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ЗАЩИТА РАСТЕНИЙ СОИ ОТ ФИТОФАГОВ В УСЛОВИЯХ ПРИМОРСКОГО КРАЯ

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Изучена эффективность предпосевной обработки семян сои и применения биорациональных инсектицидов в снижении численности основных вредителей сои в условиях Приморского края. Представлены результаты использования инсектицидов и биопрепаратов для регуляции численности доминантных вредителей сои. Исследования проведены в 2020 и 2021 гг. В полевых экспериментах изучена эффективность инсектицидных протравителей Имидор Про, КС (2,0 л/т) и Табу, ВСК (1,0 л/т), биоинсектицидов Фитоверм, КЭ (0,16 л/га), Проклэйм, ВРГ (0,3 кг/га), Бацикол, Ж (15 л/га), Биослип БВ, Ж (2 л/га), Биослип БТ, П (2 кг/га) против листоеда соевого полосатого (*Medythia nigrobilineatus* Motsch.) и плодожорки соевой (*Leguminivora glycinivorella* Mats.). Предпосевная обработка семян инсектицидами Имидор Про и Табу снижала поврежденность растений сои в фазу всходов жуками *Medythia nigrobilineatus* по сравнению с контролем на 94,0–98,2%. Протравливание семян препаратами на основе имидаклоприда обеспечивало эффективную защиту посевов культуры против вредителя в фазы всходы – ветвление. Высокую биологическую эффективность (71,1–98,8%) на 5–10-е сутки после обработки против листоеда соевого полосатого показали биорациональные инсектициды на основе аверсектина С и *Bacillus thuringiensis.* Поврежденность семян сои при использовании биоинсектицидов против *Leguminivora glycinivorella* составила 1,9–3,0% в сравнении с 5,6% в контроле. Проведенные исследования свидетельствуют о перспективности применения препаратов биологического происхождения для контроля численности доминантных вредителей в посевах сои.

Ключевые слова: соя, насекомые-фитофаги, инсектициды, биорациональные инсектициды, биологическая эффективность

PROTECTION OF SOYBEAN PLANTS FROM PHYTOPHAGES UNDER CONDITIONS OF THE PRIMORSKY TERRITORY

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The effectiveness of pre-sowing treatment of soybean seeds and application of biorational insecticides in reducing the number of major pests of soybean in the conditions of the Primorsky Territory have been studied. The results of using insecticides and biopreparations to regulate the number

of dominant pests of soybean have been presented. The studies were conducted in 2020 and 2021. The efficiency of insecticidal protectants Imidor Pro, SC (2 l/t) and Tabu, WSC (1.0 l/t), bioinsecticides Fitoverm, EC (0, 16 l/ha), Proclaim, WSG (0.3 kg/ha), Batsikol, L (15 l/ha), Biosleep BW, L (2 l/ha), Biosleep BT, P (2 kg/ha) against two-striped leaf beetle (*Medythia nigrobilineatus* Motsch.) and soybean pod borer (*Leguminivora glycinivorella* Mats.) were studied. Pre-sowing seed treatment with insecticides Imidor Pro and Tabu reduced damage of soybean plants in the sprouting phase by *Medythia nigrobilineatus* beetles compared to the control by 94.0–98.2%. Seed dressing with imidacloprid-based preparations provided effective protection of crops against the pest in the sprouting – branching phase. Biorational insecticides based on avermectin C and *Bacillus thuringiensis* showed high biological efficacy (71.1–98.8%) on the 5–10th day after treatment against the two-striped leaf beetle. Soybean seed damage when bioinsecticides were used against *Leguminivora glycinivorella* was 1.9–3.0% compared to 5.6% in the control. The conducted studies testify to the prospect of using the preparations of biological origin to control the number of dominant pests in soybean crops.

Keywords: soybean, phytophagous insects, insecticides, biorational insecticides, biological effectiveness

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INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is the dominant agricultural crop in the Primorsky Territory. The sown areas in the region are gradually increasing: in 2021, they amounted to 277,000 hectares, and in 2022 – 345,000 hectares.

The main factors limiting the yield growth of this crop are harmful organisms: phytophages of various families, phytopathogens of fungal, bacterial, and viral nature, and weeds. The fauna of soybean pests in the region is represented by polyphagous species. These include sod webworm, noctuid moths, soybean yellow butterfly, aphids, bugs, and polyphagous soybean leaf beetle. Among the dominant and most widespread are specialized pests of the crop: two-striped leaf beetle (*Medythia nigrobilineatus* Motsch. (= *Paraluperodes suturalis nigrobilineatus* Motsch.)), soybean pod borer (*Leguminivora glycinivorella* Mats.)[1]. In other regions of Russia and abroad, the dominant soybean pests include the cotton budworm (*Helicoverpa armigera* Hbn.), lima-bean pod borer (*Etiella zinckenella* Tr.), and dusky stink bug (*Nezara viriduta* L.) [1–3].

Two-striped leaf beetle causes significant damage to the crop's seedlings. Both larvae and adult beetles are harmful. The beetles gnaw pits on the lower side of the cotyledons and sometimes damage young stems. Harmfulness of the phytophage increases in dry warm weather. The damage caused by the pest during this phase can lead to plant death. The larvae live in the soil, penetrate the nodules, and feed on their contents. Damage to the nodules reduces soil nitrogen enrichment, decreasing soy's role as a forecrop in crop rotation. The damage caused to soybean plantings by the soybean pod borer results in not only yield losses but also a reduction in seed quality. Inside the pods, caterpillars eat the seeds, and damage to the hilum and embryo often leads to a complete loss of germination [4].

[1]*Mashchenko N.V.* The most common pests of soybean in the Amur region and measures to combat them: method. manual. Blagoveshchensk: Publishing house DEI "Zeya", 2012, 32 p.

Increasing soybean productivity and improving crop quality depend on the effectiveness of protecting the crop from harmful organisms. Therefore, the issue of protecting soybeans from pests remains relevant. Most protective measures for soybean crops are based on chemical means, the range of which is constantly being improved, and the share of combined preparations is increasing [5–7]. Pre-sowing seed treatment is the most environmentally safe and effective way to use pesticides for regulating the numbers and reducing the harmfulness of phytophages at the early stages of plant development [8–10]. Using biological means of protection is one way to reduce the pesticide load on the agroecosystem. Research conducted in our country and abroad shows the prospects of using bioinsecticides based on actinomycetes, *Bacillus thuringiensis*, *Beauveria bassiana* against pests in soybean crops [1, 8, 11–12].

Research is needed to assess their effectiveness in specific agroclimatic conditions to include biological-origin products in the soybean plant protection system.

The purpose of the study is to investigate the effectiveness of pre-sowing soybean seed treatment and the use of bio-rational insecticides in reducing the number of main soybean pests in the Primorsky Territory.

MATERIAL AND METHODS

Research on protecting soybean crops from key phytophages was carried out at the Federal Scientific Center of Agricultural Biotechnology of the Far East named after A.K. Chaiki. The subjects of the study were *Medythia nigrobilineatus* Motsch. (Coleoptera: Chrysomelidae) and *Leguminivora glycinivorella* Mats. (Lepidoptera: Tortricidae). The study examined the influence of pre-sowing treatment of soybean seeds with the products Imidor Pro, SC (imidacloprid, 200 g/l; AO "Shchelkovo Agrokhim") and Tabu, WSC (imidacloprid, 500 g/l; AO "August") at usage rates of 2.0 and 1.0 l/t on the phytosanitary state of soybean crops. During vegetation, the plants were treated in the first ten-day period of June in the full emergence phase and in the first ten-day period of August in the flowering – bean formation phases. The following means of protecting soybean crops from phytophages were studied: Batsikol, L (*Bacillus thuringiensis*, FSBSI VNIISKhM), Biosleep BW, L (*Beauveria bassiana*, OOO "Organic Park"), Biosleep BT, P (*Bacillus thuringiensis*, OOO "Organic Park"), Fitoverm, EC (avermectin C, 50 g/l, OOO SBC "Farmbiometservice"), Proclaim, WSG (amamectin benzoate, 50 g/kg, OOO "Syngenta"), Biokill, EC (abamectin, 10 g/l, OOO "Vashe Khozyaistvo").

The effectiveness of bioinsecticides was studied in comparison with the use of the insecticide Espero, SC (imidacloprid, 200 g/l + alpha-cypermethrin, 120 g/l; AO "Shchelkovo Agrokhim"). The Primorskaya 86 soybean variety was used in the experiment. Sowing was carried out in the third ten-day period of May in 2020 and 2021. The forecrop was cereal crops, with a four-fold repetition, and the plot area was 10.8 m². The working fluid usage rate for seed treatment was 10 l/t, and for spraying vegetating plants, it was 400 l/ha. Counts of the number of two-striped leaf beetle and the damage caused by soybean pod borer to the soybean pods were carried out in accordance with the guidelines[2]. The biological effectiveness was calculated using the Abbott formula. The harvest was manually collected in the first ten-day period of October. The biological yield of soybean seeds (g/m²) was determined in four samples from an area of 0.25 m² in each repetition of all the variants of the experiment and recalculated per hectare. Statistical data processing was conducted according to B.A. Dospekhov[3].

RESULTS AND DISCUSSION

The settlement of soybean crops by two-striped leaf beetle was noted in the early first ten-day period of June in 2020 and 2021. The conducted counts showed that the pre-sowing

[2]Methodological guidelines for registration tests of insecticides, acaricides, molluscicides and rodenticides in agriculture / edited by V.I. Dolzhenko. SPb.: VIZR, 2009, 321 p.

[3]*Dospekhov B.A.* Methodology of field experiment (with the basics of statistical processing of research results). Moscow: Kolos, 1985, 336 p.

treatment of soybean seeds with Tabu and Imidor Pro preparations contributed to a decrease in seedling damage by the pest by 94.0% and 98.2% respectively, compared to the control (see Table 1).

High temperature regime and periodic precipitation in the second ten-day period of June in the years of research contributed to the activity and harmfulness of the phytophage.

The degree of leaf damage to soybean plants in the control group was 1.7 points, while in the variants with seed treatment, this indicator was significantly lower by 1.4 points. The biological effectiveness of insecticides against the pest ranged from 81.0% to 83.7%. In 2020, heavy rains at the end of the third ten-day period of June restrained the activity of the phytophage in the soybean crops, while hot, dry weather in 2021 was favorable for the development of two-striped leaf beetle. The effectiveness of the insecticides 14-21 days on average was at the level of 73.2% to 76.0%. No significant differences between the variants were noted.

The conducted assessments of soybean plant damage by the two-striped leaf beetle have shown that seed treatment with imidacloprid-based preparations provides effective protection for crop plantings against the pest from the germination to branching stages.

When treating mature soybean plants in the full emergence stage, bioinsecticides Batsikol and Fitoverm, applied on the 5th day after treatment, exhibited effectiveness against *M. nigrobilineatus* at the level of the chemical pesticide Espero (see Table 2). In the variants using the Biosleep product based on *B. bassiana* and *B. thuringiensis*, the effectiveness was significantly lower, ranging from 61.7% to 76.2%. On the

Табл. 1. Биологическая эффективность обработок семян сои протравителями против *M. nigrobilineatus* Motsch. (среднее за 2020, 2021 гг.)

Table 1. Biological effectiveness of soybean treatments by protectants against *M. nigrobilineatus* Motsch. (average for 2020 and 2021)

Experiment option	Average score of plant damage after adult emergence in the control by days of counting				Decrease in damage relative to the control by days of registration, %			
	3rd	7th	14th	21st	3rd	7th	14th	21st
Control	1,1	1,7	0,5	0,7	–	–	–	–
Imidor Pro, SC 2,0 l/t	0,05	0,3	0,1	0,2	94,0	83,7	76,0	74,0
Tabu, WSC, 1,0 l/t	0,03	0,3	0,2	0,1	98,2	81,0	73,2	75,9
LSD_{05}	0,4	0,5	0,1	0,1	4,7	3,8	7,1	7.1

Табл. 2. Биологическая эффективность биоинсектицидов против *M. nigrobilineatus* Motsch. в посевах сои (среднее за 2020, 2021 гг.)

Table 2. Biological effectiveness of bioinsecticides against *M. nigrobilineatus* Motsch. on soybean sowings (average for 2020 and 2021)

Experiment option	Preparation consumption rate, l/ha, kg/ha	Reduction of pest population relative to the control after treatment by days of counting, %		
		5th	10th	15th
Espero, SC	0,2	100 ± 0	92,4 ± 1,2	63,1 ± 1,7
Biosleep BW, L	2,0	61,7 ±1,0	54,3 ± 4,0	26,8 ± 1,5
Biosleep BT, P	2,0	76,2 ±2,5	71,1 ± 1,2	46,3 ± 0,9
Batsikol, L	15,0	98,8 ± 0,7	75,5 ± 2,6	46,2 ± 1,4
Fitoverm, EC	0,16	96,7 ± 1,0	84,9 ± 1,1	41,5 ± 1,1
LSD_{05}	–	4,5	6,3	4,0

Табл. 3. Биологическая эффективность препаратов в борьбе с соевой плодожоркой (среднее за 2020, 2021 гг.)

Table. 3. Biological effectiveness of preparations against *Leguminivora glycinivorella* Mats. (average for 2020 and 2021)

Experiment option	Preparation consumption rate, l/ha, kg/ha	Damaged beans, %	Reduced bean damage relative to the control, %	Yield, t/ha
Control	–	5,6	–	1,6
Biosleep BW, L	2,0	3,0	46,4 ± 1,1	1,8
Biosleep BT, P	2,0	2,6	53,6 ± 1,6	1,8
Proclaim, WSG	0,3	2,0	64,3 ± 1,2	1,9
Biokill, EC	0,4	1,9	66,0 ± 0,4	2,0
Espero, SC	0,2	0,9	83,9 ±1,3	2,2
LSD_{05}	–	0,3	2,6	0,2

10th day after treatment, Fitoverm demonstrated relatively high effectiveness (84.9%), while the reduction in pest population in variants using the Biosleep BT and Batsikol products was 71.1% and 75.5%, respectively. The lowest effectiveness (54.3%) was observed when using Biosleep BW. The conducted assessments have shown that the application of the above-mentioned preparations provides effective protection for soybean plants at the vulnerable emergence stage.

Treating soybean plants with preparations during the flowering and pod formation stages aims to reduce damage by the soybean pod borer. As the research has shown, when using bioinsecticides, the number of damaged soybean pods (1.9–3.0%) by soybean pod borers was significantly lower compared to the control (5.6%) (see Table 3). The highest effectiveness (64.3% and 66.0%) was observed with the preparations based on amamectin benzoate (Proclaim) and abamectin (Biokill). There were no significant differences between these variants. The effectiveness of Biosleep based on *B. bassiana* and *B. thuringiensis* was lower. Significant differences were observed in the reduction of soybean pod damage when using these two preparations. The use of the chemical pesticide Espero reduced pod damage by the pest by 83.9% compared to the control.

The use of bioinsecticides ensured the preservation of grain yield, with yield increases ranging from 0.2 to 0.4 tons per hectare.

CONCLUSIONS

1. As a result of the conducted research, the effectiveness of insecticidal and bioinsecticidal seed treatments in reducing the population of the two-striped leaf beetle and soybean pod borer damage has been established.

2. The use of Imidor Pro, SC, Tabu, WSC preparations contributed to reducing soybean emergence damage by *M. nigrobilineatus* compared to the control by 94.0–98.8%. Imidacloprid-based seed treatments provided effective protection for crop plantings against the two-striped leaf beetle in the germination to branching stages.

3. A single spraying of mature soybean plants with Fitoverm, Batsikol, Biosleep BT, and Biosleep BW preparations resulted in a reduction in the population of *M. nigrobilineatus* by 5–10 days compared to the control by 54.3–98.8%. Under the influence of Biosleep BW, Biosleep BT, Proclaim, and Biokill preparations, soybean pod damage by soybean pod borer decreased by 46.4–66.0%. The flight of butterflies and egg laying by soybean pod borers were delayed, and the protective effect of bioinsecticides lasted up to 14 days. Therefore, when using bio-rational insecticides, it is necessary to increase the frequency of treatments: the first treatment against *L. glycinivorella* should be carried out in the first ten-day period of August, and the second one after 2 weeks.

4. The results of the conducted research indicate the potential for using bio-preparations

based on actinomycetes *B. bassiana* and *B. thuringiensis* against pests in soybean crops to reduce the pesticide load on agroecosystems.

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