Technological features of biological protection of grain stocks against complex of phytophages of Lepidoptera (Pyralidae, Tineidae, Gelechiidae)

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Abstract

Introduction. The receptions of biological protection with use of entomophages and entomopathogens in conditions of granaries in relation to complex of dominant populations of phytophages of Lepidoptera of grain stocks were scientifically grounded.

Materials and methods. During 2010–2017 years of researches were investigated stocks of cereals, legumes and industrial crops for food, fodder and seminal appointments, complex of arthropods – insects and mites, which related trophic and environmentally with them, and laboratory cultures of entomophages and entomopathogens. For researches were used receptions of visual (analysis of average samples) and instrumental (food and pheromone traps) monitoring, microbiological, population and statistical methods.

Results and discussion. As result of long-term researches was shown principled possibility of effective biological protection, as well control of strength of dominant complex of phytophages of Lepidoptera of grain stocks. Technological parameters and expediency of using laboratory cultures of entomophages combined with microbiological preparations have been optimized. It is important that whole arsenal of biological protection was used during critical periods of ontogenesis of insect-phytophages. This process was accompanied not only by fighter effect of operational character, but also by regulatory influence with subsequent transition of populations in long depressive state. The specific biocenotic regularity was established. It is because population of entomophages and active substances of biological preparations were characterized by pronounced aftereffect, which manifests in physiological anomalies, in particular, violation of rhythm of oogenesis with subsequent decreasing real fecundity of females and trophic activity of caterpillars. Constituent parts of original technology showed pronounced efficiency in relation to phytophages. In particular, laboratory cultures of entomophages parasitized corresponding stages of phytophages at level of 64.2 %. Effect and aftereffect of microbiological preparations as part of the technology were also effective. Mortality of phytophages was 70.4 %. As result, the biological strategy of protection of grain stocks provided total efficiency at level of 82.7 % against 93.1 % in chemical standard. Approbation of biological receptions has shown their manufacturability and adoption by practice of plant protection under such specific conditions.

Conclusions. The realization of technology ensures preservation of 96.6 % of gross stock of grain from phytophages of Lepidoptera.

Introduction

Relevance of topic in the world

It is generally accepted that among other indicators economic well-being of the state determine by its food stock. Particularly relevant is issue of protecting plant products in connection with latest global environmental, economic and political problems. In most cases, these problems are solved by comparatively long-term storage of harvest stocks of current year, according to existing traditions for each individual state, its size, character and consumer ability of population.

It is known that row of stress factors of biotic and abiotic origin accompany process of storage of grain and products of its processing, including in modern high-tech elevators. Often negative consequences of their manifestation acquire catastrophic character, accompanied by losses not only of gross part of harvest, but also decrease indicators of its quality. We also emphasize that over 80 % of all negative factors concern to harmful activity of phytophages – insects and mites. Their species composition in granaries is more than 400 species. It should be noted that class of insects characterize by exceptional viability, reproductive activity, survival and property to withstand any stress anomalies. To these representatives of the animal world are over 400 million years old with corresponding physiological and ecological parameters of sustainability.

Many countries of the world use wide variety of receptions, means and technologies for solving problem of protection of strategic biological raw materials against expansion of arthropod–phytophages. In their composition are rather low-effective receptions of preventive character, with considerable expenditure of manual labor and other efforts, and modern technologies of total destruction of complex of arthropods, using all existing assortment of chemical preparations.

Existing assortment of preparations is characterized by rather significant level of toxicity, in relation to not only target objects, but also exhibit poisoning effect to animals and human. However, it is necessary to search real alternative technologies for protection of grain stocks and products of its processing, which involve partial or radical decrease of pesticide press in this branch, taking into account level of newest developments in the field of population ecology, genetics, toxicology and medical hygiene.

Literature review

There are technologies providing receptions from partial decrease of pesticide load to most radical approaches in the system of organic plant growing. Objective critical analysis of latest scientific and technical developments in this system was showed principal possibility of realization to known technologies, based on use of natural populations of entomophages, as means, partially restraining to expansion of phytophages in conditions of closed rooms (Drozda, Bondarenko, patent of Ukraine № 119532. Way of protection of grain and grain products against phytophages during long-term storage in the system of organic plant growing).

Among pathogens of insects are viruses, bacteria, protozoa and fungi (Moore et al., 2000). There are data about absence of side action of entomopathogens of bacterial and fungal etiology to parasites. Insects able to be as sources of accumulation and vectors of spread of entomopathogens.

Using spores of white muscardine was most common among entomopathogenic fungi (Lord, 2005). The expediency of using various microbiological preparations on basis strains

of entomopathogenic microorganisms, which really existing in nature, mainly bacterial and fungal etiology was established experimentally (Flinn, Scholler, 2012). However, at this stage fungal entomopathogenic preparations for practical use were not registered to control of strength of the population of phytophages of grain stocks (Lord, 2005).

Most researches are aimed at studying features of mass laboratory production of cultures of entomophages – species of the genus Trichogramma sp. and Habrobracon sp. in branches of integrated protection of grain stocks and organic plant growing (Chen et al., 2013; Chimire, Phillips, 2014; Shah Alamet al., 2016). Specific predictors that allow assessing suitability of host for laboratory rearing of Trichogramma and Habrobracon, namely level of parasitizing, quantity of laid eggs by female, lifetime of entomophage, sex ratio in received posterity were developed (Drozda, 2005; Chimire, Phillips, 2014; Gavriliţa, 2015). The problems of role of nutrient media to development of phytophages and their entomophages, and action of hydrothermal conditions by them are investigated (Eslampour, Aramideh, 2016; Golizadeh et al., 2017). The exploring biology, physiology and ecology of entomophages and their hosts for increasing their reproductive potential and lifetime occupies important part of experimental researches (Drozda, 2003, 2011; Pezzini et al, 2017).

There are fragmentary researches to introduction of biological technologies with use of entomophages – parasites, predators and entomopathogens, as elements of integrated protection of plant products during long-term storage (Grieshop et al., 2006; Casada et al., 2008; Hagstrum, Subramanyam, 2009; Adarkwah et al., 2010; Scholler, 2010; Upadhyay, Ahmad, 2011; Flinn, Scholler, 2012; Drozda, Bondarenko, 2017).

Nowadays, the world mass production of useful insects for branch of grain protection is limited by three European countries – Germany, Netherlands and Switzerland. The use of entomophages in protection of grain stocks has become commercial character in Central Europe. There are several biological laboratories for mass rearing of cultures of entomophages in order to using them as element of integrated protection of grain and products of its processing in period of long-term storage against arthropod-phytophages (Scholler, 2010). At this stage, realization of technologies of biological protection of grain has not acquired scale of industrial storage. Seven species of parasites and predators are commercially available for protection of grain stocks against arthropod-phytophages in the United States of America (White, Johnson, 2010). Expert analysis was showed that the realization of technologies of biological protection in system of organic plant growing characterized by pronounced economic efficiency with certain perspectives. It is also stressed that guaranteed efficiency ensured by joint use of entomophages (Grieshop et al., 2006; Niedermayer, Steidle, 2010; Scholler, 2010).

In the countries of central and eastern Europe, the distribution has received mass production of laboratory cultures of Trichogramma in order to protecting agricultural crops, mainly in agrocenoses (Drozda, 2000; Reiliants, 2008; Gavrilitsa, 2010; Molchanova et al., 2015). Elements of biological control in protection of grain stocks are represented only fragmentarily by partial use of current spectrum of commercial microbiological preparations, predominantly bacterial etiology in mixtures with insecticides (Bondarenko, 2015).

At the same time, there are no fundamental works based on thorough exploring biology, ecology and physiology of dominant phytophages of grain stocks, trophic activity of entomophages and entomopathogens, connectivity of their life cycles. In fact, at this stage were obtained contradictory, unsustainable effects by indicators of positive result with clear trend of perspective of this direction.

Proceeding from the above, it is obvious that qualitatively new approaches to solution of such important state problem as ensuring protection of grain stocks are needed. The authors assume that these approaches should be based on detailed exploring features of physiology and ecology of phytophages, their entomophages and entomopathogens, taking into account their life strategies, level of adaptability and ecological heterogeneity.

Purpose of researches

The main purpose of researches was assessment of level of viability of phytophages and their entomophages with original elements of their physiological monitoring, ecological valence and adaptability. On such peculiar scientific foundation were determined most important technological parameters, based on real production characteristics of level of technical equipment of granaries, periods of beginning expansion of phytophages, character of mastering ecological niches and initial manifestation of phenomenon of phytophagy. The task was set to propose of separate receptions as part of completed technologies of biological and integrated protection of grain stocks against complex of phytophages of Lepidoptera for production.

The clear technological parameters, concerning prediction of level of risk and appropriateness of use of biological receptions as part of holistic technology according to results of these researches are formulated. An important component of experimental work was determining sequence and compatibility of individual elements as part of original technology of grain protection. During researches was set task of justification not only level of protection and preservation of harvest, but also ecological aspect, namely problem of using organic product as raw material for food industry.

Materials and methods

Investigational materials

Long-term experimental researches (2010–2017 years) in warehouses of granaries for floor storage of grain and modern technically equipped modules of elevators, mainly in regions of the Forest-Steppe and Polissya of Ukraine were carried out. The main biological substrate is cereal grains with predominance of winter wheat, leguminous and industrial crops.

As means of biological control were used laboratory cultures of egg parasite of phytophages of Lepidoptera – *Trichogramma evanescens* Westw. (Hymenoptera, Trichogrammatidae). This parasite is reared massively in numerous bio-laboratories of Ukraine, using standard culture of Angoumois grain moth – *Sitotroga cerealella* Oliv. (Lepidoptera, Gelechiidae) (Drozda, parent of Ukraine № 22701. Way of mass rearing Trichogramma). As part of arsenal of biological control of phytophages was ectoparasite of caterpillars – *Habrobracon hebetor* Say. (Hymenoptera, Braconidae) with using known technologies of his laboratory production in our modification (Drozda, patent of Ukraine № 49250. Way of rearing laboratory populations of ectoparasite – *Habrobracon hebetor* Say.).

Order of conducting researches

The receptions of visual and instrumental phytosanitary monitoring of granaries and elevators were integral part of technology of grain storage and its protection. Instrumental

monitoring has assumed use of various technical adaptations for catching individual stages of insects. In addition, we used pheromone traps with set of modern assortment of targeted dispensers.

The obtained results of phytosanitary monitoring served as basis for choice of means and receptions of control of strength of phytophages of Lepidoptera, taking into account such universal indicator as threshold level of harmfulness. At the same time, level of domination of individual phytophages, density of their populations, relative prevalence, potential and real harmfulness were established.

In course of industrial tests were conducted receptions of manual resettlement of entomophages, taking into account fragmentarity and hearths of initial expansion of various grain substrates by phytophages. Starting populations of entomophages were reared by original author's technology, aimed at induction of such characteristics as motor activity of adult females and their search ability. This is essential methodological feature of proposed technology.

Trichogramma and Habrobracon – entomophages of first class of quality, previously adapted to conditions of closed rooms, was exhibited in special containers. The norm of resettlement of Trichogramma was 10,000 individuals per 1 m^2. The reception of resettlement of adults of Habrobracon at period of beginning emergence of caterpillars of phytophages of Lepidoptera of third age was carried out in norm of 15–20 individuals per 1 m^2 of area of grain substrate.

In addition, character of oogenesis of females of entomophages, functioning in pro- and synovigenic regimes was taken into account. As rule, the starting populations of entomophages only first class of quality were used. Evaluation predictors are based to level of viability, motor activity of females of entomophages in process of searching certain stages of development of phytophages.

We accounted pronounced species-specific reaction of caterpillars to acting substances of biological preparations. It's biological and ecological basis for using fungal entomopathogens in form of preparations. This allowed entering two microbiological preparations as part of technology – Boverin and Petsilomin, created on basis of entomopathogenic fungi of white muscardine (*Beauveria bassiana* (Bals.) Vuill.) and pink muscardine (*Paecilomyces farinosus* (Holmsk.) A.H.S. Br. & G. Sm.) (Deuteromycetes, Fungi Imperfecti).

Usually entomopathogenic preparations were used sequentially after resettlement of entomophages in event of existence of threat of increasing strength of populations of phytophages of Lepidoptera. It should be noted that their acting substances do not have pronounced entomocidal activity in relation to entomophages. The interval between these receptions was from 10 to 14 days. The hearths of spreading target phytophages were treated by working suspensions of entomopathogenic preparations. As rule, large quantity of initial material in laboratory and production experiments was involved, which allow making objective conclusions about efficiency of conducted receptions.

Description of methods, installations

Special engineering constructions are aimed at protection of biomaterial against mechanical damage and influence of other stress factors. In addition, these modules capable of supporting optimal regimes for daughter populations, nutrition in form of specific carbohydrate-protein diet, mating and unhindered resettlement in thickness of grain in places of concentration of corresponding stages of phytophages. In most cases, natural honey and hemolymph of caterpillars of senior ages of owlet moths as diet were used.

Developed devices are specific plastic containers with corresponding blocks of multifunctional use. Modules with biomaterial are designed for its resettlement on surface of grain. Their construction is protected by patents of Ukraine.

Processing research results

The obtained digital material was processed statistically. The statistical processing results of phytosanitary monitoring on infestation of grain by phytophages with use of program Excel was involved. Levels of dominance and density of populations of phytophages were established. The level of dominance was determined by the formula:

$$D = 100 \text{ x} \frac{k}{K},$$

where D – the degree of dominance of phytophages; k – quantity individuals of certain species; K – total quantity of all collected species.

The density of populations of phytophages of grain stocks was determined by the formula:

$$V = \frac{k}{n}$$

where V – density of populations of phytophages in samples; k – the sum of all individuals of species in samples; n – quantity of investigated samples.

For determining indicators of linear correlation ($Y = a + b \cdot X$) of obtained experimental data was used computer program of «Statgraphics plus».

Results and discussion

Researches of species composition of arthropods-phytophages of grain stocks. As results of long-term researches have shown, the total fund of phytophages of grain stocks was over 80 species of arthropod, which belong to 3 classes (Arachnida, Entognatha, Insecta), 9 orders (Psocoptera, Pseudoscorpionida, Thysanura, Sarcoptiformes, Trombidiformes, Acarina, Mesostigmata, Coleoptera, Lepidoptera), 29 families (Psocidae, Atropidae, Cheliferidae, Lepismatidae, Acaridae, Glycyphagidae, Cheyletidae, Tydeidae, Pediculoididae, Parasitidae, Lealaptidae, Curculionidae, Tenebrionidae, Cucujidae, Dermestidae, Cryptophagidae, Bostrychidae, Anobiidae, Ostomatidae, Nitidulidae, Ptinidae, Bruchidae, Lathridiidae, Notoxidae, Cleridae, Tineidae, Gelechiidae, Pyralidae, Noctuidae). During phytosanitary monitoring of granaries and elevators, it was established that percentage of species of Lepidoptera was about 30 % from general structure of phytophages. Among phytophages of grain stocks from order of Lepidoptera were observed such species as *Plodia interpunctella* Hb., *Ephestia ellutela* Hb., *E. kuehniella* Zell., *Pyralis farinalis* L. (Pyralidae), *Sitotroga cerealella* Oliv. (Gelechiidae), *Nemapogon granella* L., *Tineola bisselliella* Humm., *Tinea translucens* Meyr., *Haplotinea ditella* P. et Diak., *Niditinea fuscipunctella* Hw. (Tineidae). Detailed exploring their biology, physiology, and ecology (*Table 1*) showed that all of them develop in polyvoltinic regime.

Table 1

Characteristic of population structure of dominant phytophages of Lepidoptera of grain stocks

Species of dominant phytophages of Lepidoptera of grain stocks	Quantity of generations in conditions of closed rooms	Reproductive potential	Reaction to biogenic stress factors	Manifestation of trophic competition	Character of formation of ecological niches
Indianmeal moth (*Plodia interpunctella* Hb.)	1–6 generations during year	The total fecundity of female is 70–160 eggs; scattered oviposition alternates with group of 30 eggs per day on surface of plant products	The spread of snout moth is limited to temperature indicators; insect is sensitive to action of low temperatures, however, shows resistance in relation to high	Indianmeal moth prefers cereal, technical and oil crops as trophic substrate; it is observed broad polyphagia, partially keratophagy, characterized elements of predation; trophic substrate of caterpillars is grain embryo	It is observed characteristic expansion of grain substrate with penetration to depth of embankment of about 10 cm, migration increases to 1.5–2.0 meters at low temperatures
Mediterranean flour moth (*Ephestia kuehniella* Zell.)	during year is changed 2–6 generations	The total fund of egg production is 50–200 eggs; scattered or group oviposition with emphasis on various unevenness's in buildings, significant part of eggs is concentrated on grain substrate	Process of oviposition of females and development of caterpillars are limited by conditions of temperature regime and quality of trophic substrate; Mediterranean flour moth are characterized by pronounced adaptation to low temperatures, insect is resistant to high temperatures	Caterpillars are broad polyphages, mainly feed on products of grain processing, trophic specialization is phytophagia and keratophagia; snout moth is adapted to feeding by solid varieties of agricultural crops	Characteristic feature of expansion of substrate is superficial uniform distribution followed by intensive migration in embankment on depth up to 15 cm

Table 1 (Continue)

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Cacao moth (*Ephestia ellutela* Hb.)	For this species is characteristic 2–3 generations	Genetically determined reproductive function ensures the deposition of highly viable eggs in the range from 60 to 130	The process of oviposition and duration of development of caterpillars are determined temperature regime, genus and quality of trophism; insect is adapted to various synoptic anomalies	Trophic specialization is broad polyphagia, insect prefers cereals, oilseeds and products of its processing, feed on germ of grain that ensures high level of viability of daughter generations	This species is adapted to expansion predominantly surface portion of grain
Angoumois grain moth (*Sitotroga cerealella* Oliv.)	High level of strength and constant presence at warehouses are explained by existence of 3–4 generations and insignificant mortality of preimaginal stages	Females are characterized by mixed strategy of egg placement in time and space; the competitiveness of moth is ensured by oviposition on ears of grain in field and shell or longitudinal groove in granaries; fecundity is in range from 80 to 150 eggs	The spread of this species is determined largely temperature regime; the development of caterpillars is limited strongly by level of relative moisture of environment and trophic substrate	Moth is characterized broad polyphagia, caterpillars prefer mainly cereals, less often legumes and corn as trophic resource, in this case use endosperm	Characteristic feature of this species is that adults create colonies exclusively on surface of grain, where they lay eggs, subsequently population occupies depth of no more than 10 cm

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European grain moth (*Nemapogon granella* L.)	Not pronounced competitiveness among Lepidoptera is determined limited quantity of generations (1–2)	Real fecundity of females is from 50 to 70 eggs; scattered oviposition is concentrated on surface of grain substrate	Pronounced sensitivity to synoptic anomalies, the activity of this moth is limited moisture content of grain substrate	Caterpillar feeds by endosperm within grain, preferring to threshed grain of wheat, rye, barley, oats as trophic substrate	Insect belongs to group of phytophages that occupy upper part of embankment of grain
Drab clothes moth (*Haplotinea ditella* P. et Diak.)	Significant quantity of generations (up to 4) provides permanent presence and pronounced harmfulness of this species in warehouses	As rule female lays insignificant quantity of eggs, within limits of 40–100, but newly born caterpillars are characterized pronounced trophic activity	The dependence of development of this moth from level of moisture content of trophic substrate and ambient temperature is traced	Insect specializes on nutrition by grain and products of its processing; prefers products of plant origin, especially affected by mold fungi and putrefactive bacteria	Uniqueness of ecological niches is explained by preference of excessive moisture and presence of fungal and bacterial microflora

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Their development are limited not so much trophic factor, so much hydrothermal parameters. It is also established that the lower limit for development of populations of most species of phytophages of Lepidoptera of grain stocks is from 10 to 15 degrees. It means that period of active nutrition and harmfulness is limited by the summer-autumn season. Two expressed peaks of trophic and flight activity, intensive increase of strength of Lepidoptera in June and September were observed.

Experimental researches of the author's technology of biological protection of grain against phytophages of Lepidoptera

These materials were served as basis for optimization of receptions of biological protection of grain against phytophages (*Table 2*). In fact, the first three years of researches against background of high level of strength of phytophages of Lepidoptera were conducted. It was observed domination of such species as Indian meal moth (*Plodia interpunctella* Hb.), cacao moth (*Ephestia ellutela* Hb.), Mediterranean flour moth (*E. kuehniella* Zell.) (Pyralidae) and Angoumois grain moth (*Sitotroga cerealella* Oliv., Gelechiidae). It is over 85 % of the total fund of Lepidoptera. The technology with sequential using *Trichogramma evanescens* Westw. (Trichogrammatidae), entomopathogenic fungal preparations and *Habrobracon hebetor* Say. (Braconidae) is realized for transition of populations of these phytophages to prolonged depressive state. It is this sequence was maximized biological fighter activity of different stages.

Special meaning was attached to resettlement of Trichogramma that is important reception, taking into account prevention of spreading caterpillars of phytophages in range from 35 to 65 %. This reception is one of the most effective, ecologically safe and characterize by pronounced economic importance. As rule, it is enough to hold two receptions of resettlement of Trichogramma in period of beginning process of mass oviposition at indicators from one to three threshold levels, based on materials of pheromone and visual monitoring. This period lasts from 10 to 12 days. Obviously, reception is prevented potential harmfulness of phytophages of Lepidoptera.

As result, Trichogramma parasitized from 43.4 to 68.7 % eggs, mainly ineffective part of populations of phytophages of Lepidoptera. The most viable females of Trichogramma parasitized from 16.8 to 34.6 % of effective part of populations of snout moths and moths. This is most significant part of researches that indirectly characterizes heterogeneity of the starting populations of phytophages, trophic and ecological specialization of Trichogramma. It also should be noted that significant part of ovipositions of effective population of phytophages died as result of act of nutrition of females of Trichogramma by their hemolymph. It is from 13.4 to 18.6 % of the total stock of eggs. Trichogramma does not lay eggs in such eggs of phytophages. As result, phytophages are eliminated.

However, remainder part of populations of Lepidoptera represents real threat of increasing harmfulness, given high initial level of strength of phytophages. Therefore, one reception of local treatment of grain substrate with aqueous solution of entomopathogenic fungal preparation – Boverin was carried out. This reception was conducted only in initial period of mass emergence of caterpillars of Lepidoptera. The titer of viable spores of fungus of white muscardine was 6.3 billion in 1 g. Shelf life of preparation did not exceed 2 months. The efficiency of this reception ranged from 48.4 to 68.5 %.

Table 2

Efficiency of technologies of protection of grain stocks against phytophages of Lepidoptera (Industrial testing, 2010–2017 years)

Technologies of protection of grain stocks	Initial strength of phytophages of Lepidoptera, ind. / kg	Level of dominance, %		Factors of mortality of phytophages, %		Harmfulness, %	Efficiency of grain protection, %
		Snout moths	Moth	Entomophages	Entomopathogens		
Original author's technology of biological protection	29,6	76,4	23,6	64,2	70,4	3,4	82,7
Chemical standard	33,7	80,2	19,8	2,1	4,3	1,2	93,1
Control	45,8	77,9	22,1	5,7	5,2	24,6	–
SSD_{05}	–	–	–	1,2	1,6	1,3	5,7

As our researches have shown, the period of emergence of caterpillars from eggs lasts from 23 to 32 days. The viable part of caterpillars after realization of these two receptions represented also immediate threat, primarily as factor of growth populations of phytophages. In this case, the application of laboratory culture of Habrobracon, exclusively of first class of quality was justified. Adults of Habrobracon function during long period, namely from 17 to 24 days, in contrast to Trichogramma. It is essential that process of oogenesis of females also characterized by high activity and duration. It was provided parasitization of caterpillars of phytophages of Lepidoptera at level from 63.2 to 74.8 %, given high motor and search ability of Habrobracon. The tactic of their operational control are timed strictly to this period due to specific rhythmics of ontogeny of these phytophages, in particular their trophic binary activity.

The status of phytophages for Angoumois grain moth (*Sitotroga cerealella* Oliv., Gelechiidae) and European grain moth (*Nemapogon granella* L., Tineidae) in second period of activity of Lepidoptera actually was lost. Only single individuals were noted. The results of phytosanitary monitoring indicated about trend of increase of strength of dominant species of snout moths, which is observed in beginning September. It created certain threat of hearth spread. These materials were basis for application of reception of single-entry resettlement of Trichogramma as restraining and regulatory factor, followed by continuous treatment of grain substrate by entomopathogenic fungal preparation – Petsilomin. Acting substance of preparation is spores of pink muscardine with titer of 5.5 billion in 1 g. The choice of this preparation was due to much higher level of adaptability to low temperatures and pronounced entomocidal activity, in comparison with Boverin. The terms of treatment were analogical to first receptions. The level of mortality of different stages of Lepidoptera was within of 56.9–82.3 %.

Discussion of research results

The proposed strategy provides acceptable efficiency of sharp decline of starting populations of phytophages of Lepidoptera with use entomophages and entomopathogens. The expediency of introducing further fighter technologies with use biological receptions depends on quality phytosanitary monitoring for determine occupancy and infestation of grain stocks by phytophages. Trichogramma is mandatory reception in all cases regarding practical realization of technologies of biological protection of grain at moderate indicators of strength of phytophages of Lepidoptera. It is explained by comparative simplicity of obtaining unlimited quantity of biomaterial, its cheapness, and small size of adults.

By results of researches, important biocenological aspect was established. This aspect is manifested in fact that the deceased populations acted as source of accumulation, passive and active spread by inoculum of fungi in grain substrate. Beetle-phytophages (Coleoptera), accompanying insects and adults of Habrobracon were as vectors. The phenomenon of partial process of self-regulation of this particular ecological niche by rather pronounced activity of daughter generations of entomophages, and circulation of spores and vegetative bodies of entomopathogenic fungi was noted.

The absence of phenomenon of formation of resistant populations of target phytophages was established. According to the results of long-term researches, this fact is important point in using entomopathogenic fungi. The evolutionary saprophytic genetic life strategy of these entomopathogens in conditions of closed rooms is practically not realized. It is due to total absence of relevant trophic substrate. Consequently, adaptation and directed selection form only entomocidal activity of preparations. In the authors' opinion, proposed technology is main integral part of organic plant growing, taking into account

sanitary-hygienic characteristic of these preparations with absence of negative action to warm-blooded, human and entomophages. Important role is played by the fact that these preparations and authoring receptions of using entomophages are intellect-product of domestic technologies.

Conclusions

The strategy of scientific search to original technical solutions was formulated on the grounds of expert analysis of condition of branch of grain protection during its long-term storage. They are aimed at solving important state problem, related to radical ecologization of existing technologies of protection of grain stocks, predominantly pesticide receptions.

The conducted experiments showed principal possibility of adaptation of laboratory cultures of species of the genus Trichogramma and Habrobracon for specific conditions of closed rooms. The phenomenon of trophic interaction of these entomophages with target species of phytophages (moths and snout moths) was established. The norms, terms and multiplicities of application of entomophages during storage of grain based on worked parameters were established. Various technical improvements, aimed at preserving biomaterial and their long-term contact with phytophages for optimization parameters of realization of biotic potential of entomophages were suggested.

Experimentally were established feasibility and efficiency of using entomopathogenic fungal preparations – Boverin and Petsilomin for destabilize structure of populations of phytophages. The operational sequence of application of entomophages and biopreparations was shown. For the first time have been studied in detail features of biology, physiology and ethology of dominant species of phytophages, established critical periods in their ontogeny. This made it possible to effectively influence on processes of reproduction and spread of phytophages. A range of problems was defined that must be studied for increasing efficiency of technologies of biological protection with simultaneous search of promising species of entomophages and entomopathogens for needs of production.

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