Plant protection technologies: from advanced to innovative

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Abstract. The purpose of this study is to analyze the readiness to use innovative technologies for plant protection. The authors are interested in the readiness of specialists in the agricultural sector, scientists, agricoltors to introduce innovative technologies. The authors are conducting this research as part of the project "Social Research of Science and Technology". The authors review the existing plant protection methods and analyze their effectiveness. The authors reflected the agrotechnical method, the biological method, the chemical method, the physical and mechanical method, the integrative method and the innovative method of plant protection. Agricultural technologies are one of the most interesting sectors for investment. Innovations in science and technology, the availability of modern technologies and equipment make it possible to make agricultural production a high-tech business. In conclusion the authors note that for the full implementation and achievement of effective indicators it is necessary to do a lot of legal, economic, technological and organizational work.

1. Introduction

Modern technologies require an integrated approach to all technological processes, especially in agriculture. With the introduction of new technologies, a production site is becoming an increasingly complex biocenosis, since changes in one of its elements affect all the others. The effectiveness of using various methods of plant protection depends on the current state of the soil, weather conditions, the population of insects living in the field under consideration, and many other factors. Thus, plant protection is a system of interrelated and complementary organizational, agrotechnical, chemical and biological measures [1-16]. To create an adequate plant protection system, it is required to take into account the number of harmful insects, knowledge of their characteristic features, and the creation of a forecast of field contamination.

The purpose of this study is to analyze the readiness to use innovative technologies for plant protection. First of all, we are interested in the readiness of specialists in the agricultural sector, scientists, agricoltors to introduce innovative technologies. The research is carried out within the framework of the project "Social Research of Science and Technology" [1]. To achieve this goal, we will review the existing plant protection methods and analyze their effectiveness. The relevance of the study is based on the fact that agricultural technologies are one of the most interesting sectors for investment. Innovations in science and technology, the availability of modern technologies and equipment make it possible to make agricultural production a high-tech business. Currently, the industry is actively collecting information from various sensors and stations. The information is
coming from various platforms of the production chain and collecting in one place. Thus, specialist can receives information of a new quality, finds patterns, apples modern scientific processing methods and to make the right decisions on their basis [11-15].

The development of agriculture is focused on resource and energy efficiency, environmental safety and profitability. This was facilitated by the transition to adaptive intensification of crop production. The development and assimilation of innovative technologies for the cultivation of agricultural crops is of particular importance. The large-scale development of such technologies is predetermined by advanced world and domestic scientific and practical experience, general trends in the development of modern crop production. In European countries, innovative technologies based on plowless tillage methods and resource-saving sowing methods have been successfully used for more than 30 years [17]. The massive assimilation of new technologies has become an urgent task at present, not only because they accumulate the latest achievements of foreign and domestic agricultural science and technology, but also the need to find ways to overcome a number of difficulties in field cultivation (decrease in profitability, deterioration of the fleet of machines, drop in soil fertility, etc.). In economic terms, these new requirements for technologies in crop production are associated with the need to obtain competitive products in the face of an increasing cost of technical resources: fuel, fertilizers, plant protection products, agricultural machines and tools.

2. Methods, results and discussion
Agrotechnical methods of plant protection include various technique of soil cultivation with agricultural machines; their essence is mechanical action on weeds and soil. An important role in the organization of the plant protection system is played by the scientific substantiation of all stages of the applied agricultural technology. All these works give a synergistic effect only in a single complex. The greatest attention should be paid to the introduction of advanced crop rotations, the use of high-quality seeds of zoned varieties, compliance with the conditions for the applied technological methods. Agrotechnical methods of combating pests and plant diseases are of a preventive nature, anticipating the development of populations of pests and pathogens [11-19]. The use of agrotechnical methods has advantages, it is environmental friendliness and low cost. However, a study of the effectiveness of this method showed the next results:
- significant complexity of application;
- the impossibility of planting one species in the same area more than 2-3 times.

Chemical measures are a group of methods that use different mineral compounds to create more favorable conditions for cultivated plants. Basically, they are reduced to dressing seed material, spraying the field with pesticides. It is required to comply with the terms and norms. The role of these measures has continued to increase in recent decades, thanks to the introduction of new chemical compounds [18]. Despite the fact that the production of chemical preparations for pest control has taken a fairly stable position in the market of goods, the results of a study of the effectiveness of this method show a rather high level of danger of using chemical methods such as:
- toxicity
- some pesticides can accumulate in unacceptable concentrations in soil, water and food;
- pests develop a stable susceptibility to drugs.

Biological plant protection methods include various measures to reduce the number of pests and do not affect the yield. They consist in preserving useful organisms living in plantations (natural enemies of pests) and enhancing their role; the use of artificially bred entomophages (parasites and predators) by launching them into pest foci; introduction (delivery, resettlement) and acclimatization of useful organisms new to the area (classical biomass); the use of various pathogens (disease-causing organisms) as bacterial, fungal and viral pesticides. The biological method is more promising compared to other methods, but it is applied to a limited extent (in greenhouses), and is not sufficiently developed to prevent weeds [18].

The physical and mechanical method of control consists in the destruction of pests and diseases by changing the temperature and humidity conditions of the environment or removing (cutting) the
affected parts or the entire plant. The main technique of the physical and mechanical method of protection is pruning, especially sanitary. It involves cutting out damaged and affected plant parts (dry, frozen, spotted shoots or parts of them to healthy wood, removing diseased flowers and leaves) [15]. The physical and mechanical method is ecologically safe, but according to the research results it turns out to be difficult to apply for crops of large scale.

Integrated plant protection is a pest control that takes into account economic thresholds of harm. Integrated plant protection uses, first of all, natural limiting factors along with the use of all other methods that meet economic, environmental and toxicological requirements. A characteristic feature of integrated protection is the most complete use of all non-chemical agents, techniques and regulation of the use of pesticides [11-20].

Integrated plant protection is complex and includes: selection of genetically resistant varieties; phytosanitary preparation of seed material; computerized monitoring of dangerous types of pests; the use of biological and chemical plant protection; competent crop rotation; rotation of varieties, etc. Studies have shown that the costs of integrated plant protection are almost the same as chemical protection. However, integrated protection provides a longer-term effect, contributes to an increase in yield by 10-30%, increases the quality characteristics of products, reduces climatic risks, and has a pronounced environmental advantage.

Innovative technologies are the methods of plant protection are based on constant monitoring, visual control and analysis of the current situation in which a person is the main actor in the production process. Today the situation is changing. The first stage in the digitalization of the agricultural industry is the widespread introduction of various sensors and operational control stations into production. Slowly but surely, video monitoring by satellites, copters, hyperspectral, infrared, thermal imaging is entering the industry. It informs about the biophysical parameters of plants: leaf surface area, stress state of plants when damaged by harmful objects and weeds. There is a timely identification of areas with a risk of possible damage or death of crops, as well as mapping of the affected area [19].

Controlling and executive electronic systems are installed on the sprayers, which make it possible to fully automate the control of the operation of the unit. They provide the required amount of application of the working solution and maintain it within the agrotechnical requirements, regardless of the terrain of the site, the speed of the equipment, the pressure in the hydraulic system. Such units, on average, consume 10% less pesticides compared to conventional sprayers. The next stage of digitalization is the connection of multiple sensors and field controllers into a single information network that can provide more useful information for the user. Information processing is carried out in real time, and provides the results of analysis of many factors, as well as the rationale for subsequent actions. Such data helps to adjust technologies for each site [19].

European companies have developed and are actively using various applications that help protect plants, for example, the Plantix application (Germany) for the diagnosis of crop diseases; Simplot Spray Guide program (USA) - calculation of the amount of drugs required for the preparation of complex plant protection products; SpraySelect (USA) for spraying drugs; seeCrop mobile application (UK) for identification of plant diseases, the position of pests and weeds. Robotics are also being actively introduced, for example, the ecoRobotix robot weeding machine (Switzerland), works on solar panels, scans with the required dose of herbicides; robot Ladybird or "Ladybug" (Australia), capable of mapping; robot RIPPA (Australia), equipped with a special knife, and mechanically destroys weeds if chemical treatment is not acceptable [19].

3. Conclusions
Within the framework of the project "Social Research of Science and Technology" in the field of agricultural sciences and technologies, in particular in the field of plant protection, a survey was conducted among scientists, research institutes and agronomists on the effectiveness of using plant protection methods and readiness to use innovative technologies, taking into account the experience of European companies. A total of 248 respondents took part in the survey: 40% are agricultors of...
Siberian companies, 20% are agricoltors of companies in Central Russia; 10% are scientists from Siberian research institutes and universities, and 30% are scientists and researchers from metropolitan research institutes. The study showed that 79.6% of respondents note the need to find ways to overcome a number of difficulties that have developed in field cultivation (reduced profitability, deterioration of the car park, decline in soil fertility, etc.), but only 65% of respondents are ready to introduce innovative technologies and training. The majority of respondents work in field areas remote from the city.

The introduction of innovative technologies in Russia is proceeding at a slow pace; the reasons for this are the lack of a developed regulatory framework, the availability of network connections in remote areas, and the demand for advanced training, taking into account innovations [21-28]. Innovative technologies not only facilitate the work of a specialist, but in the future can partially or completely replace a person. However, in Russia it is too early to talk about this, for the full implementation and achievement of effective indicators it is necessary to do a lot of legal, economic, technological and organizational work [29].

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