Selected aspects of biotechnology in horticulture – protection of genetically modified plants

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ABSTRACT

Before discovering methods of genetic transformation, people had to improve the quality of plants by artificial selection and crossing. Nowadays, these actions have been taken up by genetic engineering which requires significantly less time to achieve the expected features. Genetically modified are mostly plants of great economic value. Changing the genome is expected to result in obtaining a plant with desired features. The most common modifications are: 1. Resistance to crop protection chemicals. Giving the plant the resistance to the herbicide allows for its farming without the risk of damaging the crop. The modified plants have either completely new or additional copies of an already present gene responsible for synthesizing enzymes decomposing herbicides. A plant able to decompose herbicides becomes resistant to them. 2. Resistance to diseases caused by fungi, viruses, and bacteria. It may be acquired by introducing a transgene encoding the enzymes destroying the pathogens’ cell wall. Another transformed gene encodes osmotin – a protein associating with the pathogen’s cell membrane, causing its destruction. Resistance to viruses is acquired by introducing genes which encode the proteins of the virus’ capsid and its enzymes. The presence of these proteins results in a milder infection caused by this virus or significantly delayed onset of the disease’s symptoms. 3. Resistance to pests – insects. The Bt gene responsible for such resistance is obtained from a soil bacteria Bacillus thuringensis. The gene encodes a specific protein – Cry – which is toxic to insects. The pest dies after consuming the plant’s cells. Currently, contrary to popular opinion, the range of genetically modified crops is rather small. In Europe, only two genetically modified plants have been allowed for use: MON 810 corn (Monsanto) and Amflora potato (BASF). However, genetic modifications of plant aimed at improving their protection against pathogens or their tolerance to plant protection chemicals give various positive results. Resistance to herbicides results in, among others: less strict rules concerning time of application, lower number of uses needed since both monocotyledonous and dicotyledonous weeds are destroyed, environment protection by reduced use of...
the active agent, reduction of production cost by limited expenses on herbicides. Also, implanting the plants with resistance to fungi, viruses and bacteria, as well as to pests, result in economic, environmental and health profits. Thus, there is need for continued research in the use and protection of genetically modified plants.

**Keywords:** GMO plant protection, transgenic plants, plant genetic modification, GMO in horticulture

1. INTRODUCTION

Before discovering methods of genetic transformation, people had to improve the quality of plants by artificial selection and crossing. Plants have been subjected to such treatment for almost 10 000 years. Today, it has been taken up by genetic engineering which requires much less time to achieve the desired feature. Genetically modified are mostly plants of significant economic value. The genome changes are expected to give rise to the required feature, e.g. resistance to pests, bacteria, viruses and tolerance to crop protection chemicals. Modified are also ornamental plants, which are made to live longer, have a different or more intensive color, more pleasant scent. Most of the plants significant for man have been genetically modified. Moreover, plants are able to synthesize almost any protein, which makes them a potential bioreactor for production of biopharmaceuticals or biodegradable plastics.

This paper has been written on the basis of the analysis of available literature and scientific articles on genetically modified plant protection.

2. THE MOST COMMON TYPES OF GENETIC MODIFICATION OF PLANTS

2.1. Resistance to crop protection chemicals:

The role of herbicides is to eliminate weeds. These chemicals are used separately against monocotyledonous and dicotyledonous weeds, and against especially bothersome weeds. The use of herbicides requires knowledge since their improper use may damage the entire crop or significantly lower the harvest. Making plants resistant to herbicides is currently their most common genetic modification. These modifications allow for using these substances without the risk of damaging the crops. The modified plants have entirely new genes or copies of already present genes responsible for synthesizing enzymes decomposing herbicides.

Plants able to decompose herbicides become resistant to them. Many plants have been modified this way: soya, corn, rape, tobacco, tomatoes. In order to make a plant resistant to the actions of a total herbicide, Roundup Ready-type modification is performed, which is one of the most commonly used methods. The active agent destroying a non-transgenic plant is glyphosate. Glyphosate inhibits the EPSPS synthase – an enzyme responsible for the synthesis of aromatic amino acids. A transgenic plant is equipped with a gene encoding the EPSPS synthase resistant to the action of glyphosate as well as with a gene encoding glyphosate oxidoreductase – a GOX enzyme decomposing glyphosate. Soya, which is one of the most commonly cultivated plants resistant to the herbicide has expanded the offer of biotechnological companies which addressed the farmers’ needs and now offer herbicides
together with the seeds of plants resistant to them. Another way to modify plants for herbicide resistance is introducing the PAT gene to them. This gene comes from a soil bacterium \textit{Sterptomyces hygroscopicus} and encodes resistance to glufosinate – the active agent of the herbicide Basta. Genetically modified with PAT have been, among others, rape, soya and sugar beet. Transgenic triticale obtained in 1995 by prof. Janusz Zimny from The Plant Breeding and Acclimatization Institute in Radzików was the first ever resistant to the Basta herbicide [1-4].

2. Resistance to diseases caused by fungi, viruses and bacteria

Plant diseases can be caused by viruses, bacteria and fungi. Disease of crop caused e.g. by fungi of the \textit{Fusarium} genus negatively affects the farmer’s finances as well as the customers’ health. The infected crops contain mycotoxins which, apart from causing food poisoning, result in blocking DNA synthesis and interfering with RNA metabolism thus leading to cancer. Resistance to fungal and bacterial infections can be achieved by introducing a transgene encoding the enzymes – chitinase and glucanase which destroy the pathogens’ cell wall. Another transformed gene encodes osmotin – a protein associating with the pathogen’s cell membrane and destroying it. Resistance to viruses can be achieved by introducing genes of the virus’s shell (capsid) and its enzymes: replicase, protease. The appearance of these proteins results in a much milder infection and a significantly later onset of its symptoms. The plant contains virus proteins, but it does not suffer from the disease; moreover, the virus does not infect such cells, since it appears to it that all the cells have already been infected. Some examples are: tobacco resistant to the tobacco mosaic virus (TMV), cucumber resistant to cucumber mosaic virus, cauliflower resistant to cauliflower mosaic virus, pumpkin resistant to zucchini yellow mosaic virus (ZYMV) and watermelon mosaic virus (WMV). 80% of the papaya crops in Hawaii are transgenic crops of the UH Rainbow type. The reason for using the transgenic variety is the papaya ringspot virus (PRSV) which is transferred by aphids. This papaya has been given resistance to the virus through genetic modification [5-7].

2.3. Resistance to pests (mainly insects)

The gene responsible for such resistance – the Bt gene – is acquired from a soil bacterium \textit{Bacillus thuringensis}. This bacterium, living in soil, has allowed for the use of its protein – Cry – as a natural plant protection chemical as early as in 1930’s. Thanks to genetic engineering, there is no problem in transferring the gene into the plant’s genome in such a way that its product makes the plant resistant to pests, but at the same time it is neutral to animals and people. In order to make this biopesticide work effectively, the insect’s digestive tract must contain proper receptors which then bind the Cry protein, allowing it to act. This solution reduces the need for chemical protection which significantly decreases the cost of production. The first plant with the Bt gene was a potato resistant to the potato beetle, others are: cotton, cabbage, tomatoes and most importantly Bt corn (MON 810), resistant to the European corn worm (\textit{Ostrinia nubilalis}). This pest is not only a problem for the farmers in the US and southern Europe, but also in Poland. The crops marked with the Bt symbol will flourish in near future due to the lack of need to use crop protection chemicals in order to stop, among others, pests from the \textit{Lepidoptera} order. This makes the farming cheaper and, most importantly, healthier [8-10].

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3. CONCLUSIONS

Currently, contrary to popular opinion, the range of genetically modified crops is rather small. In Europe, only two genetically modified plants have been allowed for use: MON 810 corn (Monsanto) and Amflora potato (BASF). The MON 810 corn has been implanted with the Cry gene from the soil bacterium *Bacillus thuringensis* encoding the Bt protein – an insecticidal toxin. The Amflora potato, on the other hand, has been modified so that the starch that it produces does not contain amylose, but only amylopectin which has wide industrial use (in paper-making, textile and glue industry). However, genetic modifications of plant aimed at improving their protection against pathogens or their tolerance to plant protection chemicals give various positive results. Resistance to herbicides results in, among others: less strict rules concerning time of application, lower number of uses needed since both monocotyledonous and dicotyledonous weeds are destroyed, environment protection by reduced use of the active agent, reduction of production cost by limited expenses on herbicides. Also, implanting the
plants with resistance to fungi, viruses and bacteria, as well as to pests, result in economic, environmental and health profits. Thus, there is need for continued research in the use and protection of genetically modified plants.

Biography

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References


