colloquium-journal

ISSN 2520-6990

Międzynarodowe czasopismo naukowe

Historical sciences
Philological sciences
Pedagogical sciences
Agricultural sciences
Philosophical sciences

№9(96) 2021
Część 2

colloquium-journal

ISSN 2520-6990

ISSN 2520-2480

Colloquium-journal №9 (96), 2021

Część 2

(Warszawa, Polska)

«Colloquium-journal»
Wydrukowano w Annopol 4, 03-236 Warszawa Poland, «Interdruk»
E-mail: info@colloquium-journal.org
http://www.colloquium-journal.org/

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UDC 632.934.2

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DOI: 10.24412/2520-6990-2021-996-10-15

НАУКОВО-ПРАКТИЧНІ ОСНОВИ ТА ПРАКТИЧНИЙ ДОСВІД ІНТЕГРОВАНОЇ СИСТЕМИ ЗАХИСТУ РОСЛИН В УКРАЇНІ

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SCIENTIFIC-PRACTICAL FUNDAMENTALS AND PRACTICAL EXPERIENCE OF THE INTEGRATED PLANT PROTECTION SYSTEM IN UKRAINE

Анотація.

В умовах інтенсифікації спеціалізованих аграрних господарств, попри зростаюче застосування мінеральних та органічних добрив, засобів захисту, щорічні втрати від шкідників, хвороб і бур'янів сягають 25–30 % валового врожаю, а по деяким культурам і значно більше. Тому, без вирішення проблем захисту рослин неможливо розраховувати на підвищення ефективності та стабільності одержання сільськогосподарської продукції.

В статті представлено сучасні уявлення про теоретичну основу інтегрованої системи захисту рослин, принципи, методи і етапи її розробки в світі, а також застосування цієї системи в Україні.

Встановлено, що в Україні створено певні правові, організаційні та економічні передумови для широкого впровадження екологічно безпечних методів захисту рослин – біологічного та інтегрованого. Однак нині зона їх поширення і застосування є вкрай незначною.

Abstract.

In the conditions of intensification of specialized agricultural farms, despite the growing use of mineral and organic fertilizers, pesticides, annual losses from pests, diseases and weeds reach 25-30% of the gross harvest, however, in some cultures much more. Therefore, without solving the problems of plant protection it is impossible to count on increasing the efficiency and stability of agricultural production.

The article presents modern ideas about the theoretical basis of an integrated plant protection system, principles, methods and stages of its development in the world, as well as the application of this system in Ukraine.

It is established that in Ukraine created certain legal, organizational and economic preconditions for wide introduction of ecologically safe methods of protection of plants - biological and integrated. However, today the area of their distribution and application is extremely small.

Ключові слова: *захист рослин, шкідливі організми, методи захисту, аграрне виробництво, екологічна безпека, інтегрований захист рослин.*

Keywords: *plant protection, pests, methods of protection, agricultural production, ecological safety, integrated plant protection.*

Formulation of the problem.

Since the beginning of agriculture, pests, diseases and weeds have caused significant crop losses, leading to increased cultivation costs and threatening human food security. Ancient Greeks, Roman and Chinese scientists were involved in plant protection, but the complex application of scientifically sound measures appeared about 150 years ago.

Starting with traditional and holistic approaches, these measures were based on a natural and scientific understanding of pests, their impact on the growth and development of crops. From the middle of the 20th century the process of intensification of agriculture began all over the world, which led to a sharp increase in the use of pesticides, nitrogen and other mineral fertilizers in crop production, in particular in vegetable growing and led to negative consequences: increased nitrates and residual pesticides in crop production products, decreased the amount of vitamins and sugars and, as a consequence, deteriorated environmental safety and quality.

Food overproduction has led to a sharp deterioration in agriculture, growing consumer demands for safe and healthy food, and pressure from environmental groups have led to changes in agricultural policy in developed countries. There is an urgent need to limit the chemicalization of agriculture and pay attention to environmental and economic security in the agricultural sector.

Human diet is 80 percent consists of plant-based. Plant foods are high in fiber and low in calories. Vegetables, fruits, grains and legumes contain simple and

complex carbohydrates, which makes them a good source of energy. Plant-based foods also help to promote good health and well-being. But at the same time, plants are constantly threatened by pests and diseases. Up to 40 percent of food crops worldwide die every year because of them. As a result, the total loss of trade in agricultural products is more than $ 220 billion a year, millions of people are at risk of starvation, and agriculture - the main source of income for rural people - is severely damaged. That is why measures and actions aimed at protecting plant health are so important for achieving the goals of sustainable development [1].

Currently, in most countries - producers of agricultural products, the leading place in plant protection is occupied by the chemical method of pest control. This method avoids most of the potential crop losses. This is due to the high efficiency and versatility of the chemical method, the simplicity and practical availability, obviousness and speed of the effect. However, the manifestations of the negative impact of pesticides on the environment can occur very quickly, namely: their accumulation in soil, water bodies and living organisms; the emergence of stable populations of pests, violations of natural biocenoses, a sharp decrease in their ability to self-regulation [2].

The relevance of the research topic is due to modern achievements in the field of integrated plant protection systems, solving problems of phytosanitary condition of crops and optimization of agricultural systems in the agro-industrial complex of Ukraine, as well as problems of increasing the competitiveness of domestic agricultural producers in modern conditions.

The purpose of the article is to analyze the state of the integrated plant protection system in Ukraine, also to highlight the problems and prospects for the development of domestic integrated plant protection systems.

Analysis of recent research and publications.

The transition of mankind from organic farming to the chemical type of agricultural technologies, which involve the introduction of a large number of pesticides, has taken place over the past 40-50 years. The use of pesticides has a significant impact on the quality and environmental safety of food, and subsequently on human health. Nutritionists claim that 80% of our health depends on healthy meals.

The integrated plant protection system belongs to the production system of the first category of "environmentally friendly", more precisely, "environmentally better" agricultural products, as it allows the use of pesticides and mineral fertilizers in limited quantities. An integrated method of plant protection is a system of measures to manage intra-population and overpopulation relations within a specific agro biocenosis. In this matter, the approach to the development of planned measures to ensure their effectiveness is considered fundamental.

The following foreign and domestic scientists have devoted their scientific works to strategic issues related to the organization of integrated plant protection against pests, in order to optimize ways to obtain the highest possible yields of high quality and reduce energy costs per unit of output: J. Avilla, O.S. Demyanyuk, E.F. Boller, V.P. Duktov, O.S. Zamotaylov, G.O. Kosilovich,
D.O. Morozov, I.I. Mostovyak, R.F. Smith.

However, the practical experience of applying the integrated plant protection system in Ukraine has not received a proper scientific assessment. In addition, it is necessary to develop qualitatively new solutions adapted to the conditions of a market economy. Elaboration of guidelines and practical priorities of the integrated system of plant protection to ensure efficient agricultural production requires constant reflection and search for effective measures solving issues.

Research methodology.

During the research the state and problems of development of the domestic integrated system of plant protection, the works of domestic and foreign scientists, primary materials of the author's own research, periodicals were studied. Monographic, statistical-economic, computational-constructive, abstract-logical and other methods were used as research methods.

Results of the research.

Due to the excessive use of chemical plant protection products, since the 60s of the last century, became pollution of the environment and agricultural products, especially in the industrialized countries of the world. The indisputable fact in this situation is that the corresponding share among the factors of pollution is accounted by pesticides, especially insecticides, which are used to control pests and mites.

Despite the fact that pesticides of chemical origin are a real, active and quite effective means of protecting crops from pests, there are a number of negative facts that encourage them to seek alternatives. The analysis of scientific publications on this problem shows the absence of a common criterion for determination, but currently scientists have developed some general approaches that determine the development of integrated plant protection systems against pests, diseases and weeds. In our country, and around the world, the modern strategy of plant protection is based on the concept of integration of chemical and various non-chemical methods of pest control (primarily - biological).

The rapid intensification of agriculture, the expansion of the range of chemical plant protection products has caused problems in the development of pests resistance. There have been alarming reports of significant damage to the health of workers directly employed in agriculture, as well as people who consume crop products.

Due to the chaotic, scientifically unreasonable use of pesticides, they pose a great potential threat to soil and environmental pollution. According to scientists, only 3% of insecticides act directly on pests, and the remaining - 97% enters the soil, plants and causes negative effects on other components of the ecosystem. As for herbicides, it uses only 5-10% of the applied amount of drugs. Currently introduced approaches to agricultural production are mainly based on the quantitative regulation of the use of agricultural intensification, this also applies chemicals [3].

In the system of measures to increase yields, American scientists give the largest share (in%) of fertilizers – 41%, followed by herbicides - from 13% to 20%, favorable weather conditions – 15%, hybrid seeds – 8%, irrigation – 5% and other factors - from 11% to 18%. German scientists attribute half of the increase in yield to the use of fertilizers, French - from 50 to 70%, Russian - up to 50-60%. According to research by Ukrainian scientists, the average share of chemical plant protection products in the total production costs of domestic crop products is relatively low and does not exceed 2-5% (fertilizers – 37%, fuel – 35%, technological means – 13%, transport – 9%). Yield losses from pests and diseases can reach 25-30%, and sometimes 50% and more [4].

The realization of crop productivity is influenced by a number of factors, the dominant of which is the technology of cultivation. In this regard, in recent years the improvement of elements of agricultural technology is becoming increasingly important: the introduction of scientifically sound crop rotations, tillage, application of optimal doses of fertilizers, use of sorts and hybrids resistant to pests, etc.

According to many scientists and specialists in agricultural production, an important place belongs to measures to control pests, diseases and weeds. In our country, more than 90% of the area of field crops is heavily and moderately weeded, which leads to a decrease crop productivity by 20% or more. Management practice shows that in Ukraine losses from pests, diseases and weeds amount to 33-48% of the potential harvest. Therefore, an effective and reliable protection of crops from diseases, pests and, especially, weeds, is a component of modern intensive technology for growing major crops without the cost of manual labor, which allows to use the potential of cultivated plants.

The experience of countries with developed agriculture shows that due to the high probability of pest infestation, insufficient number of developed and tested non-chemical pesticides completely against chemical plant protection products is not possible, and therefore the use of pesticides (phytopharmaceuticals) is economically justified and feasible. But from the standpoint of ecological safety of agroecosystems and ensuring the quality of agricultural products, modern agricultural technologies should be based on integrated methods of plant protection, taking into account climate change, rational use of chemical methods with minimal negative impact on the environment and man [5].

Negative experience of mass and excessive use of pesticides in the cultivation of agricultural products in the 50-70's. years of the last century, when plant protection was based on the principles of total destruction of pests in agrocenoses, showed the erroneousness of this approach in the technology of growing crops. Therefore, the emergence of resistance and significant environmental pollution by chemical residues, rising costs of pesticides and the cost of their use have led to awareness of the need to improve plant protection, the transition from certain techniques and methods of protection to their integration into the system.

The creation of artificial agroecosystems in order to obtain the maximum amount of crop production and profit per unit area is the basis of agricultural production. The increase in the productivity of the agrobiocenosis is associated with an increase in the level of additional technological energy, moreover a significant share forms the cost of plant protection products against harmful objects. The concept of "integrated plant protection" was first formulated in 1967 by a group of FAO experts. They viewed integrated plant protection as a pest management system in the context of the environment and the dynamics of pest populations through all possible measures and methods that keep pests below economic damage. Farming is based on the use of agronomic, chemical, biological and other methods of plant protection. The criteria of feasibility (economic threshold of harmfulness) of pesticides are important [6].

Integrated pest management in its original form was considered by scientists as a combined use of biological and chemical methods (Smith, Allen, 1954, Fluiter, 1967). Later, the term "integrated control" began to be embedded with a deeper and broader meaning associated with the general ecological basis of pest control measures aimed not so much at the extermination of harmful species, but at managing their development [7].

According to American scientists [8], integrated plant protection systems should be considered as an ecosystem management of plant health through the use of natural and artificial mechanisms to protect them from pests. According to their point of view on this issue, the basic principles of health management of cereals include:

- programming of a really achievable level of harvest;
- maximum preservation of soil organic matter;
- scientifically sound crop rotations;
- application of zonally adapted resistant sorts and hybrids;
- seed certification;
- application of fertilizers for the planned harvest;
- chemical and biological plant protection.

Integrated plant protection is a pest control strategy that uses all available methods to control the minimal use of chemical pesticides [9].

In modern form, an integrated protection system is understood as a system of management measures for intra- and interpopulation relations within the agro-ecological system and its constituent agrobiocenoses. Integrated methods of plant protection involve the choice of such means of pest control, which would not only preserve but also intensify the activities of beneficial ones. In other words, the integrated method of plant protection is a system of measures to manage intra- and interpopulation relations within a particular agrobiocenosis. This is its fundamental difference from previous systems [10].

In the modern sense, integrated plant protection involves the management of pest populations within specific agrobiocenoses by applying the optimal system of measures for specific conditions in order to optimize the phytosanitary condition of crops.

Phytosanitary control involves the gathering and analysis of information on the state of life forms of

agroecosystems (energy resources and consumers at all levels) in the current weather conditions.

Diagnosis of agroecosystem is necessary for:

- forecast of development and harmfulness of harmful objects;
- planning of protective measures;
- making decisions on plant protection in a specific period.

Based on theoretical ideas about the development and connection that occur in the agrobiocenoses of ecological systems, processes develop a system of phytosanitary control, which includes regulations for accounting and observation, methods of their implementation and logistics. To obtain reliable results, each field must be inspected at least 10 times per season. Moreover fields with sensitive crops (rapeseed, soybean, sunflower) should be inspected every 2-3 days. Researches have shown that choosing the right pest control strategy in the agrocenosis can reduce crop losses by up to 80%, and plant protection is considered one of the main components in increasing crop productivity and ensuring national food security [11].

The experience of successful agricultural enterprises shows that an independent audit of the enterprise and a transparent tender for the purchase of plant protection products and agricultural chemicals can save (earn) even a relatively small enterprise (800-1200 hectares) about 15-40 thousand euros per season. For horticultural enterprises, the amount will be much higher.

A clear understanding of the subject and methods of solving a particular problem is the key to its successful overcoming. This also applies to resistance control. Ukrainian agricultural producers, in contrast to farmers in Europe and the United States, where pest resistance is already present, have the opportunity to prevent the potential problem of resistance. The introduction of an integrated control system will allow to obtain maximum profits and get clean fields without weeds, diseases and pests [12].

For domestic integrated plant protection units, the necessary condition for successful operation is the acquisition of specialized knowledge that will allow them to develop objective and effective solutions for pest and disease control based on conceptual theory and empirical environmental - evolutionary, molecular and genetic data that can satisfy needs of modern and new crop production systems.

In the modern sense, an integrated plant protection system is based on the following interconnected elements:

a) a high level of agricultural technology, which allows to grow full-fledged plants resistant to abiotic factors. Includes the use of special agronomic techniques to prevent or inhibit the development of certain harmful objects;

b) cultivation of sorts and hybrids resistant to pests and diseases;

c) the use of techniques aimed at preserving and activating the activities of natural entomophagous and other organisms that regulate the number of pests, phytopathogens and weeds;

d) the use of active actions to suppress the number of pests - primarily biological and chemical on the basis of a detailed analysis of the agrobiocenosis in a strictly objective assessment of the expected development of the pest and the level of losses.

An integrated crop protection system provides a holistic approach to the proper organization of pest, weed and disease control measures. In this case, the agroecosystem is perceived as a whole and involves the use of various physical, chemical, biological, cultural and genetic methods of pest, weed and disease control with minimal impact on the environment. One of the strategies of integrated crop protection is complex pest control, which may include growing two or more crop species in one crop rotation and applying classical biological control methods with the introduction of natural antagonists, pests and weeds without the introduction of invasive alien species [13].

Although comprehensive crop protection has been successfully implemented in a variety of growing conditions and in all regions of the world, its spread in developing countries is relatively slowly. For example, small Ukrainian farmers are still reluctant to switch to integrated pest management; the scope of its application for the protection of crops of major food crops is limited, despite the fact that it is promoted as the main strategy for crop protection in the country.

Today in Ukraine certain legal, organizational and economic preconditions are created for wide introduction of ecologically safe methods of protection of plants - biological and integrated. However, today the area of their distribution and application is extremely small.

A review of the literature on the topic of the research showed that more than 70 definitions of the concept of integrated plant protection (Integrated Pest Management, IRM) are currently known. According to the EU Framework Directive 2009/128 / EC, the IRM is a careful consideration of all available plant protection methods and further integration of appropriate measures that hinder the development of pest populations and maintain the use of pesticides and other interventions at levels that are economically viable and reduce or minimize risks to human health and the environment [5].

In 2012, FAO expanded the definition of IRM with a focus on the economic, social and environmental aspects of pest control. Since 2013, the introduction of the ideas of integrated plant protection is facilitated by the rapid development of agricultural technologies [14].

The modern strategy of integrated plant protection is based on agrotechnologies, which are based on an attempt to reach a compromise between the desire to obtain a high environmentally friendly crop and preserve soil fertility. The ideal direction for this is a system of organic farming, based on a set of organizational, economic and agro-technical measures and technologies. This is the structure of sown areas; use of perennial and annual legumes; scientifically sound crop rotations; shallow tillage; use of organic fertilizers; greens; quality seed preparation; optimal terms of works; use of microbiological preparations. For the rational organization of plant protection it is important to take into account the number of species harmful to plants and their parasites and predators [6].

Integrated Pest Management (IPM) combines the use of biological, agronomic and chemical methods to control phytophagous in agricultural production. It involves the use of natural predators or parasites to control pests, using selective pesticides only when the pests cannot be limited to natural enemies. IRM should be distinguished from the organic system. It does not prevent the use of pesticides. However, selective spraying is used only when the crop requires it, that usually means the use of pesticides is limited.

The main task of the integrated plant protection system, in addition to attracting a wide range of natural beneficial organisms, was to improve their efficiency by biotechnological methods. In particular, the task was to fundamentally improve the pathogenicity of microorganisms in the formation of biological preparations that will be used against harmful insect species. The main focus is on bacteria and viruses, as their nature is better studied and it is easier to manipulate them. [15].

One of the biggest problems of many IPM developments over the years has been the tendency to generalize and make recommendations to farmers in large and very heterogeneous areas. This applies to all types of recommendations for the application of fertilizers, pesticides and crop sorts.

This problem, and environmental heterogeneity, has also severely limited the effectiveness of state monitoring systems and phytosanitary services in predicting the spread of pests and diseases of agricultural plants. All these practical issues differ on a small spatial scale, and therefore there are some limitations for practical application. This local specificity requires farmers to become IPM experts.

Development and effective implementation of the IRM is a constan training and search for solutions taking into account changing conditions. Therefore, the FAO Regional Office, which also has a representative office in Ukraine, prefers farmers' field schools (PSFs), where farmers meet regularly for classes conducted by qualified professionals, share their problems and discuss possible solutions. Farmers' field schools are helping to increase knowledge and create local ecosystems to ensure sustainable agriculture and food systems. Training and awareness have a positive impact on agricultural productivity, environmental protection, the health and safety of agricultural enterprises, and the sustainable and rational use of natural resources.

Practice shows that the developed recommendations or certain decision-making criteria for each specific approach demonstrate significant progress in reconciling environmental heterogeneity and farmer control over agroecosystem management [16].

The European Union has identified eight general principles for integrated pest management, which should guide the development of specific guidelines for different crops and relevant areas of specialization.

1. Such means will help to prevent and (or) eradicate pests:

- scientifically substantiated alternation of crop rotation with the use of crops with high competitiveness;
- correct tillage system;
- use of sorts resistant to certain diseases and pests;
- balanced use of fertilization, irrigation and drainage methods;
- prevention of the spread of harmful organisms through hygiene measures (for example, control of cleaning machines and equipment);
- protection and improvement of important beneficial organisms, (for example, through phytopharmaceutical measures aimed at the preservation of beneficial organisms or the use of environmental infrastructure inside and outside production sites).

2. Pests should be controlled using appropriate methods and tools, if they are. In this context, it is also important to record weather conditions. Appropriate methods should include field observations and systems of prediction and diagnosis.

3. Based on the results of the monitoring, the specialist must decide whether and when to apply plant protection measures. Scientifically sound and reliable thresholds are important elements in making appropriate decisions.

4. Persistent biological, physical and other non-chemical methods must outweigh chemical methods if they allow satisfactory control of diseases and pests of agricultural crops.

5. The used pesticides must be as specific as possible to the object of their use and have minimal side effects on human health, non-target organisms and the environment.

6. The plant protection professional should support the use of pesticides at the required levels, taking into account that the level of risk to vegetation should be acceptable and that these remedies should not increase the risk of resistance in pest populations. If there is a risk of resistance to plant protection measures and when pest levels require repeated application of pesticides to crops, available resistance strategies should be applied.

7. Based on records of pesticide use and pest monitoring, the specialist should check the success of the applied plant protection measures [17].

The mass occurrence of diseases in most cases is associated with the inconsistency of ecological conditions of cultivation, the nature of the development of this association, with the mistakes that are made during agronomic measures, which greatly contributes to the development of pathogenic organisms. Therefore, during the studying the causes of the mass spread of diseases, it is necessary to comprehensively study the environmental conditions, ie to determine the main connections between the host plant, the pathogen and environmental conditions [18].

Therefore, it should be understood that maintaining the optimal physiological condition of crops is necessary for successful agriculture, both in terms of yield and in terms of quality of products grown. This requires long-term strategies to minimize the emergence of pests and diseases, mainly by strengthening the natural mechanisms of control, growing a "healthy culture".

Any plant protection measures, especially involving substances harmful to humans or the environment, must be carried out using the latest knowledge and modern equipment.

Effective agricultural practices should include certain measures, among which the most important in terms of plant protection are:

- crop rotation, tillage system, fertilizer system, cleaning and sorting of seeds, timing and methods of sowing, methods of crop care, weed control, timing and methods of harvesting, spatial isolation, etc.;

- regular quantitative assessment of the balance between pests and diseases and beneficial organisms of all crops;

- if possible, the use of methods for predicting pests and diseases;

- understanding and use of non-chemical methods of pest control;

- making a decision on intervention after consideration of all possible methods and their short-term and long-term impact on farm productivity and environmental impacts in order to minimize the use of pesticides, in particular to promote integrated pest management (IPM);

- storage and use of agrochemicals in accordance the requirements of the legislation.

At present, Ukraine faces numerous economic, political and social challenges. On the way to sustainable development, domestic agriculture and related industries that form the basis of the economy are the only source of income and livelihood of the rural population.

Climate change, soil depletion, and the reckless use of pesticides and fertilizers threaten the sustainability of food and agricultural systems. In particular, excessive use of pesticides leads to the destruction of natural ecosystems, which leads to further outbreaks of pests. This can undermine food security at both the national and regional levels. Intensive abuse of especially dangerous chemicals in small farms hinders agricultural work, provides adequate nutrition, endangers the health of the population and the future of agriculture in general.

Conclusions.

World experience shows that any system cannot be effective without perfect protection of plants from pests. There are a number of ways to control pests, diseases and weeds, but for many decades the chemical method has prevailed as a radical and universal remedy in protective measures. However, the widespread use of pesticides has shown not only the advantages and prospects, but also the serious disadvantages of their widespread use.

Today, the most acceptable and effective methods of pest control are integrated plant protection systems. Protective measures should be based on the integration of all methods and techniques of entomo- and phytocenosis management, in which the use of chemicals should be an action of operational control, when other methods of preserving the crop don't work.

In this regard, domestic farmers should pay more attention to agricultural techniques. First of all, it is necessary to ensure the selection of genetically resistant sorts, pre-sowing preparation of seed material, to use scientifically sound crop rotation and other methods. Experts' calculations show that due to the optimization of the sorts structure and timely varietal substitution, an increase in the gross harvest of the main grain crops is possible - up to 10-15%.

Evaluation and verification of the effectiveness of the applied plant protection measures should be carried out on the basis of accounting data on the use of pesticides and on the basis of the results of pest monitoring. In the future, this will help producers to improve plant protection methods, using the acquired knowledge and experience.

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