecilomicine-B on phytoseiulus survival rate and its ability to reproduce (greenhouse farm "Zhdanovichy", 2006). Soybean plants with the entomophage culture were treated with preparation (1 %). Phytoseiulus number in the control (without treatment) increased 2.3 times (up to 134 individuals), on Pecilomicine-B treated plot – 2.6 times (up to 146) for 12 days (Fig. 2).

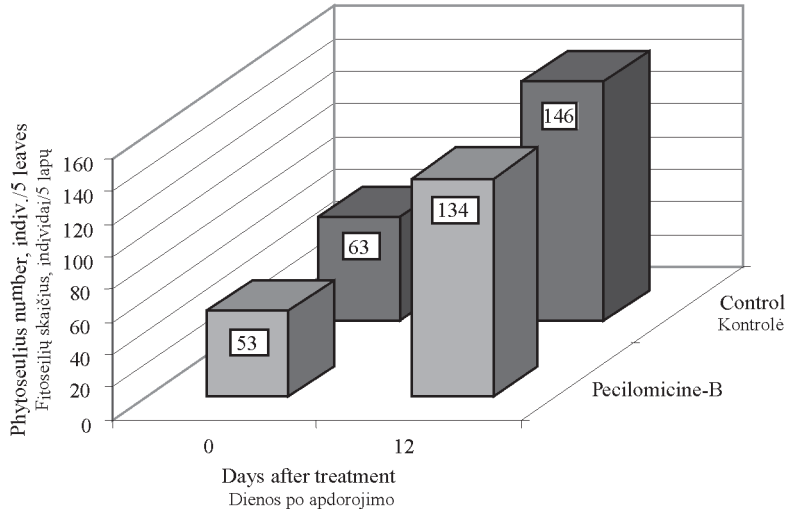

Fig. 2. Influence of Pecilomicine-B on phytoseiulus *Phytoseuilus persimilis* Ath. (greenhouse farm "Zhdanovichy", soybean, 2006)
2 pav. Pecilomicine-B įtaka fitoseiliams (*Phytoseiulus persimilis* Ath.) (šiltnamių ūkis "Zhdanovichy", sojų pupelės, 2006 m.)

Discussion. There are recommendations on the expediency of pest economic thresholds of harmfulness to use as a reference point for plant protection products application (including the biological ones) against it. So, according to the data presented by V. A. Pavlyushin and his co-workers (2001), for greenhouse whitefly it makes 40 individuals of different development stages per cucumber leaf and 10 individuals per tomato leaf. At the same time there is an opinion that the use of indicators of thresholds of harmfulness in the greenhouses where action of limiting factors of the environment on dynamics of phytophage populations number is considerably weakened is inadequate to situation. Martens (1993), Osborne, Landa (1992), Faria et al. (2001) recommend for increasing the efficiency of *P. fumosoroseus* application to carry out mycoinsecticide treatments during occurrence of early stages of tobacco whitefly development (from the moment of the first whitefly imago appearance and not more than 1 imago per plant). The results of our researches showed that the most effective Pecilomicine-B action (the biological efficiency up to 100 %) on the phytophage is observed in case of consecutive application of a preparation beginning at the initial stage of greenhouse crop plantings colonization by whitefly (right after the first imago occurrence in plants). Therefore, in pest population the necessary "patho-

genic press" is initially created. Thus, a full suppression of population development was noticed within 14–30 days, while in the control variant larvae number increased. Similar dependence was observed in the experiments on the efficiency of Pecilomicine-B on cucumber midge. As it is seen in Table 3, higher biological efficiency of a preparation (83.3 %) has been noted in case smaller initial cucumber midge number (0.12 imago/cm^2). Nevertheless, in case of significant initial pest larvae number (whitefly – 20–82 larvae per 25 registration leaves, cucumber midge – 0.22 imago/cm^2) the application of a preparation has appeared sufficient (60–88 % for whitefly, 35.0–71.5 % for cucumber midge) to lower considerably speed of pest population increase.

Availability of insecticidal properties in entomopathogenic fungi assumes a possibility of their influence not only on target objects, but also on pest entomophages and parasites. In this connection a number of authors (Павлюшин, Агансонова, 1994; Павлюшин, 1996) consider a combination of mycoinsecticides and useful insects in the protection systems problematic. There are messages on a competition between entomophage and pathogen in relation to host, resulting in efficiency decrease of both agents (Соловей, Забудская, 1985). Nevertheless, the results of many researches testify to the absence of negative action of fungi on certain useful insect species (Михневич, Климпиня, 1988; Roditakis et al., 2001; Alma et al., 2007). Also the increase of entomophage activity with the combined use of biological preparations is marked, caused by immunity decrease in noxious insects to parasites as a result of their organism weakening under the pathogen influence (Исаева, 1976). Our evaluation of Pecilomicine-B action on arthropods at combined application under greenhouse conditions and also the results of our preliminary laboratory and vegetative experiments (Прищепа et al., 2007) testify the absence of the negative preparation action on survival, ability to reproduce, predatory and parasitic activity of phytoseiulus and encarsia.

Conclusions. 1. It is the most expedient to start the application of Pecilomicine-B at a stage of primary colonization of greenhouse crop plantings by phytophages: in case with greenhouse whitefly – at occurrence of the first imago on plant leaves by carrying out 2 treatments at 7–14 days interval. Later on, Pecilomicine-B (1 % concentration) is applied up to 4 times considering the dynamics of greenhouse whitefly number, namely in case of its stable increase. It allows avoiding within 1.5–2 months the intensive increase of phytophage number without chemical plant protection products application. Against cucumber midge it is expedient to apply Pecilomicine-B (4 % concentration up to 2 times at 23–27 days interval) with the beginning of mass pest imago flight.

2. Application of Pecilomicine-B in greenhouses in a combination with the release of phytoseiulus and encarsia (at 7–14 days interval) does not render a negative influence on survival, reproduction, parasitic and predatory activity of entomophages and does not decrease the efficiency of their action.

3. Pecilomicine-B application according to the above-mentioned parameters allows constraining phytophage population number at economically imperceptible level.

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Biologinio insekticido Pecilomicine-B poveikis šiltnamio kenkėjams

A. Yankouskaya

Santrauka

Šiltnamio sąlygomis buvo įvertinta kai kurių technologinių parametrų (terminų, apdorojimų skaičiaus ir intervalų tarp jų) įtaka biologiniam bioinsekticido Pecilomicine-B poveikiui šiltadaržinio baltasparniui (*Trialeurodes vaporariorum* Westw.), uodeliams (*Bradysia brunnipes* Mg.), entomofagams – enkarzijoms (*Encarsia formosa* Gahan.) ir fitoseiliams (*Phytoseiulus persimilis* Ath.). Nustatyta, kad efektyviausia naudoti Pecilomicine-B, vos tik ant šiltnamio augalų pasirodo fitofagai: šiltadaržinio baltasparnio atveju – kai ant lapų pasirodo pirmieji suaugėliai, kas 7–14 dienų apdorojant juos du kartus. Vėliau 1 % koncentracijos Pecilomicine-B naudojamas iki 4 kartų, priklausomai nuo šiltadaržinio baltasparnio populiacijos gausumo (jeigu jų gausumas didėja). Tai leidžia 1,5–2 mėnesius be cheminių augalų apsaugos priemonių išlaikyti fitofagų populiaciją ekonomiškai nežalingame lygyje. Nuo uodelių šiuo preparatu (4 % koncentracijos) reikėtų apdoroti iki 2 kartų kas 23–27 dienos suaugėlių masinio skraidymo pradžioje. Kai Pecilomicine-B naudojamas šiltnamio sąlygomis (kas 7–14 dienų) kartu su fitoseiliais ir enkarzijomis, jis nedaro neigiamos įtakos entomofagų išlikimui, dauginimuisi, parazitinei bei grobuoniškai veiklai ir nesumažina jų efektyvumo. Naudojant Pecilomicine-B pagal minėtuosius technologinius parametrus, galima išlaikyti fitofagų populiacijas ekonomiškai nežalingame lygyje.

Reikšminiai žodžiai: bioinsekticidų efektyvumas, bioinsekticidų įtaka entomofagams, *Bradysia brunnipes*, *Cucumis sativus*, *Encarsia formosa*, *Lycopersicon esculentum*, *Paecilomyces fumosoroseus*, Pecilomicine-B, *Phytoseiulus persimilis*, *Trialeurodes vaporariorum*.