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PART 3. THE MECHANISMS OF ENSURING ECOLOGICAL, FOOD, TECHNOLOGICAL, AND ENERGY SECURITY IN THE DYNAMIC ENVIRONMENT

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ECOLOGICAL PROBLEMS RELATED TO THE USE OF TRANSGENIC PLANTS

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In the human imagination, genetically modified organisms are associated primarily with the danger to the health of the population. According to experts, the risks to the environment are much more significant. After all, the first group of risks (for human health) can be assessed accurately enough to prevent them and almost eliminate them. In the case of environmental risks, the situation is much more complicated. It is especially difficult to predict long-term consequences, various cascading effects. If GMOs are released into the environment, reproduced, and passed on their genetic information to other species, it is almost impossible to return everything to its original state in the event of any adverse effects.

The following adverse effects of GMOs on the environment are possible: 1) the destructive impact on biological systems and loss of valuable biological resources; 2) creating new parasites and increasing the damage to existing ones; 3) production of substances that may be toxic to organisms that live or feed on genetically modified organisms and are not targets of transgenic traits; 4) adverse effects on ecosystems of toxic substances derived from the incomplete destruction of hazardous chemicals [1].

The problem of the emergence of superweeds and superpests is also among the main ones when considering the environmental risks associated with GMOs. Weeds are a group of plants with a certain set of adaptive traits that help them to exist in the environment, including among crops, against competition from other organisms, as well as constant human influence.

The use of transgenic varieties with insecticidal properties (due to the Bt gene) immediately raised the question: will these varieties negatively affect biodiversity by affecting insects that are not a "target" of the transgenic trait? These are primarily beneficial insects such as bees. But Bt-proteins are highly selective. However, the possible negative effects associated with the non-target effects of GMOs on other organisms must be carefully weighed when assessing their biosafety.

Because the effectiveness of weed control with a combination of GMOs and the appropriate herbicide is higher than in conventional chemicals, the total amount of herbicides applied to fields with genetically modified varieties is lower than usual.

To determine the risk of possible adverse effects associated with the release of GMOs into the environment, a special technique has been developed that allows for a comprehensive and comprehensive assessment of their safety. This technique is used in all countries where GMOs are grown. Its main provisions are enshrined in several international agreements. The technique has proven itself in practice. No case of the negative impact of genetically modified organisms on the environment is known due to a careful assessment of the safety of all GMOs that are released into the environment [2].

In assessing the risk of possible adverse environmental consequences of the release of GMOs into the environment, information is taken into account regarding the systematic situation, the method of reproduction and dispersal, survival in the environment.

Particular attention is paid to information on the nature of genetic engineering modification: 1) a description of the DNA fragment embedded in the genome of the recipient organism; 2) data on the structure and functional compliance of the embedded DNA fragment, the presence of known potentially dangerous sequences, the location of the insert and the stability of incorporation, the number of copies of transgenes.

Information concerning the biological features of GMOs and the nature of their interaction with the environment, namely: 1) data on new traits and characteristics that began to appear or ceased to appear in a genetically modified organism in comparison with the recipient organism, especially those that may affect survival, reproduction, and distribution in the potential environment; 2) information on the genetic stability of GMOs, the degree and level of expression of the transgene; 3) activity and properties of the protein encoded by the transgene; 4) ability to transfer genetic information; 5) the probability of a sharp increase in the population of GMOs in the potential environment; 6) information on target and non-target organisms, the expected mechanism and result of the interaction of GMOs with them [3].

Today, the number of transgenic (genetically modified) plants already includes two hundred fields, pasture, vegetable, tree, ornamental and medicinal crops. For genetic engineering, there are no barriers that limit gene transfer in a traditional selection based on sexual hybridization. The source of new genes can be any organism – animals, plants, or microbes. Moreover, genetic engineers can change the structure of these genes to make them work more productively or during a specific period of plant development.

The main efforts of scientists are focused on protecting plants from adverse (biotic and abiotic) factors, reducing storage losses, and improving the quality of crop products. Breeders are attracted by the possibility of the purposeful genetic transformation of agricultural plants. Thus, a variety that has proven itself well in most economic characteristics can be supplemented by one missing feature, such as resistance to a particular disease [4].

Also, due to genetic modification, plants can perform a previously uncharacteristic role. They become a "factory" of drugs and food supplements or a tool for "soft" administration of drugs, vaccines, and essential food supplements. These are, for example, sugar beetroots, which accumulate low-molecular-weight fructans instead of sucrose, or bananas, which are used as edible vaccines.

Opponents of genetically modified plants rightly point out that the creation, testing, and seed production of transgenic varieties are monopolized by several multinational corporations, which can limit access to information about the adverse environmental consequences of the widespread use of GMO products. It will take several years for their environmental expertise and adaptation to the conservative tastes of consumers [5].

The guarantee against possible undesirable consequences of genetic modification of plants is the legislative regulation of their distribution and the development of related methods of environmental risk assessment. Many countries have already enacted laws to prevent the unauthorized distribution of transgenic seed and to monitor transgenes in crops, as well as the labeling of food products made from or with the addition of GMO products.

Plants weakened by adverse weather conditions are more easily affected by diseases and pests. Therefore, transgenic varieties resistant to frost, salinity, and drought, to a lesser extent require chemical protection, and the cultivation of such GMOs, which will also reduce the pesticide load on the environment.

Plant diseases not only reduce yields but also degrade product quality. At the same time, some microorganisms contaminate grain and other crop products with highly toxic metabolites. That is why the cultivation of GMOs, resistant to adverse environmental factors, will improve environmental safety and quality of life. GMOs that use mineral fertilizers more effectively will be able to significantly reduce environmental pollution by nitrates and phosphates.

The most serious objections to GMOs are related to the assumption that their spread will lead to the emergence and rapid reproduction of resistant forms of weeds. The potential threat of the horizontal transfer of modified resistance genes deserves serious attention. Crossing weeds of the same genus can lead to weeds carrying herbicide resistance genes.

Several rules must be followed to avoid the spread of acquired resistance to transgenic toxins among insect pests. Insects should receive a high dose of toxin, which ensures the destruction of most pests and reduce the number of individuals potentially resistant to the toxin. It is necessary to alternate crops of transgenic varieties so that insect populations are consistently exposed to toxins of different mechanisms of action. Finally, it is necessary to create "reserves" of ordinary (non-transgenic) plants of the same species.

Another adverse consequence could be a reduction in the genetic diversity of wild and specially cultivated plants on our planet. Reducing the number of phytophages or suppressing phytopathogens can lead to the reproduction of controlled plant species and reduce the number of entomophagous, which will change the structure of agro- and biocenoses.

The number of varieties of genetically modified plants is limited, and if they completely displace local varieties, it will reduce varietal diversity. There is a danger that under changed conditions, the transgenic variety will behave unpredictably.

Today, around $ 32 billion is spent annually on the chemical protection of plants from pests, pathogens, and weeds [6]. In this regard, attempts are being made in all possible ways, including through the media, to prevent the promotion of transgenic crops in promising agricultural world markets.

Usually, transgenic plants have a narrowly specific resistance to phytopathogens: in some cases, the inclusion of a single fragment of the virus isolated from a particular strain induces resistance of the plant to this viral strain, but not to another strain of the same virus. This reduces the practical value of transgenic plants. Therefore, the search for proteins that can induce nonspecific resistance of plants to phytopathogens. Several years ago, proteins were isolated that can induce nonspecific resistance of various plants to fungal and viral infections. Work has begun on the transfer of these genetically modified constructs into the genome of tobacco and potato cells. The results confirm the expression of target genes and the induction of a sign of resistance in transgenic plants simultaneously to several viruses.

Currently, American scientists have bred potato varieties resistant to the Colorado potato beetle, and soybean varieties resistant to glyphosate. Manufacturers are forced to carry out 4 to 8 treatments with expensive chemical insecticides to protect plantings from the Colorado potato beetle. Chemical insecticides are toxic to warm-blooded animals and humans. Also, when using compounds of the same chemical class, pests develop resistance relatively quickly.

Monsanto has transferred to the genome of several potato varieties a gene isolated from the bacterium Bacillusthuringinsis, a species of Tenebrionidae (Bt. f). The toxic effect of the protein Bt. f is because it paralyzes the digestive system of the beetle. The content of endotoxin protein Bt. f in potato leaves varies from 5.4 to 28.3 ug/g of raw weight, and in tubers - from 0.4 to 2.0 ug/g (less than 0.01% of the total protein content in the tuber) [7].

Toxicological studies have shown that the Bt. f protein is safe for humans and non-target organisms. Safety is due to the specificity of its effect only on sensitive receptor targets, available only in certain groups of insects. In the soil, this protein degrades relatively quickly. As a result, the US Food and Drug Administration excluded Bt. f protein from the official list of potentially toxic substances.

The tops of transgenic potatoes carrying the Bt. f gene are actively eaten by the 28-spotted sun without any negative consequences for the pest, which confirms the high species-specific action of endotoxin.

For the last 30 years, bioinsecticides based on Vasilusthuringiensis (Lepidocid, Dinel, Insectin, Enterobacterin, Novodor, etc.) have been widely and successfully used in agricultural production in various countries. One of the main active components of these drugs is the protein Bt. f. The World Health Organization, as well as government regulators in many countries, have authorized the use of insecticides as a safe microbiological plant protection product for humans and the environment. Monsanto's transgenic potato varieties are approved for use as food in the United States, Canada, Japan, and other countries.

The tasks that were solved when assessing the biosafety of transgenic potato varieties presented by Monsanto were as follows: 1) check the compliance of genetically modified constructions with the claimed constructions; 2) determine the level of endotoxin accumulation in plant tissues and the stability of this level in subsequent generations; 3) to study the possible influence of transgenic plants on the species composition of rhizosphere and epiphytic microorganisms; 4) to carry out the comparative characteristic of resistance of transgenic grades to the most widespread activators of fungal, bacterial, and viral diseases, to pests of crops; 5) to carry out a comparative assessment of tuber preservation; 6) to study the possibility of resistance of the Colorado potato beetle to endotoxin Bt; 7) assess the compliance of economically useful traits due to the introduction of foreign genes into the recipient plant [8].

Currently, various methods of genetic engineering have become an integral part of modern molecular and cell biology. The main tasks of genetic engineering in biotechnology of plants include their genetic transformation, the expression of foreign genes, and its regulation in the cells of transgenic cultures.

Three outstanding achievements in plant physiology have provided the basis for the integration of recombinant DNA technology into genetically engineered plant biotechnology: first, the discovery of phytohormones that regulate plant growth and development, secondly, the development of methods for culturing plant cells and tissues on media containing macro- and micronutrients, sugars, vitamins, and phytohormones (these methods allow growing cells, tissues, and whole plants under sterile conditions and carry out their selection on specific media).

Soon, the potential of genetically engineered plant biotechnology will increase significantly due to the development of methods for the genetic transformation of cellular organelles. Further, advances in genetically engineered plant biotechnology will depend on an understanding of the peculiarities of transgenic expression. Currently, we can talk about the emergence of nuclear engineering aimed at modifying nuclei using foreign and recombinant nuclear proteins and specific structural modification of foreign genes. The transgenic expression can be increased by attaching to foreign genes nucleotide sequences strongly associated with the nuclear matrix.

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