The role of biologization of processes in increasing the technological and economic efficiency of viticulture

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Abstract. The necessity of increasing the technological and economic efficiency of viticulture is substantiated. The assessment of the influence of negative manifestations of chemical and technogenic intensification factors in viticulture on the stability of agrocenoses with the participation of grape plantations is given. The priority role of biotechnologies in ensuring the stability of grape agrocenoses to negative manifestations caused by an increase in chemical and man-made loads, which are a set of industrial methods that use living organisms and biological processes for the production of industrial products, is substantiated. The basic principles on which the biologization of protective measures of vineyards is based are considered. The effectiveness of the main methods of biological protection of industrial vineyards is assessed, the use of which will reduce the negative impact of xenobiotics on the environment, material costs for the purchase of insecticides in the cultivation of products and ensure the development of optimal agrotechnological solutions for the protection of perennial plantations, which will contribute to the growth of technological and economic efficiency of industrial production.

1 Introduction

Viticulture is one of the priority sectors of agriculture in the Russian Federation, one of their main indicators of development of which, according to the federal project "Stimulating the development of viticulture and winemaking", is to increase the fruit-bearing areas of grape plantations by 35% by 2030. In 2023, about 4 billion rubles were allocated for the development of viticulture in the Russian Federation. The development of viticulture is mainly concentrated in the Southern and North Caucasian Federal Districts, which account for 97.4% of the area of grape plantations. During the period 2013-2023, 55.3 thousand hectares were laid, while the annual renovation rate was 5.4% (the annual renewal rate is 5%). The total area of grape plantations increased 1.6 times during this period and amounted to 103 thousand hectares in 2023, the gross grape harvest increased 1.6 times [1, 2].

Despite the positive dynamics in the development of industrial viticulture in the Russian Federation, risks remain due to the negative impact of climatic factors, chemical and man-

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made intensification on the elements of grape agrocenoses, as well as macroeconomic imbalances on the stability of reproductive processes, which actualizes the need to substantiate promising areas in the modification of industry technologies to ensure their technological and economic efficiency and competitiveness.

2 Materials and Methods

The reliability and accuracy of the results obtained is determined by the use of modern methods and world-class instrumentation and analytical equipment, the complexity and multiplicity of interrelated studies, modern economic and mathematical methods of statistical analysis [3, 4].

3 Results and Discussions

Industrial grape plantations belong to complex natural and man-made systems with significant anthropogenic load, intensive cultivation technologies and the highest risks of phytosanitary condition destabilization.

As a result of the negative influence of chemical and technogenic intensification factors on the elements of grape agrocenoses, bioresource deformations are formed, which lead to a violation of environmental management rationality, a decrease in the stability of agroecosystems and the effectiveness of reproductive processes [5, 6].

The additional costs of carrying out agrotechnological measures related to leveling the negative consequences of bioresource deformation in the elements of grape agrocenoses amount to more than 150 thousand rubles/ha, which causes a decrease in the efficiency of grape production by an average of 6.8-7.2 points.

The ongoing bioresource deformations in the pathocenosis lead to a violation of the stability of microbio-, acaro- and entomosystems, a decrease in the phytosanitary stability of agrocenoses due to increased risks of formation of resistant populations, mass outbreaks of pests and a decrease in the realization of the productive potential of grape plantations. With the negative impact of pests in agrocenoses involving grape plantations, crop losses can be up to 50-80%, which leads to a decrease in technological and economic efficiency by more than 12 percentage points.

In ensuring the stability of grape agrocenoses to negative manifestations caused by an increase in chemical and man-made stress, a priority role is assigned to biotechnologies, which allow not only to restore the bioresource potential of the grape agrocenosis, but also to ensure optimal technological and economic efficiency of the manufacture of industrial products.

Biologization of the protection of industrial vineyards is a reasonable integration of biomethod with chemical and other methods. The main principles on which the biologization of protective measures of vineyards is based are the following: the effectiveness of operational control of pest populations; manufacturability of application, including compatibility with chemical plant protection products; adaptability or multivariance (according to criteria of zoning of cultivation territories, varietal stability, age of plantings, pest stock, weather and climatic conditions); optimization long-term complex resistance of perennial plants to environmental (biotic and abiotic) stress factors; cost-effectiveness of use.

Biotechnologies of pest population regulation are developed on the basis of reproduction and industrial replication of bioagents – the development of entomopathogens, extraction or synthesis of analogues of biologically active substances, mass breeding of beneficial arthropods, respectively, microbiological, chemoregulatory and entomoacariphage methods are used. The most popular methods of protecting grape plantations in conditions of increasing chemical and technogenic intensification of reproductive processes are microbiological and chemoregulatory methods, which have a fairly wide economically and technologically attractive list of tools for controlling dominant harmful objects in grape agrocenoses. There is sufficient and still untapped potential for the method of immunoinduction of plants to pests.

A comparative analysis of perennial crop protection systems for the period from 2005 to 2023 showed a significant increase in the use of biologized pest protection systems – their use increased almost 3 times. Thus, in protection against lepidopteran pests (European grape moth and cotton budworm), the share of biologized control technologies based on microbiological, biorational (avermectins, juvenoids, chitin synthesis inhibitors) insecticides occupies 60-80%, in protection against herbivorous mites – up to 100%.

Microbiological regulation of the number of harmful arthropods is one of the basic directions of biologization of pest protection in industrial grape plantations, since it imposes fewer requirements on a biological agent, is less labor-intensive and is more affordable and technologically advanced compared, for example, with the entomoacariphage method. For the use of entomopathogens in vineyards, 2 biotechnological techniques have been developed at the FSBSI North Caucasus Federal Scientific Center for Horticulture, Viticulture and Winemaking: bioinsecticidal and epizootic [7, 8].

Bioinsecticidal treatment is the main one in the microbiological regulation of pests in vineyards. It is used in the operational seasonal protection of grapes and limits the number of phytophages for a certain short-term period (up to 7-14 days). At the same time, the main role in limiting the number of openly living sucking pests (spider mites, herbivorous thrips, leafhoppers), as well as caterpillars of the European grape moth and cotton budworm belongs to biologics based on metabolites of entomopathogens and actinomycetes (toxins, antibiotics), since their biological activity is less dependent on environmental conditions than that of preparations based on the spores or cells of the microorganism, and the lethal effect is achieved in a shorter period of time [9-10].

A comparative assessment of the biological effectiveness of microbiological insecticides in the fight against grape lepidopteran pests showed that all preparations approved for use on grapes have a fairly high efficiency – at the level of 78-99%, the greatest effectiveness was noted in Lepidocide, SC (3.0 l/ha) both in reducing the number of European grape moth (84-96%) and cotton budworms (92-99%). Another group of preparations that can be classified as microbiological are insecticides and acaricides based on metabolites of the soil actinobacterium *Streptomyces avermitilis* (fam. *Streptomycetaceae*), having high biological activity. Avermectin-based insecticides can be introduced into lepidopteran pest protection systems throughout the growing season, observing the anti-resistance principle [11-14].

Live cells and spores of entomopathogens are more actively involved in epizootic intake compared to bioinsecticidal one. The inclusion of epizootic intake in phytophagous population control systems makes it possible to increase its effectiveness in general. This technology is low-cost – cost savings on protective measures ranged from 32% to 63%, depending on the option.

Another effective biotechnological unit based on the use of the chemoregulatory method has been formed in the system of protection of vineyards from pests to date. Modern chemoregulatory technologies used in regulating the number of pests on grapes are based on management methods using synthesized biologically active substances (hormones, pheromones) at different levels of biosystems – cellular, organismal, population, ecosystem. In modern grape protection, biorational preparations based on synthesized analogues of the juvenile insect hormone (JG) phenoxycarb (Insegar, Fora, Phasis, etc.) and inhibitors of chitin synthesis (ICS) lufenuron, diflubenzuron (Lufox, Twingo, Proclaim Fit) are used, the effectiveness of which is shown in Table 1 [15-19].

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Table 1. The effectiveness of the chemoregulatory method in the control of Lepidoptera pests of grapes, on average for 2019-2022.

Preparation	Application norm	Active substance	Class	Target object	Biological efficiency, %
Twingo, CS	1.2 l/ha	Diflubenzuron 180 g/l + imidacloprid 45 g/l	Chitin synthesis inhibitors	*L. botrana*	92-100
				H. armigera	95-100
Insegar, EDG	0.6 kg/ha	Phenoxycarb, 250 g/kg	Juvenoids	*L. botrana*	89-93
Lufox, CE	1.2 l/ha	Phenoxycarb 75 g/l+ Lufenuron 30 g/l	Chitin Synthesis inhibitors + Juvenoids	*L. botrana*	92-98
				H. armigera	95-99

Other chemoregulators that have good prospects for use in modern biologized pest protection systems in grape plantations are pheromones.

The advantages of the pheromone disorientation method as a technology for combating lepidopteran pests are manufacturability, independence from weather conditions, and high economic efficiency. Traditionally, pheromones in vineyards are used to monitor the summer of Lepidoptera pests and determine the timing of treatments.

Over the past 5 years, biotechnology has been adapted in the vineyards of the region to control the number of European grape moth by pheromone disorientation based on the use of the Shinetsu pheromone. The biological effectiveness of the Shinetsu pheromone is shown in Figure 1.

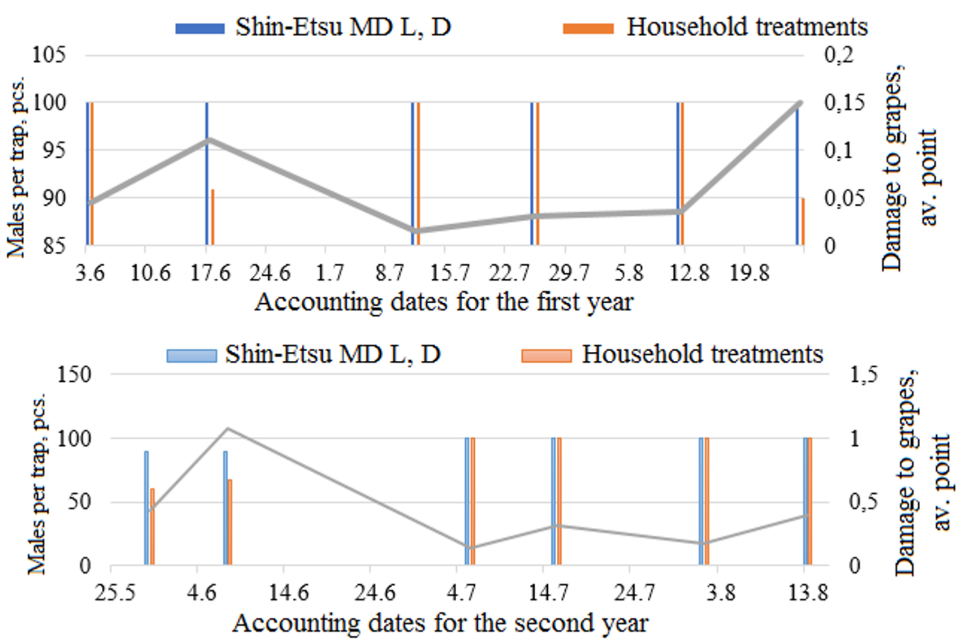

Fig. 1. Biological efficiency (%) of the Shin-Etsu MD L, D pheromone in the fight against European grape moth on grapes, Krasnostop variety, Yuzhnaya LLC.

Figure 2 shows the economic efficiency of using the method of biological regulation of the number of European grape moth.

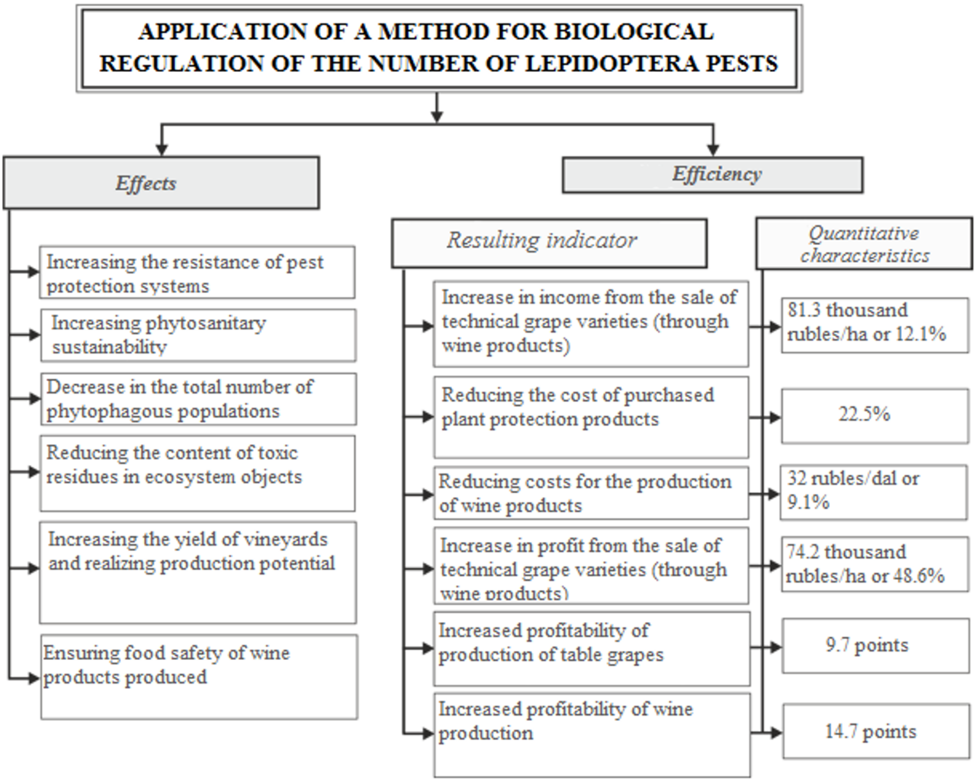

Fig. 2. Economic efficiency of biologized systems for protecting grape plantations from Lepidopteran pests (in prices of 2023).

As a result of the use of biologized systems for protecting grape plantations from lepidopteran pests, there is an increase in yield by an average of 25% due to a decrease in the phytotoxicity of protective measures and a more complete realization of the biopotential of the variety, a decrease in the content of toxicological residues in ecosystem objects, a reduction in plant protection costs by an average of 22.5%; an increase in the profitability of grape and wine production by an average of 9.7 points and 14.7 points, respectively, which indicates their high ecological and economic efficiency.

4 Conclusions

The development of modern systems for protecting plantings and grape crops from pests using highly effective biorational, low-toxic chemical and biological preparations of a new generation in controlling the number and harmfulness of phytophages will reduce the negative impact of xenobiotics on the environment, material costs for the purchase of insecticides in growing products and ensure the development of optimal agrotechnological solutions for the protection of perennial plantations, which will contribute to the growth of the technological and economic efficiency of the production of industrial products.

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