ESTIMATION OF ELECTROSTATIC FIELD INFLUENCE ON QUALITY INDICATORS OF GRAIN MOTH EGGS FOR PRODUCTION *TRICHOGRAMMA*

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Abstract. The effectiveness of *Trichogramma* that is used in the production of environmentally safe products is also determined by the quality of grain moth eggs used in its production. A portion of 300 g of grain moth eggs was divided in half, one part of which was passed through the electric separator, and the other used as a control. The level of regeneration of grain moth caterpillars, the level of grain contamination by grain moth caterpillars, and the total fecundity of grain moth females were determined. The influence of the electrostatic field on the fractional composition of grain moth eggs was also determined. To study the levels of regeneration of grain moth caterpillars and of grain contamination by grain moth caterpillars, experimental and control portions of grain moth eggs were placed in 100 kg of barley, respectively. The total fecundity of grain moth females was determined by the daily collection of eggs and the summation of their total weight after finishing the process of production of grain moth eggs. To determine the fractional composition of grain moth eggs, 100 eggs were selected from each portion to determine their volume. The results of the studies showed that the level of regeneration of grain moth caterpillars for eggs treated by the electric separator was 91%, and for the control – 93%, the level of grain contamination by grain moth caterpillars for eggs treated by the electric separator was 93%, and for the control – 95%. It was also found that the total fecundity of grain moth females was 1,028 g for eggs treated by the electric separator, and for the control – 1010 g, and the number of large eggs in the portion treated by the electric separator was 39%, and for the control – 29%. Thus, when the electric separator is used, the levels of regeneration of grain moth caterpillars and of grain contamination by grain moth caterpillars are within the experimental error, while the total fecundity of grain moth females and egg size improved.

Keywords: electric separator, electrostatic field, grain moth eggs, grain moth caterpillars, quality indicators.

Introduction

The use of chemical preparations for plant protection leads to a gradual increase in pest resistance and a further decrease in the effectiveness of drugs. This requires an increase in the number of treatments or an increase in the concentration of insecticides, as well as their constant updating, usually to more expensive and more toxic ones, which negatively affects the quality of agricultural products.

The use of insecticides in the production of agricultural products also negatively affects the balance of natural ecosystems and agrocenoses by destroying beneficial entomophages, primarily pollinating insects. One of the ways to preserve the environment and natural biodiversity, and restore natural soil fertility is to use biological methods of plant protection, which is one of the elements of organic production.

In Ukraine, one of the most common entomological preparations is *Trichogramma*, a natural feature of which is the destruction of pests at the egg stage. The effectiveness of *Trichogramma* depends on its quality indicators. In order to improve the quality indicators of the entomological preparation *Trichogramma*, scientists use several methods in their research: periodic use of eggs of natural hosts, collection of starting colonies of natural populations of *Trichogramma*, heterosis, introduction of *Trichogramma* into diapause, feeding adult insects with honey solution and using large eggs of grain moths [1]. In [2], the effect of ultraviolet radiation at temperatures of 24, 28, and 32°C on the qualitative parameters of *Trichogramma chilonis* was determined. The results of studies showed that the optimal temperature at which *Trichogramma* was quite actively revived and infected host eggs was 28°C; the minimum rate of parasitization was at 32°C. A positive effect of ultraviolet radiation on the level of egg parasitization by *Trichogramma* was also obtained. The effect of low temperatures on the storage of *Trichogramma*, which lasted from 25 to 150 days, was studied [3]. The results showed that the high quality of the drug remains for 50 days, and with the growth of the term, there is a sharp decrease in quality indicators (the revival of individuals decreases, the number of deformed individuals increases, and mobility is lost).

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The possibility of Trichogramma pretiosum parasitizing various host eggs (*Pseudoplusia includens* and *Anticarsia gemmatalis*) at variable temperatures from 18 to 32°C was also investigated [4]. The results showed that the development of *Trichogramma pretiosum* in *Pseudoplusia includens* eggs took place depending on temperature changes from 6.8 to 20.3 days, and *Anticarsia gemmatalis* eggs – from 6 to 17 days. The influence of temperature regimes on the intensity of *Trichogramma* production and development was also studied in [5; 6]. The results showed that the rate of development of *Trichogramma* individuals increased in accordance with temperature changes from 12 to 30 ºC, and from 32 to 35 ºC – started to decrease. Significant studies have been conducted to determine the attractiveness of natural host eggs after production on various laboratory host eggs [7]. There are known studies using artificial breeding media for *Trichogramma* to replace eggs of natural or false hosts, which in turn positively affected the cost of entomophages production [8].

It was found [9] that the size of grain moth eggs from the second to the seventh generations of *Trichogramma* had the greatest positive effect on the level of search ability, the level of deformed individuals and fecundity of females of *Trichogramma*. The influence of the size of grain moth eggs on the level of regeneration of individuals, the relative number of females and the fecundity of females of *Trichogramma* from the second to the seventh generations was not statistically significant. The influence of the size of corn moth and rice moth eggs on the biological parameters of *Trichogramma ostriniae* was determined [10]. The results showed that *Trichogramma ostriniae* grown on larger corn moth eggs had a longer life span, greater fecundity, females were larger, stronger, and could parasitize pest eggs of all ages.

In order to improve the quality indicators of *Trichogramma*, studies were conducted that concerned crossing and determining further changes in the effectiveness of *Trichogramma* collected at different sites over 25 generations [11]. At the same time, biological changes in *Trichogramma* individuals, the number of parasitized eggs, the intensity of rebirth, life expectancy, and the level of deformed individuals were determined. These studies have shown that breeding can be carried out with crossed individuals of *Trichogramma* that were imported from different sites; and over 25 generations there were no negative changes in the quality indicators of *Trichogramma*.

There are well-known studies that use technical devices to influence the quality indicators of *Trichogramma*. In [12], a pneumatic calibrator of grain moth eggs was used, which was used to select large eggs for breeding *Trichogramma* with improved quality indicators. The use of various winnowers, cleaners, and electrostatic devices for cleaning grain moth eggs in *Trichogramma* production technology has been carried out for quite a long time [13], but the results of determining their influence on the quality indicators of grain moths, and in general *Trichogramma*, are almost absent. The results of studies to substantiate the method of selecting large grain moth eggs using a pneumatic calibrator, an electric separator and a rotating disk [14] showed that comparative evaluation of experimental studies of each method of dividing grain moth eggs into three fractions showed that the separation of conglomerates from the total mass is best performed by a pneumatic calibrator (80% of conglomerates fell into the first fraction). An electric separator and a rotating disk provided less than 60% of conglomerates to the first fraction. The entry of large grain moth eggs into the second fraction is best provided by a rotating disk – 38%, when using an electric separator and a pneumatic calibrator, 34% and 26% of large eggs were obtained, respectively.

The analysis showed that studies are carried out in the direction of selecting a host for breeding *Trichogramma*, determining the conditions and modes of production and use of *Trichogramma* against various types of pests, depending on natural conditions. Studies have shown that the qualitative characteristics of host eggs determine the qualitative characteristics of *Trichogramma*. However, only a small part of the research is related to the benefits of using technical mechanisms and devices to improve the quality of *Trichogramma* host eggs. One way to clean and separate *Trichogramma* host eggs is to use an electrostatic separator, but there are no research results showing the effect of an electrostatic field on the quality characteristics of a *Trichogramma* host. Therefore, it is topical to determine the influence of the electrostatic field on the quality indicators of such *Trichogramma* host as grain moth, namely: the level of regeneration of grain moth caterpillars from eggs; the level of infection of grain by the caterpillar; the total fecundity of grain moth and most importantly – an increase in the level of the size of grain moth eggs.

Materials and methods

Grain moth eggs were used to conduct studies to determine the effect of the electrostatic field on the quality indicators of *Trichogramma*. An electrostatic device (electroseparator) was used in the research (Fig. 1). In the electrostatic separator, grain moth eggs from the hopper fell into the electrostatic field, where they were processed. The electrostatic field was created by applying a constant voltage of 25 kV to the drums.

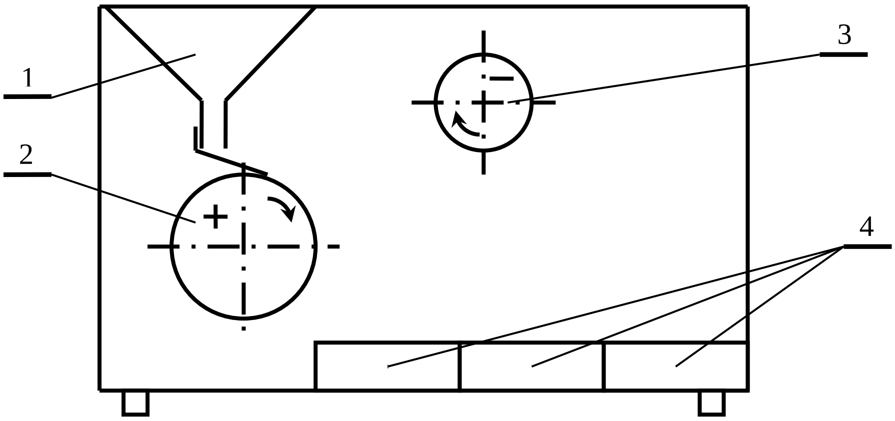

Fig. 1. **Electrostatic separator diagram:** 1 – hopper; 2, 3 – cylinders; 4 – receiving containers

To determine the level of regeneration of grain moth caterpillars from eggs and the level of infection of barley grain by the grain moth caterpillar, 200 kg of barley grain that underwent heat treatment were taken. After that, the grain was scattered in trays, which were installed on racks, where the grain acquired the necessary humidity. Before applying grain moth eggs to the grain, in the experimental and control part of the grain trays, a 5-by-5 cm paper was placed on one of the trays on the grain surface. 150 g of grain moth eggs were applied to the experimental part of the grain trays, which underwent electrostatic treatment. Another part of the grain trays was used to infect grain moth eggs in the amount of 150 g of grain moth eggs that were not subjected to electrostatic treatment (control). At the same time, the eggs of the grain moth were evenly scattered on the surface of the grain trays. The application of grain moth eggs to grain was carried out in such a way that approximately 0.5 g of grain moth eggs fell on the surface of paper measuring 5-by-5 cm on one of the trays in the experimental and control part of the grain trays.

After the completion of grain infestation by grain moth caterpillars, characterized by the disappearance of caterpillars from the grain surface in trays, the level of caterpillar regeneration from grain moth eggs was determined. To do this, 5-by-5 cm paper with grain moth eggs was taken from the control and experimental batches of grain. These grain moth eggs were roughly evenly distributed across 10 separate sectors. Using the MBS-10 type AC 3.850.005 RE stereoscopic microscope, in each sector the total number of grain moth eggs was calculated and the number of eggs from which the caterpillar was reborn and which were white in color, as opposed to eggs with red color, which indicates that the caterpillar had not been reborn from these eggs. The level of caterpillar regeneration from grain moth eggs was defined as the ratio of the number of eggs from which the caterpillar was reborn to the total number of grain moth eggs as a percentage.

Subsequently, after the grain was infected with the grain moth caterpillar, the barley grain in trays was moistened 2 times a week with a solution of potassium permanganate and mixed 5 times a week. 3 weeks after the completion of the development of the grain moth caterpillar, which is characterized by the beginning of grain moths flying, the level of infection of the barley grain with the grain moth caterpillar was determined. To do this, 100 barley grains were selected from the experimental and control batches; they were cut and the presence or absence of infection by the grain moth caterpillar was recorded. The level of barley grain infection by the grain moth caterpillar was defined as the ratio of the number of barley grains infected by the grain moth caterpillar to the total number of selected barley grains.

With the beginning of the grain moth flying, the grain was transferred to separate boxes. During the entire period of grain moth flying, daily collection and weighing of grain moth eggs was carried out.

After the end of the grain moth-flying period, the barley grain was unloaded from the boxes and the total mass of grain moth eggs was summed, which were collected during the entire period separately for experimental and control samples. Thus, the effect of the electrostatic field on the total fecundity of female grain moths was determined.

In the middle of the period of mass grain moth flying, selected grain moth eggs from the control and experimental boxes were tested for belonging to a certain fraction, namely conglomerates, large, and small eggs. At the same time, the length and width of 100 eggs were measured on both sides using a stereoscopic microscope MBS-10 type AC 3.850.005 RE. Subsequently, the volume of grain moth eggs was calculated, taking their form in the shape of an elongated ellipsoid, as described in [12]. Thus, the effect of the electrostatic field on the fractional composition of grain moth eggs was determined. The integral probability of volume distribution of individual grain moth eggs was determined using the adapted application "Data Analysis" in Excel.

Results and discussion

It was established that the rate of caterpillar regeneration from grain moth eggs treated with an electrostatic field was 91%, and for the control sample, it was 93% (Fig. 2). The research data showed the presence of a slight effect of the electrostatic field on the embryos of grain moth eggs. Most likely, the influence of the electrostatic field occurred on weak embryos of grain moth eggs (underdeveloped embryos and embryos that were formed in deformed eggs), which led to deviations in the regeneration of caterpillars. Therefore, it can be assumed that this operation can be used as a method of partial rejection of low-quality grain moth eggs.

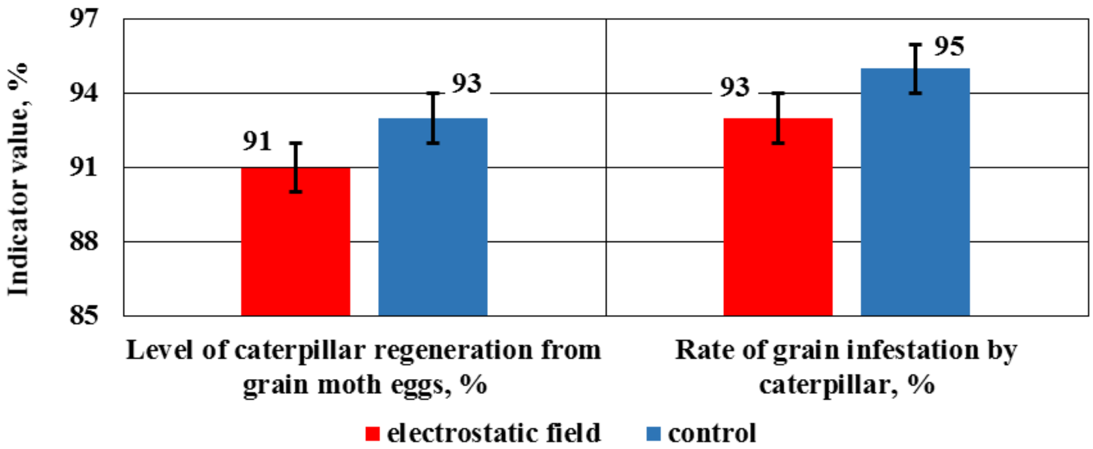

Fig. 2. **Results of studies of the influence of the electrostatic field on the grain moth quality indicators**

The results of the studies showed that the level of infection of grain with a grain moth caterpillar obtained from grain moth eggs that were treated with an electrostatic field was 93%, and for the control sample, it was 95% (Fig. 2). This result correlates with the previous result of caterpillar regeneration from grain moth eggs. A lower level of caterpillar regeneration from grain moth eggs treated with the electrostatic field led to a decrease in the level of grain infestation by the grain moth caterpillar.

Determination of the fractional composition of grain moth eggs and the presence of fractions of large grain moth eggs in them showed that grain moth eggs laid by grain moth, which was bred using eggs treated with the electrostatic field, contained: conglomerates – 32%; small eggs – 29%; large grain moth eggs – 39%. The fractional composition of grain moth eggs laid by a grain moth that was bred using eggs without the influence of the electrostatic field was as follows: conglomerates – 26%; small eggs – 45%; large grain moth eggs – 29%. It is most likely that the difference in the number of the obtained large grain moth eggs, which is 10%, can be explained by the fact that after treating grain moth eggs in the electrostatic field, inactivation of underdeveloped embryos and embryos formed in deformed eggs occurred. Subsequently, these eggs did not produce a weak generation of grain moth caterpillars, which in turn led to a decrease in the number of small eggs and an increase in the number of large grain moth eggs. The integral volume distribution of individual grain moth eggs (without conglomerates) is shown in Fig. 3.

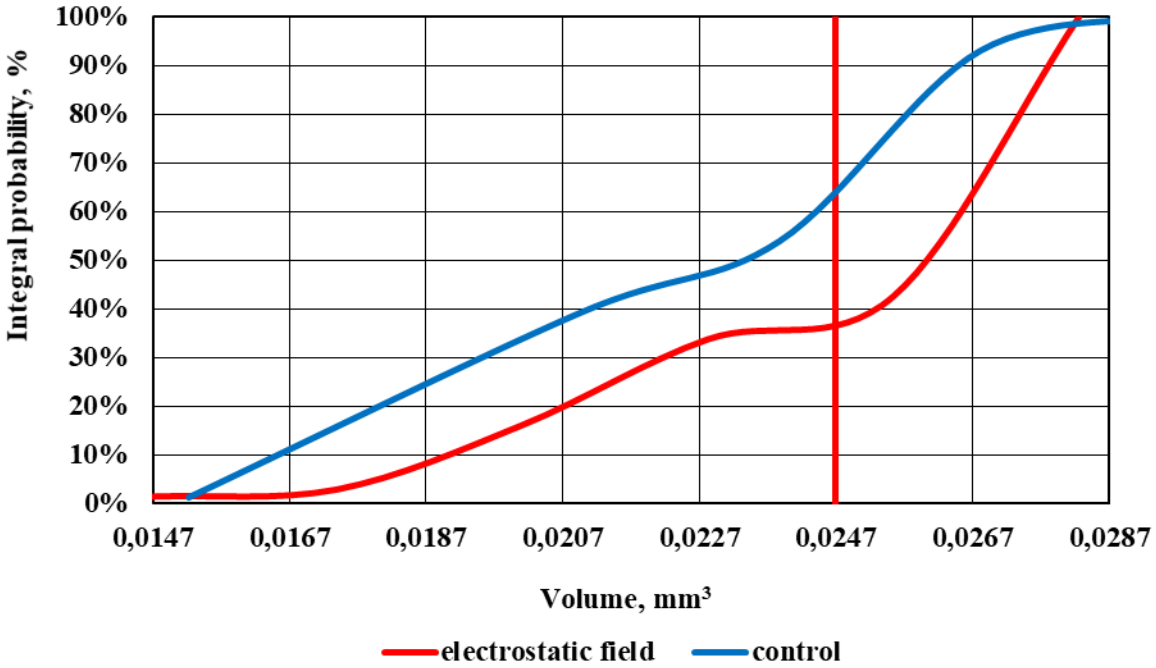

Fig. 3. **Integral probability of grain moth egg volume distribution**

The total fecundity of female grain moths that were reborn from eggs treated with the electrostatic field was 1028 g, and the total fecundity of female grain moths that were reborn from eggs treated with the electrostatic field was 1010 g, despite the slight difference in the total fecundity of female grain moths, it should be noted that the total fecundity of female grain moths that were reborn from eggs treated with the electrostatic field was formed primarily from large grain egg moths, which indicates an increase in the total fecundity of female grain moths in qualitative terms.

The research results are summarized in Table 1.

Table 1

Results of studies of the effect of the electrostatic field on grain moth

Indicator	Value	
	Electrostatic field	Control
Level of caterpillar regeneration from grain moth eggs, %	91 ± 2	93 ± 2
Rate of grain infestation by caterpillar, %	93 ± 2	95 ± 2
Total fecundity of females, g	1028	1010
Relative number of large eggs in a fraction, %	39	29

Thus, the conducted studies have shown that the use of the electrostatic field in cleaning and separating grain moth eggs does not lead to negative consequences. Although the caterpillar regeneration rate and grain infestation rate of the grain moth caterpillar were slightly lower in the electrostatic field variant, the total female fertility and relative number of large eggs were higher. The use of the electrostatic field for processing grain moth eggs in the *Trichogramma* production process can ensure the culling of underdeveloped and deformed grain moth eggs. This increases the total fecundity of female grain moths and the content of the fraction of large grain moth eggs.

Conclusions

1. The results of the studies showed that the level of regeneration of grain moth caterpillars for eggs treated by the electric separator was 91%, and for the control – 93%, the level of grain contamination by grain moth caterpillars for eggs treated by the electric separator was 93%, and for the control – 95%. Thus, when the electric separator is used, the levels of regeneration of grain moth caterpillars

and of grain contamination by grain moth caterpillars are within the experimental error, while the total fecundity of grain moth females and egg size have improved.

2. It was found that the electrostatic field has a positive effect on the level of fertility of female grain moths that was 1,028 g for eggs treated by the electric separator, and for the control – 1,010 g. This was ensured by an increase in the fraction of large eggs by 1.8 times when compared to the control.

Author contributions

Concept, conducting experiments, Oleh Marus; processing the results of experiments, Gennadii Golub; methodology, Yaroslav Yarosh and Gennadii Golub; software, participation in experiments, Natalja Karpiuk. All authors have read and agreed to the published version of the manuscript.

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