

Biological method as the basis of sustainable development of domestic agriculture

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Goal. To study the dynamics of processes and the current state of application of biological plant protection products in Ukraine, the main trends in world markets for organic products and domestic production of biological products, to identify tasks for the implementation of bio methods in the context of organic farming in Ukraine. **Methods.** Analytical, economic and statistical, comparative analysis, graphical, cartographic. **Results.** On the background of significant growth in the production and use of biological plant protection products in the EU and the world, the use of safe methods of protection in Ukraine is declining. With the growth of the range of microbiological means of protection included in the «List of pesticides and agrochemicals in Ukraine», the production capacity for the production of biological products has sharply decreased. Thus, in 2019, there were 24 biofactories and bio laboratories in Ukraine, and their total number, including private-sector production, was over 45, while by 1990 there were 268 biofactories and bio laboratories in Ukraine. **Conclusions.** The use of environmentally friendly biological plant protection products in Ukraine for a long time is at a very low level and tends to further decrease. To intensify the transition to environmentally friendly methods of plant protection, the development of domestic production of biological plant protection products, as well as the process of greening agriculture, they propose strategic approaches to the formation and development of a common system of environmentally friendly methods of plant protection on the new technological and organizational basis.

Key words: *development of modern agricultural production, biologization of plant protection, biological products, ecological quality of products, biofactories, bio laboratories.*

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The strategic development of agricultural production in the vast majority of countries is based on sustainable development, environmental friendliness of agriculture, high quality agricultural products, the transition to environmentally friendly technologies in agricultural production, the abandonment of harmful and dangerous means of plant protection and growth. Processes have been intensified, according to which priority is given to the direction of integrated biologization of agriculture and production of agricultural products of the highest ecological quality without the use of chemical pesticides and mineral fertilizers. A significant result of activity in this direction is the formation of a strong global market for environmentally friendly agricultural products and food, the capacity of which has already exceeded 50 billion dollars USA and tends to grow further. This became possible due to the consistent implementation of the policy of greening of agriculture in a broad context and the formation of a general culture of environmentally friendly agricultural production, an important and essential element of which is the use of biological methods of plant protection. This method has significantly intensified in recent decades in the EU, the US and most other developed agricultural countries.

It should be noted that plant protection in agricultural production is given increased attention, because pests and plant diseases can significantly reduce crop yields and agricultural production. According to analysts, more than a third of the losses of the agricultural sector fall on the destruction of crops by pests and plant diseases [1]. According to the FAO, 40 % of crop yields are lost annually due to exposure to dangerous plant pests.

Excessive fascination with chemical methods of plant protection results in an increase in biocenoses and, above all, in agrocenoses of threatening phenomena associated with contamination of plants, soils, water and food by chemical pesticide residues, reduced pest resistance to protection, impaired ecosystem resilience due to loss of part biota due to the action of chemicals. This directly and negatively affects human health and the environment.

Today, threatening phenomena with the state of the plant world are growing, which are caused, first of all, by diseases and mass deaths due to climate change and exposure to pests, including those that are not typical for certain climatic conditions. There are also losses of the agricultural sector due to the destruction of crops by diseases and pests. In an effort to draw public attention to the importance of issues in this area, in December 2018, the UN General Assembly declared 2020 the International Year of Plant Health.

Due to the close link between plant health and environmental protection, the use of environmentally friendly methods of pest and disease control through an integrated plant protection system and a

biological method of plant protection is becoming relevant and promising. Minimal use of toxic substances in pest control contributes not only to the protection of the environment, but also to the protection of pollinators, natural enemies of pests, beneficial organisms, as well as humans and animals that depend on plants.

Biological control or biocontrol in its narrow classical sense is a method of controlling pests, weeds and plant diseases using natural enemies. It is based on natural mechanisms ("predator-victim", "parasite-host") and on active human intervention in the process of regulation and suppression of pests and pathogens.

A number of scientists distinguish four types of biological control: natural, environmental, classical and auxiliary biological control [2].

In the agricultural sector, in the vast majority of cases, auxiliary biological control is used – the release of a large number of mass-grown in biolaboratories of natural enemies to control pests and their suppression [3-6].

Biological control can be applied alone or in combination with other methods of pest control – then it will be an integrated method of pest control (integrated pest suppression, integrated pest management) – a special approach to using all available forms of pest control: mechanical, biological, chemical methods and natural regulation. This combination of pest control methods makes it possible to safely, effectively and at the lowest cost to reduce the pest population.

Particular interest in the biological method as a means of wide industrial application in agricultural production appeared in the 60s of last century. This gave impetus to new research on the biomethod in plant protection, in particular, the conditions of inclusion in the general processes of greening of agriculture, the development of new technological solutions to improve the efficiency of biocontrol and integrated methods of its application [7-32]. Practical industrial production and use of biological products have been studied by numerous foreign and domestic scientists [33-39].

However, in Ukraine, research on the application of the biological method of plant protection has not become systemic and the weakest link continues to be its economic and economic-technological aspects.

The purpose of research. To study the dynamics of processes and the current state of application of biological plant protection products in Ukraine, the main trends in world markets for organic products and the development of domestic production of biological products, to outline tasks for biomethod development in the context of ecological farming in Ukraine.

Materials and methods of research. Information from the State Statistics Service of Ukraine, the State Food and Consumer Service of Ukraine, and analytical publications by domestic and foreign authors were used to conduct analytical, economic-statistical and comparative studies. Graphical and cartographic representations of research results were performed using Microsoft Office Excel 2003 – 2007 and CorelDRAW X5.

Research results. Current trends in modern agricultural production indicate a transition to environmental practices in agriculture, more active growth of the organic production sector, which simultaneously activates biological and integrated methods of crop protection with a sharp limitation of chemical protection. This is becoming a national priority in the vast majority of countries around the world.

In the adopted Directive on the Sustainable Use of Pesticides [40], the European Union (EU) advocates the gradual reduction and abandonment of chemical pesticides and encourages the use of biological plant protection products. The European Union and individual countries are taking steps to limit the use of synthetic pesticides while promoting biosafe technologies in plant protection systems.

One of the latest initiatives is the support of the EU countries on 18 February this year of the European Commission's proposal to reduce the maximum residue levels of the active substances chlorpyrifos and chlorpyrifos-methyl in agricultural and food products. This means that from October 2020, the import of agricultural products containing residues of these substances more than 0.01 mg / kg will be banned in the EU.

The European Commission has also drafted a document that would oblige EU member states to halve the use of chemical pesticides by 2030. At the same time, European lawmakers have called for mandatory targets for reducing pesticide use in the EU. The Organic Food and Agriculture Organization (IFOAM) is also pushing for more ambitious targets of reducing synthetic pesticides by 80 % by 2030 and abandoning them completely by 2035.

Biological means of protection come to the fore in plant protection, in particular, in integrated plant protection systems.

Biological plant protection products have been known to science for a long time, but their use on an industrial scale began in the 50s of last century and has been developing rapidly since then. These processes were especially intensified in the 1990s and 2000s. It is during this period that the vast majority of biological product companies present on the world market of organic products have been established.

The production and use of biological plant protection products over the past twenty years shows a steady upward trend, and as of 2016, the global market for organic products reached \$ 3 billion USA (Fig. 1). This is a thirty-fold increase compared to 1993 and a doubling of bioproducts (in value terms) over the past four years.

Europe remains the largest commercial market for biological protection products, due in part to political support for biological control programs, consumer demand, public pressure and a well-functioning, highly developed biological control industry. The largest markets are North America, Asia, Latin America, Africa and the Middle East. A significant increase in the biological means of control of arthropods occurs in Latin America, and is expected to occur in Asia. According to the latest marketing reports, North America is now the largest market for biopesticides, followed by Europe.

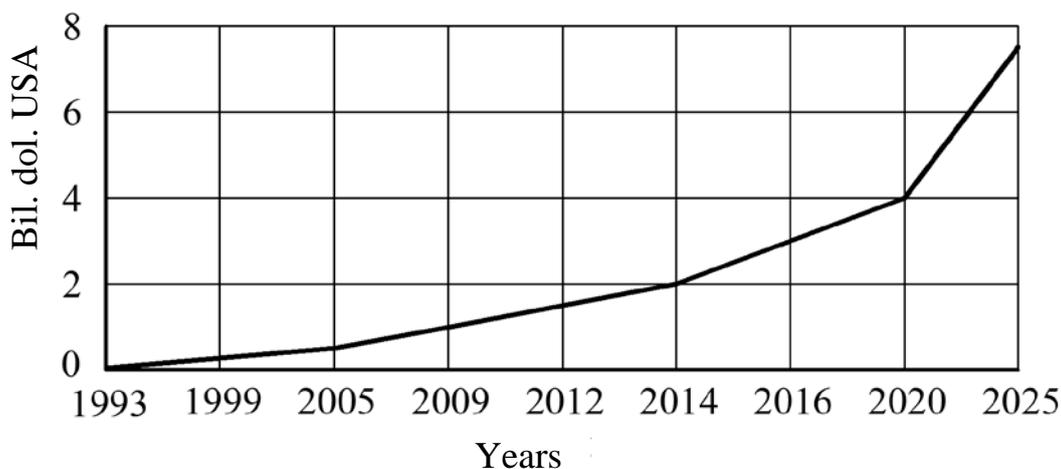


Fig. 1. The global market for organic products (according to Dunham William C., 2015)

The global market for biological control agents (invertebrates and microorganisms) in 2015 was approximately \$ 1.7 billion US, while the pesticide market – \$ 58.46 billion US. However, the growth of the biological protection market was faster (annual sales increase by 10 % until 2005 and more than 15 % per year since 2005) than the growth of synthetic pesticides (5-6 %).

According to scientists, in the near future the market for organic products will continue to grow rapidly and will reach 4 billion dollars US in 2020 and

7.5 billion dollars USA – in 2025. This will be facilitated by the transition of agricultural production to the principles of sustainability, expansion of production of ecological (organic) agricultural products, gradual transition to widespread biologization of agricultural production processes while abandoning chemical plant protection products and mineral fertilizers of industrial production.

In recent years, there has been an increase in the use of biopesticides, expanding the list of their registered samples. Thus, 420 samples of biopesticides have been registered for use in the USA, 125 in the EU, and 100 in Brazil [38].

Samples of biopesticides used, and there are more than 1000 of them today, were divided into categories as follows (Table 1).

1. Biopesticides: samples of products used (for Dunham William C., 2015)

Biopesticides	Number of product samples
Insecticides	831
Fungicides	164
Means of growth stimulation	50
Nematocides	16
Molluscicides	12
Herbicides	8
Rodenticides	1
Total	1082

In general, the annual growth of production of biological plant protection products, nutrition and stimulation of crop growth is projected at the level of 12-17 %.

In the future, the development of the market of biological plant protection products will be influenced by the following trends:

- giving preference to sustainable development technologies;
- more efficient use of pesticides, fertilizers, other nutrients and stimulating the growth of crops;
- accelerated growth of business companies for the production of organic products;
- consolidation of market participants in organic products.

In Ukraine, the use of biological plant protection products today is extremely insignificant, although in the 90s of the last century, good conditions were created for this. Recently, in the agricultural sector of the country there has been a steady negative trend of dominance of the chemical method of crop protection over biological. The decrease in the use of the biological method occurred both in relative terms and in absolute terms (Table 2, Fig. 2).

2. Application of chemical and biological methods of crop protection against pests, diseases and weeds in Ukrainian farms*

Methods of protection agricultures	1995	2000	2010	2015	2016	2017	2018
Volumes of application of methods of protection of agricultural crops, total, thousand hectares	19824	12970	38588	43816	45173	46798	49106
including:							
chemical method	16801	11916	36533	41630	43117	44730	47139
biological method	3023	1054	2055	2186	2056	2068	1967
The share of the biological method in the total amount of agricultural protection crops, %	15,2	8,1	5,3	5,0	4,6	4,4	4,0

*According to the State Food and Consumer Services of Ukraine

If in 1995 the protection of crops by biological methods was carried out on 3023 thousand hectares, which was 15.2 % of all areas where the protection of crops was carried out, then in the future the area of application of biological methods decreased and, for example, in 2018 amounted to 1967 thousand ha (4.0 % of all areas).

In Ukraine biological plant protection products of different spectrum of action are used: against pests, against diseases, to increase yields, to fix atmospheric nitrogen, to mobilize hard-to-reach phosphorus, to stimulate growth, against pests and pathogens, against rodents. The most widely used microbiological drugs of bacterial and fungal origin, as well as entomological drugs. Mass production of these agents began at the end of the last century, when an extensive network of biofactories and biolabs was established.

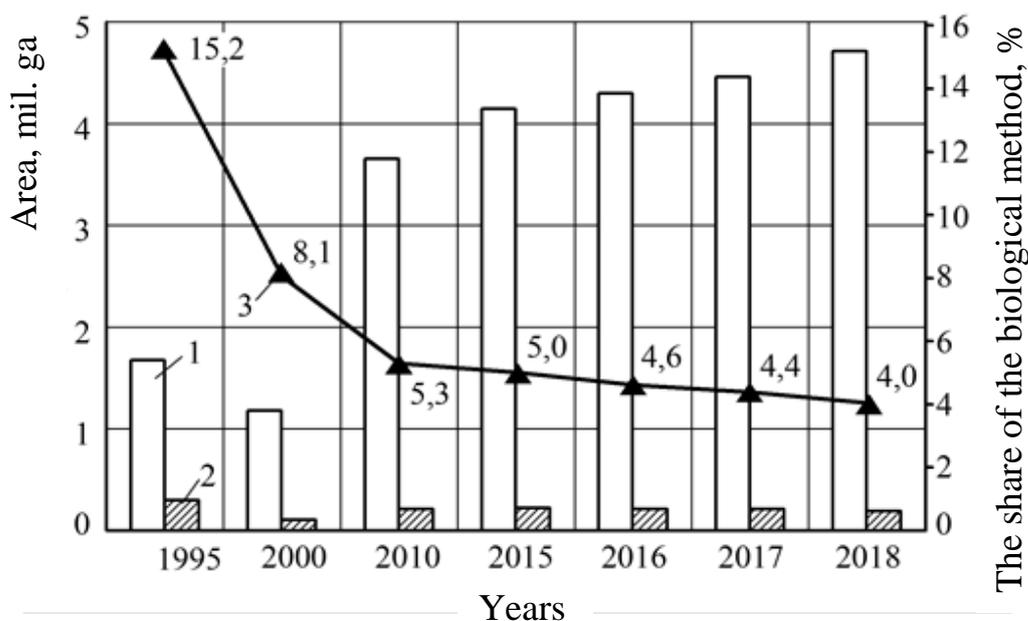


Fig. 2. Chemical and biological method of agricultural protection crops in the farms of Ukraine

There is a tendency to increase the range of microbiological protection products, which are included in the "List of pesticides and agrochemicals in Ukraine". A significant share in the overall structure are drugs that are designed to improve nutrition and increase crop yields – 28.8 %. Their number has increased

significantly compared to previous years: from 17 to 28 drugs. The number of drugs for crop protection against pathogens also increased (19 drugs against 11 in previous years) – 19.6 %. To protect crops from pests included 13 drugs (13.4 %), to control rodents – 3 drugs (3.1 %). The share of biologicals designed to improve the absorption of atmospheric nitrogen by plants is 27.8 % (27 drugs), to enhance the mobilization of phosphorus – 5.1% (5 drugs).

According to the State Food and Consumer Service of Ukraine, as of June 2019, there were 24 biofactories and biolaboratories in Ukraine, and their total number, taking into account private sector production (according to its own estimates) was more than 45 (Fig. 3). Such a disappointing picture is observed only in the last 20-25 years. By 1990, there were 268 biofactories and biolaboratories in Ukraine producing products for plant biosecurity, but since 1991, about 160 of them have ceased operations [41].

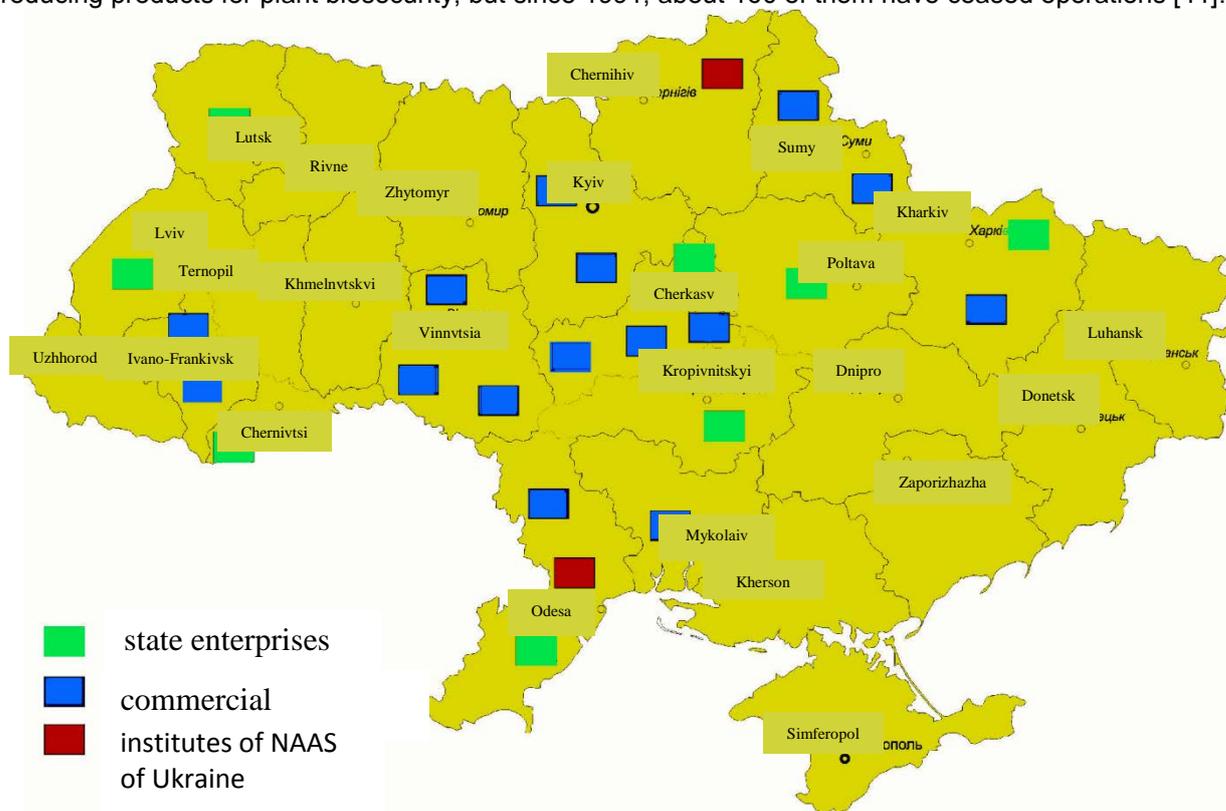


Fig. 3. Existing biofactories and biolaboratories of Ukraine, 2019

Among the most famous and largest manufacturers of biological plant protection products in Ukraine should be noted SE "Enzyme" (Ladyzhyn), LLC "BTU-Center" (Ladyzhyn), LLC "Biozar" (Nova Odessa). In particular, only in the Odessa region there are: LLC "Protection-Agro", Biofactory PE "Agro-Admiral", LLC "Bizar-Agro", PE "Agro-protection", LLC "Center Biotechnology", which have production capacity from 50 to 300 tons of microbiological drugs per year.

In the Cherkasy region, the largest producers of trichogramma: CJSC RPC Cherkasybiozahist, LLC Agronomika, LLC RPC Agrobiotechnology, LLC Biotech and LLC Shpolabiozahist (over 30 lines). Vinnytsia District Biolaboratory – production of trichogramma.

Production of uterine and commercial cultures of entomocryphages is carried out in ITI "Biotechnica" NAASU. Also ITI "Biotechnica" NAASU produces microbiological drugs: biofungicides (trichodermin, planriz, fluorescein, ampelomycin, gliocladin, bactophyte, phytosporine), bioinsecticides (boverin, actophyte, betsimid, vertocythacillin, bitozytobacillin) entomological drugs: poppy, trichogramma, common goldenrod, Galicia aphidimiza, macrolofus, orius, amblyceiulus svirsky, phytoseiulus.

Prospects for the development of production of biologization are determined by various factors. First of all, its development is stimulated by increasing demand from farmers, expanding the area under organic farming, including all types of alternative farming systems, which can be divided into two groups: organic and ecologic. According to the forecasts of ITI "Biotechnica" NAASU, the area is expected to increase by 2025: under organic farming from 1.0 to 1.2 %, and under organic – from 1.6 to 5.6 %.

The National Report "Sustainable Development Goals: Ukraine" among the identified objectives provides for "an increase in the area of organic land from 410.6 thousand hectares (1.0 % of the total area of agricultural land) in 2015 to 3000.0 thousand hectares (1, 7 % of the total area of agricultural land) in 2030".

The solution of this problem should be accompanied by the expansion of the scope and practice of biological methods of plant protection, which for organic production are the only acceptable methods of plant protection against pests and diseases.

In agricultural production, the replacement of synthetic pesticides with biological ones will make it possible to reduce soil contamination with chemical pesticide residues, stop the growth of pest resistance to plant protection products, restore and improve soil quality, increase agricultural productivity and improve storage. This, in general, will increase the level of environmental safety of agricultural production, reduce its dependence on pesticide importers, dramatically improve the phytosanitary situation in agrobiocenoses, increase profitability in agriculture and agro-industrial production and increase Ukraine's export opportunities.

Reducing the chemical load on agricultural land and the environment, stable and sufficient supply of crop biologization to the agricultural sector of the economy will contribute to:

- strengthening the export potential of the agro-industrial complex of Ukraine, first of all, high quality organic products;
- Ukraine in the circle of leading countries in the world on the practical biologization of crop production and greening of agriculture in general;
- reducing the dependence of the national economy on imports of agricultural chemicals;
- ensuring compliance with Ukraine's international obligations to protect the environment, world environmental standards.

Refusal to purchase pesticides by replacing them with biological plant protection products will reduce the need of agricultural production for pesticides of domestic and foreign production and, accordingly, will save land users at least UAH 200-500 million for a year. The priority direction of Ukraine's policy in the agricultural sector – greening of agriculture and balanced development of agricultural production – involves at least doubling the area of agricultural land under ecological and biological farming with the development of organic crop production of the highest environmental quality according to EU standards; increase of production of crop production of the 1st class of ecological quality for domestic consumption and for export purposes; transfer of 85-90 % of industrial greenhouse vegetable growing to technologies with the level of biologization of vegetable crops protection in almost all regions of Ukraine. This will increase the level of employment of the rural population through the creation of new jobs in organic farming; improve the ecological, social and economic situation in rural areas, contribute to the restoration and stabilization of biological diversity; rehabilitation of people through the consumption of food of the highest and 1st class of ecological quality; will prevent the irreversible loss of part of the country's gene, demo and eco-fund, will ensure balanced nature management in a large part of Ukraine.

The priority tasks for the implementation of the policy of greening of agriculture and the formation of a general culture of environmentally friendly agricultural production, in terms of widespread use of biological plant protection products, include:

- development of regulations governing the production and use of biological plant protection products;
- formation of the general culture of ecologically safe agricultural production, creation of system of training of personnel with skills of application of biologicals of protection of plants;
- development of mechanisms to stimulate the transition to biological and integrated methods of plant protection;
- development of new environmentally friendly technologies in crop production, storage and transportation of agricultural products;
- development of a wide network of biofactories and biolaboratories;
- conducting new research on the biologization of plant protection and developing mechanisms for their implementation in practice.

The development of biologization of plant protection in Ukraine is an important scientific and practical problem, the successful solution of which largely depends on the level of competitiveness of agricultural products in European and world markets, as well as the state of the environment.

Meeting the needs of agriculture in biological means of protection is provided by the development of a wide network of biofactories and biolaboratories in the agro-industrial complex.

To solve this problem, we propose strategic approaches to the formation and development of a common system of environmentally friendly methods of plant protection and building a network of enterprises for the production of agricultural biologization.

The main objectives of the strategy are:

- formation and implementation of priority target projects in the field of biologization of plant protection;
- creation of regional programs of ecologically safe protection of agricultural crops;
- development of optimal models of innovative activity in the field of biologization of agriculture;
- creation of a legal, economic and organizational basis for the development of domestic organic plant protection products;
- formation of a system of training for biologization of the agro-industrial sector;
- improving international cooperation.

When developing a strategy and implementing strategic goals, the calculations that determine the economic and ecosystem feasibility of plant protection measures should be used as a basis. These include:

- productivity and quality of the crop;
- range of pests;

- frequency of the problem;
- the degree of damage from pests and diseases;
- effectiveness of the biological product;
- the price of manufactured products;
- risks;
- timely availability of the necessary plant protection products;
- costs of protective measures;
- benefits from alternative programs and their cost.

Successful development and implementation of the strategy will depend on the creation of appropriate legal and policy information conditions for the development of the biomethod:

1. Development of a regulatory framework governing the production, distribution and use of pesticides, as well as reorientation of economic incentives through appropriate agricultural and environmental policies, including taxation and special fees for the use of chemical pesticides.
2. Reorientation of policy in the field of scientific research to the creation of modern biotechnologies in plant protection.
3. Creating an information system for managers, users and manufacturers about the dangerous consequences of unrestricted use of chemical pesticides.

Conclusions

In Ukraine the use of environmentally friendly biological plant protection products for a long time is at an extremely low level and tends to further decrease. In order to intensify the transition to environmentally friendly methods of plant protection, the development of domestic production of biological plant protection products, as well as the process of greening agriculture, we propose strategic approaches to the formation and development of a common system of environmentally friendly methods of plant protection and development of a network of enterprises for the production of means of biologization of agriculture on a new technological and organizational basis.

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