Biological plant protection in greenhouse, intensive and organic farming

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Abstract. The scientific schools of All-Russian Institute of Plant Protection offer a new paradigm for the development of plant protection, based on the principles of managing the phytosanitary state of agroecosystems. In recent years, the biological protection of vegetables in greenhouses develops intensively. The assortment of protective biological products are in demand on the domestic market and have proven themselves in bioprotection systems. Given the strict regulatory framework for organic farming and the presence of a wide variety of phytosanitary objects, the phytosanitary risks are of great importance when ecologically safe agricultural products are to be obtained. In intensive crop production, plant protection is largely based upon application of synthetic pesticides. Efforts are aimed at reduction of harm and one of the modern trends is the increase in usage of biological products for treatment of seeds as well as spraying crops during the vegetation season. More biological products are used nowadays and positive results are obtained.

1 New paradigm of plant protection

Modern challenges and scientific and technological progress in agricultural production pose the most complex fundamental and technological problems to plant protection, such as guaranteed preservation of crop and its quality and achievement of sufficient environmental safety in agroecosystems. For this reason, the scientific schools of All-Russian Institute of Plant Protection (VIZR) offer a new paradigm for the development of plant protection, based on the principles of managing the phytosanitary state of agroecosystems. Control of harmful species is a multilevel set of techniques and tools that limit the propagation of harmful objects, based on trophic connections (triotroph), immunity of crops, selective and multifunctional plant protection systems, phytosanitary design of agroecosystems, the functioning of parasitocenoses and plant-microbial communities [1].

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2 Plant protection in greenhouses

In recent years, the biological protection of vegetables in greenhouses develops intensively. The assortment of protective biological products (~ 50) and 16 species and populations of entomophages are in demand on the domestic market and have proven themselves in the scientific and production testing of bioprotection systems. Thus, according to Abercade Investment Company, the volume of the biological product market in the Russian Federation tripled over five years and by 2018 reached 1.5 billion rubles in monetary terms. The VIZR concept of phytosanitary optimization of greenhouse agroecosystems based on biocenotic regulation was confirmed.

Greenhouse agrobiocenosis is a closed biological system characterized by incompletely established consort connections, being therefore unstable. Formation of a protective species complex using entomo- and acariphages, entomopathogenic and antagonist microbes is crucial for effective biological regulation [2-4]. For example, microbial protection of vegetable crops in greenhouses recruits formulations based on conidia of entomopathogenic fungi and nematodes, antagonist microbes with multifunctional type of action on plants (regulatory activity) and pathogens (suppressive activity), and toxin formulations of microbial origin able control a number of harmful species (Table 1).

Table 1. The main elements of the biological protection of cucumber and tomato from diseases and pests in the greenhouses of the North-West region of the Russian Federation

Diseases and pests	Biological control means	Application method	Biological efficacy, %
Root rot	Alirin-B, Alirin-C*, Trikhodermin	Seed and soil treatment before planting seedlings and spraying at the beginning of flowering	50-90
Downy mildew	Baktofit, Alirin-B, Alirin-C*	Spraying of plants with disease symptoms	60-80
Alternariosis, ascochytosis, anthracnosis, grey mould, timber rot	Baktofit, Alirin-C*, Trikhodermin	Spraying and coating of damaged parts of plants	70-80
Bacterial diseases of tomato	Fitolavin FG-300, Gamair	Treatment of seeds, seedlings and grown plants	30-50
Spider mite	*Phytoseiulus persimilis*	Release in greenhouses	80-100
	Aktinin, Fitoverm	spraying of outbreak foci	
Greenhouse whitefly	*Encarsia formosa*	Release in greenhouses	70-95
	Vertitsillin-K, Vertitsillin-M*, Aleitsid*	Spraying of outbreak foci	
Aphids	*Aphidoletes aphidimyza, Lysiphlebus testaceipes*	Release in greenhouses	80-95
	Mikoafidin-T*, Vertitsillin-K, Vertitsillin-M*, Aleitsid*	Spraying of outbreak foci	
Thrips	Nemabakt, Boverin (*Beauveria bassiana* strain K-2)	Spraying of soil	80
Leaf miners	Nemabakt	Spraying of plants	80
Crickets	Nemabakt	Spraying of soil	Up to 100

* experimental samples of novel bioformulations

3 Plant protection in organic farming

Given the strict regulatory framework for organic farming and the presence of a wide variety of phytosanitary objects, including a group of (~ 40) especially dangerous species, the phytosanitary risks are of great importance when ecologically safe agricultural products are to be obtained. Moreover, it is necessary to consider the ecotoxicological state of soils, i.e. the accumulation of pesticides and their metabolites, heavy metals and other chemical toxicants. It is important to know the preceding phytosanitary situation, such as accumulated reserve of weed seeds which retain germination capacity over years, the presence of soil phytopathogens (*Fusarium* spp., *Synchitrium endobioticum*, phytopathogenic bacteria, etc.). The suppressive activity of soil should be concerned, and intensive introduction of antagonistic microbes can be exploited to solve this problem. Obviously, in organic farming, it is necessary to rely on the massive use of bioprotection measures, to enhance agrotechnical practices that limit the harmfulness of weeds, diseases and phytophages, and to use properly the elements of phytosanitary design of agroecosystems.

4 Biological crop protection in intensive production

This is widely accepted that plant protection in intensive crop production is largely based upon application of synthetic pesticides against major pests, disease agents and weeds. Efforts are aimed at reduction of harm incurred by toxic substances to the environment and human health using various approaches and one of the modern trends is the increase in usage of biological products for treatment of seeds as well as spraying crops during the vegetation season. More biological products are used nowadays as compared to previous period and positive results are obtained due to application of bioformulations produced by LLC PO Sibbiofarm, LLC NVP BashIncom, LLC Agrobiotechnology and other companies. For example, in 2017-2018 at the experimental station Shebekino (Belgorod region) total yield of winter wheat ranged from 67 to 70 centners/ha in three experimental variants using chemical pesticides, integrated pest management (IPM) and biological protection system. The costs of chemical pesticide application and IPM were comparable while in case of biological protection, the costs were two times as low (Table 2). This observation fairly supports the idea that biological protection means can be as effective as synthetic pesticides while the cost incurred and environmental hazards are lower.

Table 2. Total yield and cost of protection of winter wheat in Belgorod region, 2017-2018

Crop protection measures	Total yield, center/ha	Crop protection costs, roubles/ha
Chemical pesticides application	70	2812
Integrated pest management	69	3008
Biological protection	67	1420

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