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ЭФФЕКТИВНОСТЬ БИОЛОГИЧЕСКОЙ ЗАЩИТЫ КАПУСТЫ ОТ ВРЕДИТЕЛЕЙ В УСЛОВИЯХ ПРИМОРСКОГО КРАЯ

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Представлены результаты использования энтомофага и биопрепаратов для регуляции численности вредителей капусты (капустной совки *Mamestra brassicae* L., капустной белянки *Pieris brassicae* L., репной белянки *Pieris rapae* L., капустной моли *Plutella xylostella* L.). Исследования проведены в условиях Приморского края в 2018–2020 гг. Осуществлена оценка эффективности применения *Trichogramma ussuricum* Sorokina на различных сортах капусты. Эффективность энтомофага против капустной совки варьировала от 33,3 до 66,6%, против репной белянки – от 32,6 до 70,2%. В полевых экспериментах изучена эффективность биологических препаратов Фитоверм, КЭ (0,09 л/га), Акарин, КЭ (1,6 л/га), Проклэйм, ВРГ (0,3 кг/га), Битоксибациллин, Ж (10 л/га), Битоксибациллин, П (2 кг/га), Лепидоцид, СК (2 л/га), Лепидоцид, П (2 кг/га) против капустной моли. Растения капусты опрыскивали препаратами однократно. Учеты численности вредителя проводили до обработки и после обработки на 5, 10, 15-е сутки в соответствии с утвержденными методиками. Высокую эффективность 93–100% на 5–10-е сутки показал биоинсектицид Проклэйм. Эффективность препаратов на основе аверсектина С и акарина N составила 65,0–88,6%. При использовании биопрепаратов Битоксибациллин и Лепидоцид наблюдали снижение численности капустной моли относительно контроля на 61,2–97,5 и 65,0–78,0%.

Ключевые слова: капуста, вредители, энтомофаг, трихограмма, биологическая защита, биоинсектициды, биопрепараты, эффективность

EFFECTIVENESS OF BIOLOGICAL PROTECTION OF CABBAGE AGAINST PESTS IN THE CONDITIONS OF THE PRIMORSKY TERRITORY

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The results of the use of entomophages and biological products to regulate the number of cabbage pests (cabbage moth *Mamestra brassicae* L., cabbage butterfly *Pieris brassicae* L., turnip butterfly *Pieris rapae* L., diamondback moth *Plutella xylostella* L.) are presented. The study was carried out in the Primorsky Territory in 2018-2020. The efficiency of *Trichogramma ussuricum* Sorokina applications was assessed on cabbage varieties. The effectiveness of the entomophage against the cabbage moth varied from 33.3 to 66.6%, against the turnip butterfly - from 32.6 to 70.2%. In field experiments the effectiveness of biological products Fitoverm EC (0.09 l/ha), Akarin EC (1.6 l/ha),

Proclaim WG (0.3 kg/ha), Bitoxibacillin (10 l/ha), Bitoxibacillin P (2 kg/ha), Lepidocid SC (2 l/ha), Lepidocid P (2 kg/ha) against diamondback moth are studied. Cabbage plants were sprayed with the preparations once. Pest counts were carried out before treatment and after treatment on the 5th, 10th and 15th day in accordance with the approved methods. Bioinsecticide Proclaim showed a high efficiency of 93.0-100% on the 5-10th day. The effectiveness of preparations based on aversectin C and avertin N was 65.0-88.6%. Using the biological product Bitoxibacillin and Lepidocid a decrease the number of diamondback moth relative to the control by 61.2-97.5 и 65.0-78.0% was registered.

Keywords: cabbage, pests, entomophage, Trichogramma, biological protection, bioinsecticides, biological products, effectiveness

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INTRODUCTION

Cabbage is one of the most important vegetable crops in the Primorsky Territory in terms of food value and area occupied. Throughout the growing season, cabbage is damaged by leafhoppers such as diamondback moth (*Plutella xylostella* L.), cabbage moth (*Mamestra brassicae* L.), cabbage butterfly (*Pieris brassicae* L.) and turnip butterfly (*Pieris rapae* L.). Chemical control measures are carried out in the region. This leads to a significant accumulation of pesticides in food crops and has a negative effect on useful entomofauna. Biocenotic relationships are disrupted, resulting in an increase in numbers of some pest species and the development of resistance of populations to pesticides in others. Increasing crop productivity and improving crop quality are the most pressing problems of modern crop production, which can be solved by effectively optimizing the phytosanitary state of agroecosystems based on the use of environmentally low-hazard plant protection products [1]. An important part of environmentally safe systems of protection of vegetable crops is the use of agronomic methods that reduce the rate of pest reproduction and increase the resistance of plants to damage [2]. Biorational preparations based on the products of microorganisms are increasingly being used in agriculture. Fitoverm, EC, a bioinsecticide based on natural metabolites of *Streptomyces avermitilis*, shows sufficient effectiveness against leaf-eating pests [3]. The preparations based on the bacterium Bacillus thuringiensis (Bt) are effective and widely used insect pest control agents [4-8]. Entomophages play a special role in regulating the number of phytophages on cabbage [9, 10]. In the Primorsky Territory, 17 species of parasites damaging cabbage belong to five families according to their systematic position: Ichneumonidae, Braconidae, Tachinidae, Pteromalidae and Trichogrammatidae. Efficacy is 40-61% at the beginning of the growing season and 60-90% at the end[1].

One of the most important natural enemies of lepidopteran pests is Trichogramma (Hymenoptera, Trichogrammatidae). Under the conditions of the Primorsky Territory, work has been carried out to identify local Trichogramma species. The effectiveness of *Trichogramma evanescens* Westw. against pests on cabbage was established [11]. In the process of research, a new species *Trichogramma ussuricum* Sorokina was identified from the infected cabbage moth eggs. The richness of the parasite fauna

[1]Potemkina V.I. Cabbage pests and control measures using biological means. Ussuriysk, 2003. 59 p.

and the detection of local Trichogramma gives grounds for the development of a set of methods of biological control of lepidopteran pests using entomophages and entomopathogens.

The aim of the research was to evaluate the effectiveness of preparations of biological origin and the regulatory role of *Trichogramma ussuricum* in reducing the number of pests on cabbage.

MATERIAL AND METHODS

Studies on cabbage protection against major pests were conducted in the Primorsky Territory (Vozdvizhenka village) in 2018-2020. Research objects: cabbage varieties, pests of Lepidoptera order, *Trichogramma ussuricum* Sorokina. Experimental seedlings were grown in greenhouses. Planting in the open ground was carried out in the I decade of June. Studies to determine the biological efficacy of T. *ussuricum* entomophage were conducted on white cabbage varieties Podarok, Slava, Iyunskaya, Kazachok. The size of experimental plots was 8.4 m^2. Replication was carried out three times. Entomophage breeding was carried out on the eggs of grain moth *Sitotroga cerealella* Oliv. To determine the timing of trichogramma release, the number of pest eggs was counted by visual inspection of 10 plants. Point releases of the parasite were conducted in June-August at intervals of 5-7 days (at the rate of 300,000 individuals/ha). Ten releases were conducted in 2018, seven in 2019 and six in 2020. Trichogramma efficacy was determined by the degree of infestation of eggs by the entomophage, by the number of pest caterpillars.

The study of the effectiveness of the preparations was carried out on a medium-ripening white cabbage variety Slava 1305. We used Fitoverm, EC (aversectin C, 50 g/l) at the rate of 0.09 l/ha (NBC Pharmbiomed Ltd.); Akarin, EC (avertin N, 2 g/l. avertin N, 2 g/l) - 1.6 l/ha; Proclaim, WG (amamectin benzoate, 50 g/kg) - 0.3 kg/ha; Bitoxibacillin, G (Bacillus thuringiensis, strain BtH1) - 10 l/ha (FSBSI VNIISKHM); Bitoxibacillin, P (Bacillus thuringiensis var. thuringiensis) - 2 kg/ha; Lepidocid, P (Bacillus thuringiensis var. kurstaki) - 2.0 kg/ha; Lepidocid, SC (Bacillus thuringiensis var. kurstaki) - 2.0 l/ha (IA Sibbiofarm Ltd.). The cabbage plants were sprayed with the preparations once. Repeatability is three times. Plot area was 11.2 m^2. Pests were counted by visual inspection of 10 plants in each repetition before treatment and after treatment on the 5th, 10th and 15th days according to the approved methods[2]. Biological efficacy of the preparations was determined by pest reduction, corrected for control, and calculated using the Henderson and Tilton formula (see footnote 1). Statistical processing of the data was carried out according to B.A. Dospekhov[3].

RESULTS AND DISCUSSION

Natural Trichogramma in the Primorsky Territory conditions is not significant in limiting the number of cabbage pests. In our experiments *Trichogramma ussuricum* was used by the method of seasonal colonization. The identification of local Trichogramma species and study of their efficiency is very promising, because it helps to solve the problems of entomophage selection with wide ecological plasticity and adaptability to abiotic and biotic factors of the area.

In order to obtain a high effect from the application of Trichogramma egg parasite release was timed to coincide with the initial egg-laying period of the pests. Cabbage moth and cabbage butterfly had no economic importance during the years of study. Infestation of cabbage by cabbage butterflies was low (3.3-5.2%). Single butterfly egg clutches were recorded in 2018 and 2020 on the variety Slava. The biological efficacy of Trichogramma against this pest was recorded at 37.0%. First generation cabbage moths preferred early maturing (Iyunskaya, Kazachok) and medium maturing varieties (Slava) for egg laying. The number of eggs per plant varied from year to year. In the variety Iyunskaya there were 0.9 to 1.5 eggs/plant at the beginning of vegetation (1.3 on average)

[2]Methodological guidelines for registration trials of insecticides, acaricides, molluscicides and rodenticides in agriculture. SPb.: VIZR, 2009. 321 p.

[3]Dospekhov B.A. Methodology of field experience. Moscow: Kolos. 1985. 336 p.

and 1.5 to 2.5 in mid vegetation (2.0 on average), in the variety Slava - 1.3 to 3.3 eggs/plant. Trichogramma efficacy (33.3%) was observed only on the variety Kazachok (see Table 1). In 2018 cabbage moth eggs were 100% infested, in 2019 and 2020 the efficiency averaged 56 and 44%.

Oviposition of the second generation of moths was observed in the varieties Slava and Podarok with 1.6 and 3.5 eggs/plant, respectively. Against the second generation of the cabbage moth the greatest effect was obtained when the entomophage was released (from 50.0 to 66.6% of egg infestation). Oviposition of turnip butterfly was found on plants throughout the growing season. For egg laying, turnip moths more often chose the leaves of plants of varieties Iyunskaya, Slava and Podarok. A lower number of eggs was observed in the variety Kazachok during the years of study. Infestation of turnip butterfly eggs by Trichogramma spp. was observed in July; entomophage efficiency in white cabbage varieties of different ripeness groups averaged 32.6% to 43.7% in 3 years, in August - 36.5% to 70.2%. Surveys of cabbage leaf-eating pests showed low abundance of 0.03 (cabbage moth) to 0.09 (turnip butterfly) caterpillars/plant.

Among leaf-eating lepidopteran cabbage pests, the cabbage moth was the most abundant during the years of study. This phytophage is currently a dangerous pest of cabbage crops in Russia[4]. Infestation of cabbage plants by the pest in the years of study was observed in the third decade of June (in 2018 at the beginning of the decade, in 2019 and 2020 at the end of the decade). In 2018, cabbage moth abundance during the growing season was low (0.2-0.5 caterpillars/plant), limited by precipitation, with 75.4-138.8 mm in June-July. Optimum precipitation conditions during the second and third generations of the pest were between 30-45 mm. Hydrothermal conditions in 2019, 2020 were more favorable for the cabbage moth.

According to the results of field trials (see Table 2), the bioinsecticide Proclaim has a strong toxic effect on cabbage moths. Caterpillar mortality on the 5th day after treatment was 93.0%. The maximum effect (100%) was achieved on the 10th day. Proclaim provided plant protection on the 15th day, the phytophage population was 0.1 caterpillars/plant, while the control - 0.5 caterpillars/plant. Under Fitoverm application the number of caterpillars decreased by 7.0-11.6 times. The efficiency of

Табл. 1. Эффективность *Trichogramma ussuricum* против вредителей капусты (среднее за 2018–2020 гг.)

Table 1. Effectiveness of *Trichogramma ussuricum* against cabbage pests (average for 2018–2020)

Variety	Cabbage moth			Turnip butterfly		
	Period					
	June	July	August	June	July	August
Average number of eggs per plant						
Iyunskaya	1,3 ± 0,20	2,0 ± 0,34	0	0,9 ± 0,06	2,0 ± 0,23	1,6 ± 0,34
Kazachok	0	1,2 ± 0,30	0	0,2 ± 0,06	0,8 ± 0,13	0,8 ± 0,06
Slava	2,3 ± 0,68	0	1,6 ± 0,13	0	2,1 ± 0,47	2,3 ± 0,27
Podarok	0	0	3,5 ± 1,16	0	2,0 ± 0,27	1,5 ± 0,47
Trichogramma infestation, %						
Iyunskaya	0	0	0	0	43,7 ± 10,5	55,5 ± 10,5
Kazachok	0	33,3 ± 8,1	0	0	30,6 ± 1,43	46,0 ± 8,55
Slava	0	0	50,0 ± 12,2	0	34,0 ± 4,33	70,2 ± 2,72
Podarok	0	0	66,6 ± 19,0	0	32,6 ± 4,09	36,5 ± 6,13

[4]Opiakin P.Ya., Dolzhenko V.I., Ivanova G.P. Modern insecticides for protection of cabbage white cabbage from cabbage moth. Scientific support of development of agroindustrial complex in the conditions of import substitution: materials of international scientific and practical conference. SPb. pp. 59-62.

the preparation was registered at the level of 75,0-88,6%. Significant differences in the effect of these preparations on cabbage moth caterpillars on the 10th day after treatment were noted. The efficacy of Avertin N-based Akarin was significantly lower (65.0-72.0%). When using microbial preparations based on *Bacillus thuringiensis*, the greatest reduction in caterpillar numbers was observed in the variant with Bitoxibacillin, P (80.0-97.5%). The efficacy of Bitoxibacillin, G was significantly lower, the reduction in the number of caterpillars did not exceed 67.2%. The bacterial preparation Lepidocide showed low efficiency of 65.0% on the 5th day. Strengthening of the toxic action was observed by the 10th day after the treatment, and the decrease in the number of caterpillars was 70,8-78,0%. The effectiveness of bacterial insecticides depends on the preparative form[5]. The studies have shown that Lepidocid, SC was more effective against cabbage moths than Lepidocid, P.

CONCLUSION

As a result of this research, the possibility of using the entomophage *Trichogramma ussuricum* Sorokina and biopreparations to regulate the number of cabbage pests has been established. Application of Trichogramma by dispersal in white cabbage plantations reduced the cabbage moth population by 33.3-66.6% and the turnip butterfly population by 32.6-70.2%. The level of efficacy of *Streptomyces avermitilis* metabolite complex-based preparations against cabbage moths was 65-100%. The bioinsecticide Proclaim showed high efficiency (93-100%). Microbiological preparations reduced the number of caterpillars by 65.0-97.5%. The highest efficiency (80,0-97,5%) was observed in application of Bitoxibacillin, P. The use of parasiticides, bioinsecticides and microbiological preparations in cabbage protection allows reducing the application of chemical pesticides and obtaining ecologically clean products.

Табл. 2. Эффективность биоинсектицидов против капустной моли (среднее за 2018–2020 гг., сорт Слава 1305)

Table 2. Effectiveness of bioinsecticides against diamondback moth (average for 2018–2020, of Slava cabbage 1305)

Option	Rate of application of the preparation, l/ha, kg/ha	Average number of caterpillars, individuals per plant				Decrease in pest numbers relative to the baseline, corrected for control after treatment by record days, %		
		before treatment	After treatment by record days					
			5	10	15	5	10	15
Control	–	0,7	0,5	0,4	0,5	–	–	–
Fitoverm, EC	0,09	0,7	0,06	0,1	0,1	88,6	75,0	80,0
Akarin, EC	1,6	1,0	0,2	0,2	0,3	72,0	65,0	80,0
Proclaim, WG	0,3	0,6	0,03	0	0,1	93,0	100	76,7
Bitoxibacillin, G	10,0	1,6	0,3	0,3	0,4	61,2	67,2	65,0
Bitoxibacillin, P	2,0	0,7	0,1	0,01	0,1	80,0	97,5	80,0
Lepidocid, SC	2,0	1,2	0,3	0,2	0,2	65,0	78,0	76,6
Lepidocid, P	2,0	0,8	0,2	0,1	0,2	65,0	70,8	65,0
LSD_{05}	–	–	–	–	–	9,3	7,8	10,5

[5]Dolzhenko T.V. Biologization and ecological optimization of the assortment of means of protection of agricultural crops from pests: thesis of Doctor of Science in Biology. SPb; Pushkin, 2017. 301 p.

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