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BIOLOGICAL PLANT PROTECTION AND CONSERVATION OF BENEFICIAL INSECTS AS KEY COMPONENTS OF MODERN AGROECOSYSTEM MANAGEMENT

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The increasing frequency of biological invasions, the intensification of climate change effects, and the urgent need to reduce the environmental impact of phytosanitary products are driving the transition of modern agricultural systems towards sustainable plant protection approaches. In this context, biological plant protection, based on the utilization and conservation of entomophagous organisms, represents one of the most effective strategies for maintaining ecological balance and reducing crop losses caused by harmful organisms.

Research conducted in the Republic of Moldova has revealed significant changes in the structure and dynamics of phytophagous insect populations, driven both by climatic factors and by the ability of certain species to adapt to newly emerging ecological conditions. A representative example is the invasive species *Halyomorpha halys* (Stal), which has demonstrated complete acclimatization within the territory of the country through the development of three generations during a single vegetation season. The high population densities recorded mainly in the central and southern regions, together with the high reproductive potential of females, confirm the considerable phytosanitary risk posed by this species to agricultural crops. At the same time, its pronounced preference for fruit crops, particularly apple and plum orchards, highlights the necessity of implementing

efficient monitoring systems and environmentally sound population management strategies.

For the monitoring of invasive insect species and agricultural pests, pheromone traps and lures manufactured by *Ecology Center* LLC were employed. The traps were installed in various agroecosystems and agricultural crops, maintaining a distance of 50–100 m between monitoring points, depending on the biological characteristics of the target species and the specific features of the surveyed habitat. Observations and records of trap catches were conducted at three-day intervals throughout the growing season, enabling the assessment of population dynamics and activity patterns of the monitored insect species.

Similarly, studies conducted on the species *Helicoverpa armigera* (Hübner) and *Agrotis segetum* Denis & Schiffermüller have revealed specific bioecological characteristics that directly influence the infestation level of agricultural crops. Anatomical investigations demonstrated that females of *H. armigera* possess high fecundity and an extended reproductive period, favored by elevated temperatures during July–September, whereas in *A. segetum*, reproductive activity is predominantly concentrated within the first two generations. These biological characteristics, combined with favorable climatic conditions, contribute to the formation of local population outbreaks and emphasize the importance of continuous monitoring of pest dynamics.

In this regard, the application of modern digital technologies represents an essential tool for optimizing plant protection processes. The development of digital distribution maps and the integration of biological and ecological information into the EcoBioNet information system enabled the identification of areas with high phytosanitary risk and facilitated forecasting of *H. armigera* population dynamics. The obtained results demonstrate that combining conventional entomological monitoring with advanced digital mapping approaches can significantly support decision-making processes related to pest management and enhance the efficiency of integrated pest management systems.

However, the development of effective biological protection systems requires not only continuous pest monitoring but also the efficient exploitation of the natural potential of entomophagous organisms. In this context, biologically active substances with kairomonal properties represent a promising approach, as they are capable of enhancing host-searching and host-location behavior. Research findings demonstrated that these substances significantly stimulate the activity of *Trichogramma* species, increasing their parasitization capacity and locomotor activity. These results confirm the high potential of kairomonal compounds for improving the efficiency of biological control agents used in pest management programs targeting lepidopteran species.

The ecological importance of the genus *Trichogramma* within agricultural ecosystems is also supported by the specific composition of natural populations identified

in various agrocenoses. The analysis of collected material revealed the predominance of *Trichogramma evanescens* Westwood and *Trichogramma dendrolimi* Matsumura, accompanied by the presence of *Trichogramma pintoi* Voegelé and *Trichogramma embryophagum* Htg. This species diversity reflects the existence of a valuable natural potential for biological regulation of phytophagous insect populations and confirms the necessity of conserving beneficial entomofauna within agroecosystems.

The same principle of enhancing natural biological control mechanisms was demonstrated for the entomophagous species *Bracon hebetor* Say. Biologically active compounds extracted from larval excreta of *Galleria mellonella* L. exhibited a pronounced kairomonal effect, significantly increasing parasitization intensity. Furthermore, optimization of nutritional media for the mass rearing of the host species *Plodia interpunctella* Hübner improved the efficiency of biological material production intended for entomophage multiplication. These findings emphasize the importance of improving mass-rearing technologies for beneficial organisms in order to expand the practical application of biological control methods in agricultural production.

Alongside the multiplication and application of entomophagous organisms, the conservation of natural populations of beneficial insects represents an indispensable component of ecological agriculture. Monitoring studies demonstrated the effectiveness of artificial shelters as tools for maintaining functional biodiversity, with a considerable number of representatives of the families Chrysopidae and Hymenoptera using these structures for overwintering. The conservation of natural entomophage reservoirs contributes to strengthening the self-regulation capacity of agroecosystems and reducing the dependence on chemical control interventions.

In conclusion, the research results demonstrate that bioecological monitoring of pest species, implementation of digital forecasting technologies, application of biologically active substances with kairomonal effects, optimization of entomophage mass-rearing processes, and conservation of natural beneficial insect populations represent complementary components of a modern biological plant protection system. The integration of these approaches into a unified management strategy contributes to increasing agroecosystem resilience, mitigating the impact of invasive species, and promoting sustainable agriculture based on the enhancement of natural mechanisms regulating pest populations.

Keywords: Halyomorpha halys, Helicoverpa armigera, Agrotis segetum, Trichogramma, Galleria mellonella, Bracon hebetor.

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