

Conference Paper

Entomophages as a Perspective Direction of Plant Protection

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ORCID:*Tatiana Marinchenko: <http://orcid.org/0000-0003-3721-112X>***Abstract**

Increased demand for food to feed the ever-growing population led to the development and adoption of synthetic chemicals as a quick and effective strategy of managing crop pests and diseases. Such agricultural practices have contributed to environmental pollution, which is further affecting food security, human health, and the climate. At the same time, up to 40% of crops die due to pests and plant diseases. Therefore, sustainable crop production and global food security depend on the timely implementation of the latest scientific projects in various fields of crop production including genetics, breeding, agronomy, crop physiology, crop management practices, biotechnology, and even entomology. The introduction of biological agents to protect, control and stimulate the development of agricultural crops is one of the ways of increasing the efficiency and profitability of production, reducing the environmental burden and increasing the competitiveness of producers. This is consistent with the concepts of a green economy and the sustainable development of agriculture. Since the unilateral use of chemicals does not meet today's requirements, special attention must be paid to preventative, agrotechnical measures, as well as the use of natural factors for regulating the number of pests using parasitic and predatory insects. Domestic biotechnological developments for crop production which increase production efficiency and reduce the environmental burden are discussed.

Keywords: plant growing, entomophages, protection, efficiency, ecology, ecology

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1. Introduction

According to FAO estimates, 20 to 40% of global agricultural production is annually lost due to the invasion of pests. Plant diseases cost the world economy about \$220 billion annually, and the invasive insect invasion costs \$70 billion. Underscoring the importance of crop production in the provision of food, FAO believes that policies and actions to promote plant health are essential for achieving the sustainable development goals: ending poverty and lack of hunger. For all these reasons, the United Nations General Assembly declared 2020 as the International Year of Plant Health [1].

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The International Plant Protection Convention (IPPC), which is the only international body responsible for setting and implementing phytosanitary standards recognized by governments around the world, believes that given the increasing impact of pests on plants, existing resources are not enough to solve this problem. To increase efficiency and reduce environmental impact, the IPPC has adopted new standards for improving fumigation methods, which establish requirements for temperature, duration, number of fumigants, etc. The agenda is how the International Year of Plant Health can stimulate global collaboration, participation, and awareness to support plant health policies at all levels [2].

FAO believes that the global producers can both prevent plant pests and diseases, and control them in environmentally friendly ways, such as through integrated pest management. This ecosystem approach combines different management strategies and practices to grow healthy crops while minimizing the use of pesticides. Avoiding poisonous substances when dealing with pests not only protects the environment, it also protects pollinators, natural pest enemies, beneficial organisms and the people and animals that depend on plants [1].

There are globally about 9,000 harmful species of insects, 50,000 pathogens and 8,000 weeds, where more than 70% of them are invasive species introduced by humans into territories new to them, where they take root and begin to breed [3].

Manufacturers around the world are using more and more synthetic chemicals to reduce risks and deal with these threats. At the same time, the general intensification of crop production also leads to an increase in the application of mineral fertilizers and pesticides, which as a result leads to an increase in the number of pathogenic microorganisms in the soil, an increase in degradation processes and a decrease in fertility.

Therefore, there is worldwide concern about the environmental costs of conventional intensification of agriculture. Growing evidence suggests that ecological intensification of mainstream farming can safeguard food production along with accompanying environmental benefits.

Scientists consider the ecological intensification as a nature-based alternative that complements or (partially) replaces external inputs such as agro-chemicals, with production-supporting ecological processes, to sustain agricultural production while minimizing adverse effects on the environment [4].

As, in recent years, the opinion of the world community is increasingly inclined to recognize the huge threats to human health and the environment that come from the use of traditional non-biological plant protection agents, there is an increased demand

for biological preparations or biological plant protection agents and a steady increase in their production and product range using biotechnology methods. The extent of research in this area is growing and more and more there is a need for a wider implementation of the results of these studies in industrial practice [5]

There is thus a great need to find efficient and sustainable pest management strategies. Among several measures of controlling insect pests, biocontrol by means of use of natural enemies has recently gained much interest because of the problems encountered by the use of pesticides and environmental concerns. Biocontrol that uses parasitoids and pathogens has a long history of pest management. It has been outstandingly successful in many instances and has permanently resolved a number of important pest problems in a highly cost-effective manner [6].

Experts believe that the global demand for these products will lead to an annual growth rate of up to 15% in the near future, and new biopesticides and biological control products will be produced continuously [3].

2. Methods and Equipment

2.1. Research Materials

The material for the study was the Decree of the President of the Russian Federation on “The Ecological Safety Strategy of the Russian Federation for the Period until 2025”, FAO publications, scientific articles on the problems of greening production, the experimental use of biological methods in crop production, as well as data on Russian developments in the field of plant protection using entomophages.

2.2. Research Methods

The methods used were monographic, comparative and system analysis, idealization and mental modeling, as well as a logical approach.

3. Results

The potential annual crop loss in the Russian Federation calculated in terms of grain units is about 100 million metric tons [3].

In the process of intensification of crop production, the value of protective measures for crops increases, progressive and sustainable varieties are introduced, mineral fertilizers and chemicals are used on a large scale to protect the quality of crops.

A separate science has arisen that studies physicochemical characteristics of pesticides, their toxic effect not only on pests, but also on species and abiotic components of natural systems that are useful for agricultural ecosystems.

In technological terms, the biological protection of plants from harmful organisms is a highly knowledge-based agrotechnology based on an agro-landscape approach and the ecological principle of “living against living”.

Broadly, the current biological protection is a fundamental and applied field of knowledge that provides landscape- and biosphere-compatible suppression of harmful agents during the cultivation and storage of agricultural products using natural or artificially created organisms (including genetically modified ones that have pesticidal properties), as well as their metabolic products. Its main goal is to obtain environmentally friendly, cost-effective and high-quality food, fodder, and raw materials [7].

According to scientists from the All-Russian Research Institute of Biological Plant Protection, the main problems of modern biological plant protection are:

- insufficient product range of biological plant protection agents (BPPA) (50 out of 1,060 required);
- low volume of use of BPPA (1.5 to 2%);
- insufficient number of BPPA manufacturers;
- lack of broad government support for BPPA and economic mechanisms of stimulation and regulation;
- poor information preparedness of agricultural producers and the population;
- lack of proper control of the quality and effectiveness of BPPA.

As part of the greening strategy, many manufacturers are beginning to reduce the use of fertilizers, plant protection agents, regulators and growth promoters of non-biological origin. The main incentives for the use of biological products in the agricultural sector are: reducing the environmental load on the environment and cultivated objects; restoring the natural potential of production factors; improving product quality and obtaining organic products [8].

A successful biological control of the situation is the result in which the natural enemy of the pests used, being very often a parasitoid, is able to suppress the abundance of the insect pest to a level at which it no longer causes economic damage [9].

One of the promising areas of BPPA is the use of entomophages, which destroy eggs and larvae of harmful insects. Certain types of entomophages (for example, *Trichogramma*, *Encarsia formosa* Gah, *Phytoseiidae*) are able to reproduce in the laboratory. Therefore, they are cultivated and widely used in crop production [10].

The size of this market in the Russian Federation is estimated at 100 billion individuals sold annually to producers of vegetables and other crop products.

The All-Russian Research Institute of Biological Plant Protection is performing study on the development of measures for the integrated biological protection of seeds of the most important crops from harmful organisms. One of the main producers of BPPA is the Rosselkhoztsentr laboratories. Four branches of this institution produce entomophages: *Trichogramma*, *Chrysopidae*, *Habrobracon hebetor*, etc., and other thirty three branches produce biopesticides [11].

The Entarium Research and Production Center that has been established based on the Agrocomplex Churilovo in the Chelyabinsk region, has been industrially breeding useful predatory mites, bugs and wasps in the amount of 6 billion individuals annually since 2016. Today they are used mainly in the greenhouses of the Agrocomplex Churilovo agricultural facilities to protect tomatoes, cucumbers and green crops from pests.

The construction of new facilities and the introduction of modern technologies led not only to an increase in the gross harvest of greenhouse vegetables, but also a two-fold increase in crop productivity from 30 kg / m² in 2013 to 62 kg / m² in 2016.

The design capacity of the biofactory assumes the annual release of 9 billion individuals of entomophages (predators, parasites and other organisms that affect the natural regulation of the number of insects) and acariphages (predators and parasites that destroy ticks). Entomophages and acariphages, as a line of 11 certified products, are planned to be sold in retail for the destruction of *Aleyrodidae*, *Tetranychus urticae* and *Aphidoidea* in greenhouses, on open plantings of vegetables, in gardens and hothouses.

During the implementation of investment projects for the construction of greenhouses and a biological factory, Churilovo Agrocomplex has created about 700 jobs. Important scientific research is performed there, and Russian innovations are introduced into the process of growing greenhouse vegetables [12, 13].

An entomophage factory has been created in the Teuchezhsky district of Adygea, where *Trichogramma* mites are grown that destroy the eggs of other insects by laying larvae in them, and have been used with great success all over the world for controlling

Cydia pomonella, Tortricidae, Noctuidae and other pests. Grown insects will be introduced into greenhouses. In the future, they are planned to be used in horticultural farms. It is planned to increase the number of beneficial insects to 7 species. The amount of investment in the project is about 40 million rubles.

Today, the most insects for breeding are imported from countries for which biological pest control has become a standard, for example, from the UK, the Netherlands, and Israel [14].

It must be said that, as Jalali, Mohanraj and Lakshmi note, *Trichogramma* species are the most widely exploited and used for pest management across the world. There are 230 recorded species and the highest numbers of species have been described from the USA, India, Brazil, China, and Russia. These are the species that are most used for biological and integrated control of crop pests [15].

Organic Park (Kazan) established its own production of entomophages and received support for its project as part of the import substitution program [16].

Positive experience has been gained with the use of entomophages in agriculture. In most cases, their use allows protecting plants from pests and completely abandon chemical plant protection agents.

One of the leaders in the use of entomophages for the protection of greenhouse crops is the Krugliy Gorod plant, which has introduced a plant bioprotection system in all areas. These are entomophages (predatory bug cultures obtained at the All-Russian Research Institute of Biological Plant Protection) against insect pests and biological products against various diseases. As a result of a set of measures, the plant receives yields from 120 to 150 kg of cucumbers per m², more than 6,000 metric tons of products annually [17].

INAPPEN in cooperation with the All-Russian Research Institute of Biological Plant Protection will produce a new generation of biological plant protection agents, it will be a large-scale biotechnological production with a wide range of products.

4. Discussion

The BPPA introduction to the practice reduces the risk of emergencies of epizootic pests of agricultural plants, opens up the possibility of strengthening self-regulation mechanisms, reduces the ripening of crops and ultimately ensures the safety of the crop at a lower cost. At the same time, it has been proved that the effectiveness of the use of biological agents is increased when they are used in integrated protection

systems, and the proportion of the biomethod in the systems can be 25 to 30% for cereals, 60 to 70 % for vegetables, 40-50 % for fruits, and 50- 70% for grapes [10].

Cases where chemical pesticides ultimately result in significant crop losses are probably widespread, but little known. For example, in Southeast Asia, chemical treatment of rice fields against *Pyralidae*, which cause significant damage to plants due to massive propagation is usually performed. Such treatment destroys entomophages along with pests as well. As a result, *Niloparvata lugens Stal.* propagates in mass, the damage from which is almost unnoticeable, and the crop may completely disappear. A month after a single use of pyrethroids in gardens, the number of herbivorous ticks increases 2 to 3 times, while the number of acarifagus only returns to its original level. When the long-term and regular use of chemical pesticides in gardens takes place, only 2–5 species of predators remain with their efficiency maximum 5%. In this case, there can be no environmentally friendly products and the use of natural parasites and predators to protect the crop. At the same time, as a rule, the use of chemical pesticides, which leads to the death of natural entomophages, with expanding use and an increase in the product range of pesticides, pest resistance problems to pesticides more often arise, and serious damage to human health is reported. The issue of degradation of nature and a sharp depletion of fauna becomes more and more serious [18].

Therefore, it is necessary to carefully approach the use of pesticides and to take into account the high number of useful entomophages. Making rash decisions can lead to a negative result: it will take considerable time to restore the balance between beneficial insects and pests in ecosystems [19].

The opinion of the scientific environment is increasingly inclined to the fact that the widespread use of chemical plant protection agents causes harm to the environment. Main risks for ecosystems are highlighted below:

- emergence of resistant pest populations that will require even more funds to control;
- possibility of influence on beneficial ecosystem fauna and flora as well;
- resistance to the environment;
- ability to be included in the biological and biogeochemical cycles of substances in nature due to the ability not only to be transmitted by trophic chains, but also to accumulate while concentrating on each subsequent trophic level;
- toxicity for both animals and humans [20].

Research into improving existing entomophage species continues worldwide. Thus, the work on genetic improvement of various *Trichogramma* species has led to the

development of insecticide-tolerant strains that have been extensively utilized in the field on crops that are subjected to intense pesticide pressure and development of high temperature-tolerant strains [14].

5. Conclusion

Domestic developments in the field of BPPA, regulators and growth stimulants involved in economic turnover have a long-term market focus and embody the great strategic potential for the development of organic farming in this country. This area is developing as part of one of the main activities called “Development of biotechnologies” according to the State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials and Food Markets and is consistent with the Comprehensive Program for the Development of Biotechnologies in the Russian Federation for the Period until 2020.

There is an increase in demand for BPPA and research activity in this segment. An important factor for the successful implementation of the latest biological protection techniques in Russia is the creation of import-substituting domestic factories for the production of biological products and entomophages, as well as the general trend towards greening production.

The transfer of agricultural production to the principles of more environmentally friendly production can be an impetus for the development of domestic agribusiness, which allows solving the problem of reducing the environmental burden from agricultural production, restoring land fertility, and developing export of domestic high-quality products including organic ones. In fact, agricultural production within the framework of such production should be energy and resource efficient, solve the problem of food supply and reduce the environmental burden on the environment, and therefore more widely apply environmental protection and production intensification methods. At the same time, the dynamic development of domestic biotechnological production and emergence of competitive products can reduce the import dependence of this segment.

In some segments, for example, in greenhouse production, it is impossible to obtain environmentally friendly products that are competitive in the domestic and foreign markets, as well as to make cultivation of greenhouse crops safe for the environment and humans without using biological plant protection products.

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Conflict of Interest

The authors have no conflict of interest to declare.

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