Using insecticides for the protection of maize plants against the Asian corn borer

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Abstract. Maize is a global leader among grain crops in terms of planting area. Its uniqueness is related to a high potential yield and versatility. There are a great number of pest species that significantly damage maize plants reducing the yield by 30-50 % sometimes and drastically decreasing grain quality. One of the most dangerous pests in Russia and overseas is the corn borer. The paper presents the research data on five insecticides with the following active ingredients (a.i.): emamectin benzoate (50 g/l), aversectin C (50 g/l), thiacloprid (100 g/l) + deltamethrin (10 g/l), imidacloprid (700 g/l) + alpha-cypermethrin (120 g/l), and lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l). Maize plants differed in the degree of damage to cobs and stalks depending on the product employed.Our research goal was to study the effectiveness of insecticides against the Asian corn borer (Ostrinia furnacalis Guenee). The research showed that the insecticides containing imidacloprid (700 g/l) + alpha-cypermethrin (120 g/l) and lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l) were the most effective against the Asian corn borer. No damage to maize ears, peduncles, and stalks was detected if these insecticides were applied. A high percentage of damaged ears and stalks was observed in the control variant (without pesticide application).

1 Introduction

Maize plays a special role in the global agricultural production being a staple crop. Zea mays is a multipurpose crop [1-2]. It is widely used for human food and livestock feed as well as in medicine and industry. Maize grain is rich in vitamins A, E, C, PP, D, K, and B vitamins. Ears of Zea mays contain valuable minerals such as salts of potassium, phosphorous, calcium, magnesium, and iron, and micronutrients; maize protein contains essential amino acids. Maize is an unmatched source of silage and able to produce up to 100 tons of highly nutritious herbage per hectare. One kilogram of maize silage contains up to 0.30 Russian feed units, 18 g of digestible protein, various vitamins, and other essential components. Due to its high content of nutrients, maize is considered one of the best plant species for the production of concentrated feed [3-5]. Additionally, Zea mays is a beneficial predecessor for other field crops because it leaves a high amount of organic residues after cultivation enriching the soil with nitrogen and increasing biological activity.

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The yield of maize depends mainly on the environmental, agricultural, and technological conditions of its cultivation. To achieve stable yield of high-quality maize grain, it is necessary to employ modern cultivation technologies, implement control measures against plant pathogens and pests, and use high-yielding and nutrient-rich varieties and hybrids [6-8].

Maize is highly sensitive to diseases and pests. The most dangerous diseases are maize smut, head smut, maize leaf blight, and seed mold. The most harmful pests are larvae of click beetles and aphids, the corn earworm, the corn borer, and the turnip moth. The annual yield loss caused by plant pathogens might amount to 30-40%; pests might decrease the yield by 10-30% [9-11].

A recent trend in the agricultural industry of Primorsky kray has been an increase in the production of maize for grain. However, farmers now have to face a serious threat to the production of Zea mays from Ostrinia furnacalis Gn. The Asian corn borer is widely spread in various regions of East, Southeast, and South Asia. The pest is found in the Russian Far East – in Amur oblast and Khabarovsky and Primorsky kray. The Asian corn borer produces one generation under the conditions of Primorsky kray. The stage of the pest development that causes damage to maize plants is larva. The degree and character of the caused damage depends on many factors, including the instar of the pest, the stage of plant development, and climatic conditions in a certain year. The damage caused to maize stalks, cobs, and pedicels is the most dangerous. Adult larvae hibernate inside maize stalks during winter. The developmental timing of the pest, especially pupation depends on the temperature and humidity.

The research conducted previously in the steppe zone of Primorsky kray revealed that all maize hybrids and varieties that are now cultivated in the region are susceptible to the Asian corn borer to one degree or another. This phytophage can cause a grain yield loss of 40 % [12]. For this reason, plant protection against pests are of considerable importance [13-15].

Our research goal was to study the effectiveness of insecticides against the Asian corn borer (Ostrinia furnacalis Guenee).

The research objectives were:

- To evaluate the influence of insecticides on the severity of the damage caused by the Asian corn borer Ostrinia furnacalis Guenee to maize plants.
- To determine the biological efficacy of the studied insecticides against the Asian corn borer Ostrinia furnacalis Guenee.

2 Materials and methods

The experiments were carried out in the steppe zone of Primorsky kray in the experimental fields of FSBSI "FSC of Agricultural Biotechnology of the Far East named after A.K. Chaiki" in 2021-2022.

The soil of the experimental plots was meadow-brown clay-loam soil with the following agrochemical parameters: the humus content was 3.08-3.13 %, the content of NO3 was 95-99 mg/kg, pH of the salt extract was 5.7-5.9, and the contents of P2O5 and K2O were 36-41 mg/kg and 85-90 mg/kg, respectively.

Monsoon climate is characteristic of the region. The sum of active temperatures above 10ºC was 2654ºC in 2021 and 2805.5oC in 2022. In terms of precipitation amount, the year of 2021 was subhumid (the Selyaninov's hydrothermal coefficient was 1.2), the conditions in 2022 were perhumid (the HTC was 2.3). The following insecticides were used: water-soluble granules with emamectin benzoate (50 g/l) as the active ingredient; concentrated aqueous emulsion with aversectin C (50 g/l); oil dispersion with thiacloprid (100 g/l) + deltamethrin (10 g/l); concentrated aqueous emulsion with imidacloprid (700 g/l) + alpha-

cypermethrin (120 g/l); and microencapsulated suspension with lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l).

The plan of the experiment included:

- The control variant (without insecticide application).
- Emamectin benzoate (50 g/l) at a rate of 0.3 kg/ha.
- Aversectin C (50 g/l) at a rate of 0.14 l/ha.
- Thiacloprid (100 g/l) + deltamethrin (10 g/l) at a rate of 1.0 l/ha.
- Imidacloprid (700 g/l) + alpha-cypermethrin (120 g/l) at a rate of 0.2 l/ha.
- Lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l) at a rate of 0.3 l/ha.

The experiments were carried out on maize variety Slavyanka. The seeding rate was 75 000 per hectare. The seeds were sown in May. The area of one plot was 10 m2. The plot allocation was randomized. The repetition was threefold. The harvesting of maize ears was conducted manually in the phase of physiological maturity with a subsequent shelling in a threshing machine. The spaying of maize plants was performed once at the end of June during the phase of tassel emergence. The treatment of plants was conducted using a backpack sprayer OB-14 Turbo during the growing period.

The experiments with insecticide application were set up according to generally accepted guidelines on the evaluation of maize for complex resistance to pests and diseases (Vilkova N.A., Ivashchenko V.G., Frolova A.N. et al., 1988). The efficacy of the studied insecticides was determined by comparing the degree of the damage caused by the Asian corn borer in the experimental and control variants.

The efficacy of the products was determined by comparing the degree of damage to maize plants in the experimental and control variants. The degree of damage was evaluated on a scale according to I.D. Shapiro after harvest [16]: 1 point – less than 5 passages per plant; 2 points – 5 and more passages per plant; 2 points – damage caused to cobs; 2 points – tassel broke; 4 points – stalk broke. The statistical processing of the research data was carried out according to B.A. Dospekhov. Tolerance (resistance) of the studied maize accessions was determined by calculating the yield from damaged and intact maize plants.

3 Results and Discussion

As the result of our research, new scientific data were obtained on five insecticides with eight different active ingredients.

During the maize growing period, the severity of the damage caused by Ostrinia furnacalis Guenee and the number of individual Asian corn borers were recorded. The highest population density of the pest was observed in the control variant (0.28 larvae per plant) (table 1). The number of larvae ranged from 0.10 to 0.15 per plant in the variants with insecticide application depending on the used active ingredient.

Larvae of the Asian corn borer gnaw through plant tissues and create passages and cavities in maize stalks. The highest average length of passages per plant was detected in the control variant. The variant with the application of thiacloprid (100 g/l) + deltamethrin (10 g/l) had the minimum length of passages.

The degree of the damage to ears and stalks varied depending on the used insecticide (figure 1). The average number of damaged ears during the two years of our research was the highest in the control variant (4.4 %: 0.7 % in 2021 and 8 % in 2022). No damage to plants was detected in variants 2 (emamectin benzoate, 50 g/l), 3 (aversectin C, 50 g/l), 5 (imidacloprid, 700 g/l + alpha-cypermethrin, 120 g/l), and 6 (lambda-cyhalothrin, 50 g/l + chlorantraniliprole, 100 g/l). According to our data, the damage to peduncles was observed only in variant 2 (emamectin benzoate, 50 g/l) in 2022. The research revealed that the control variant and the variant with aversectin C (50 g/l) as the active ingredient had the highest number of plants with damaged stalks (1.9 % and 1.7 %, respectively) (figure 1).

The high strength of stalks and peduncles and resistance to fracture was characteristic of maize plants in variants 5 (imidacloprid, 700 g/l) + alpha-cypermethrin, 120 g/l) and 6 (lambda-cyhalothrin, 50 g/l) + chlorantraniliprole, 100 g/l). The degree of the damage was 0.

The average degree of the damage ranged from 0.1 to 1.5 in the experimental variants. The higher number of points corresponded to the variant without insecticide application; the lower number of points corresponded to the variant with the application of lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l) (table 1).

Table 1. Efficacy of the studied insecticides against larvae of the Asian corn borer (2021-2022).

Variant No.	Active ingredient	Average degree of damage	Number of larvae, larvae/plant	Average length of passages per plant, cm
1	Control (without insecticide)	1.5	0.28	3.6
2	Emamectin benzoate (50 g/l)	0.3	0.13	0.2
3	Aversectin C (50 g/l)	0.3	0.11	0.2
4	Thiacloprid (100 g/l) + deltamethrin (10 g/l)	0.4	0.11	0.1
5	Imidacloprid (700 g/l) + alpha-cypermethrin (120 g/l)	0.3	0.15	0.4
6	Lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l)	0.1	0.10	0.2

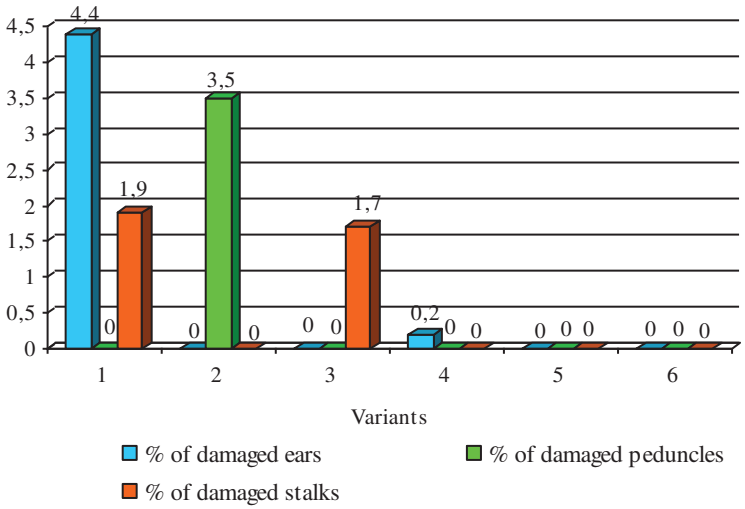

Fig. 1. Parameters of the severity of the damage to maize plants (2021-2022).

Grain weight per plant ranged from 105.7 to 143.0 g in the experimental variants (table 2) exceeding the control. The greatest yield gain was detected in variant 3 after the application of aversectin C (50 g/l) at a rate of 37.3 g/plant, the lowest gain was observed in variant 4 after the application of thiacloprid (100 g/l) + deltamethrin (10 g/l) at a rate of 10.3 g/plant. Table 2 demonstrates that the biological efficacy of the pest control against the Asian corn borer was 79.9-92.9%.

Table 2. Biological efficacy of the studied insecticides and seed productivity of maize (2021-2022).

Variant No.	Active ingredient	Biological efficacy, %	Grain weight, g/plant	Yield gain, g/plant
1	Control (without insecticide)	-	105.7	-
2	Emamectin benzoate (50 g/l)	80.0	124.2	18.5
3	Aversectin C (50 g/l)	82.4	143.0	37.3
4	Thiacloprid (100 g/l) + deltamethrin (10 g/l)	88.3	116.0	10.3
5	Imidacloprid (700 g/l) + alpha-cypermethrin (120 g/l)	79.9	137.0	31.3
6	Lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l)	92.9	132.5	26.8
HCP_{05}			17.7	

4 Conclusions

Thus, our field experiments determined the efficacy of the studied five insecticides against *Ostrinia furnacalis* Guenee. It was revealed that the use of the insecticides with imidacloprid (700 g/l) + alpha-cypermethrin (120 g/l) and lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l) led to a decrease in the damage caused by the pest to maize plants (ears, peduncles, and stalks). The insecticide with lambda-cyhalothrin (50 g/l) + chlorantraniliprole (100 g/l) as the active ingredients had the highest biological efficacy (92.9 %).

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