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GENETIC RESOURCES PROVIDED BY GENETIC ENGINEERING

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ABSTRACT
The approach to genetic modification in plant breeding and the coexistence of traditional and biotech crops is not uniform all over the world. While in the U.S. the ratio of the GM-production reached 30-40%, from which it made no longer sense to differentiate between GM and conventional, in Europe there is great resistance to the new technology. Standpoints are also diverse about the environmental advantages, mainly knowing the facts that e.g. the tendency of herbicide/insecticide consumption in some places was the opposite than expected (increased) or the potential health risks possibly caused by GM foodstuffs. In Hungary the possible future application of GM plants has more disadvantages just right now instead of providing benefits to farmers from environmental, ecological and economical point of view. It seems that consensus is still far away, the debates will go on; the counterparts will abide by their opinions for a long time.

Keywords: Genetic resources, genetic engineering, GMO-s in USA, GMO-s in Europe, GMO-s in Hungary

INTRODUCTION

Crop plants created for human or animal consumption by molecular biological techniques are referred as GMO's (genetically-modified organisms). Genetic engineering can create plants in the laboratory with desired trait(s), e.g. increased resistance to herbicides, weather extremes (droughts, cold) or enhanced nutritional value (protein/sugar content, etc.). This process is much faster than conventional breeding methods (WHITMAN, 2000). During genetic modification, the intended gene is built-in the genome of the plant with the help of a vector that contains other genes, e.g. viral promoters, transcription terminator elements, genes of antibiotic resistance and reporter genes (PUSZTAI ET AL., 2003). The three generations of genetically-modified plants (also called 'transgenic plants') with their possible advantages are shown in *Table 1*.

Table 1. Generations and possible uses of GM plants

FIRST GENERATION TRANSGENIC PLANTS	SECOND GENERATION TRANSGENIC PLANTS	THIRD GENERATION TRANSGENIC PLANTS
Abiotic and biotic stress resistance	**Modification of physiological processes**	**Production of special molecules: 'bioreactors'**
Herbicide resistance: e.g. Round-Up Ready soybean (glyphosate resistant) e.g. 'IMI/SUMO' maize hybrids (imidazolinon/sulphonylurea resistant) *Insecticide resistance:* e.g. Star Link maize (moth resistant)	*modification of metabolism* e. g. protein, carbohydrate metabolism - production of new protein - overproduction of protein - inhibition of protein production *modification of development* (e.g. male sterility, ripening)	e.g. medical, food, plastic industry human proteins, vaccines, phytase 'consumable vaccine' of GM banana

In 2020 an estimated 8 billion people will live on Earth, which will mean massive changes in the production, distribution and stability of food products. With no doubt, new methods in production are needed to feed the increased population of the planet. GM crops could significantly improve crop yields because more food can be grown on less land area. An environmental fact is that after the first some years of using herbicide tolerant GM soybean, seed rape, cotton, corn varieties and insect protected GM cotton, a dramatic reduction of pesticide use was observed (in 2000 total global reduction in pesticide use was 22.3 million kg of formulated product). Reduced use of pesticides can significantly decrease their effects on water quality through run-off and leaching of residues into surface and groundwater. Deployment of insect resistant *Bacillus thuringiensis (Bt)* varieties was estimated to have reduced the total world use of insecticides by 14% (PHIPPS AND PARK, 2002).

Plants could be modified directly to be used for environment preservation purposes, such as:

- *Phytoremediation:* removals of pollution from the environment with the help of plants, e.g. poplar trees have been genetically engineered to clean up heavy metal pollution from contaminated soil (BIZILY ET AL., 2000).
- *Phytoextraction* (or *phytoaccumulation*) uses plants to remove contaminants (heavy metals) from soils, sediments or water into harvestable plant biomass (MEAGHER, 2000).
- *Phytostabilization* focuses on long-term stabilization and containment of the pollutant. Mainly focuses on sequestering pollutants in soil near the roots but not in plant tissues. Pollutants become less bioavailable and livestock, wildlife, and human exposure is reduced. An example application of this sort is using a vegetative cap to stabilize and contain mine tailings (MENDEZ AND MAIER, 2008).

In contrast with the possible advantages of GM plants there are a lot of potential risks; among these the most important is coexistence, e.g. in case of the first generation transgenic plants (PEPO ET AL., 2005; PEPO, 2006). A series of environmental/ecological problems are listed above:

- *Escape of transgene:* (i) during the harvest, *seeds* can be scattered, mixed with seeds of non-GM plants, (ii) in the case of vegetatively propagated plants, *vegetative plant parts* (tubers) can remain in the soil and new plants can develop from them, (iii) canola in Europe can *cross* with weeds and make fertile hybrids,
- *Development of new viruses:* in the cells of GM plants viral RNA synthesized from the virus genes can recombine with the infecting viral RNAs,
- *Development of weeds that can be killed:* enhanced effect of them,
- *Effect on non-target organisms:* e.g. pollens of *Bt* species with high endotoxin content can escape into the environment, killing the useful insects,

Besides the problems mentioned above, risks on human health have to be considered:

- digestibility problems,
- development of allergic reactions,
- toxicity.

Plant with modified metabolism express/overexpress proteins, enzymes and their effects can not be predicted.

The genetically modified organisms (GMO's) are very different in their nature, use and distribution and at the same time they carry wide variety of danger to the environment. That was the driving force behind the idea that we are dealing with GMO's firstly in USA, than Europe and finally because their exceptional situation a separate chapter is paid to Hungary.

RESULTS AND DISCUSSION

GMO's in the USA

Genetically-modified foods are prevalent on the U.S. markets; we speak about not whole vegetables or fruits but processed ones like vegetable oils or breakfast cereals that may contain genetically-modified ingredients in a very small portion. Soybean derivatives also can be present in foods.

From 1996 to 2006 (the first ten years of commercially available genetically-modified plants), herbicide tolerance has consistently been the dominant trait followed by insect resistance and stacked genes for the two traits: 68%, 19% and 13%, respectively. In 2006, GM plants in the U.S. were cultivated on 54.6 million hectares. The major biotech crops were soybean, maize (these two plants are the most widely grown ones, not only in the U.S. but all over the world), cotton, canola, squash, papaya, alfalfa (ISAAA, 2006). Plant varieties meeting the requirements of commercialization determined by the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) can be found on 'The List of Completed Consultations on Bioengineered Foods' (for website see REFERENCES). Genetically-modified varieties have been widely adopted by farmers in the U.S. They expect higher yields and lower pesticide costs. This tendency between 1996 and 2005 is shown on *Figure 1*.

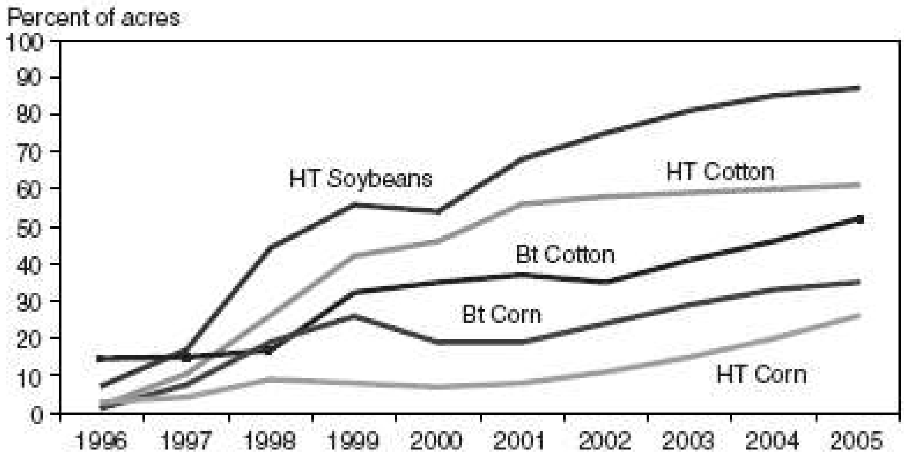

Figure 1. Adoption of genetically-modified crops by U.S. farmers
HT: herbicide tolerant, BT: insect resistant (from *Bt: Bacillus thuringiensis*)
(after FERNANDEZ-CORNEJO ET AL., 2005)

A number of surveys were conducted in the U.S. during recent years on public acceptance of foods containing GE (genetically-engineered) ingredients. In 2003-04, almost half (47%) of the population asked opposed the introduction of GE foods, while only 27% favored. 47% approved or leaned toward approval of the use of GE to make plant-based foods, 41% disapproved or leaned toward disapproval, and 12% were unsure. In 2005, 50% said likely to buy and 45% said not likely to buy GE food produced for better taste or being more fresh; 64% said likely to buy and 32% said not likely to buy GE food produced for decreased pesticide applications (FERNANDEZ-CORNEJO AND CASWELL, 2006).

Despite the expectancies, pesticide use has not decreased since the introduction of GMO's in the first eight years in the US (*Table 2*).

Table 2. Average pesticide pounds applied per acre planted to conventional, herbicide-tolerant (HT) and *Bt* transgenic varieties (BENBROOK, 2004)

	1996	2000	2003
Conventional corn			
Herbicides	2.67	2.13	1.99
Insecticides	0.18	0.18	0.06
GE corn			
Herbicide-tolerant	1.87	1.83	2.32
Bt transgenic	0.16	0.05	0.02
Conventional soybean			
Herbicides	1.20	0.99	0.87
GE soybean			
Herbicide-tolerant	0.84	1.10	1.34
Conventional cotton			
Herbicides	1.93	1.86	1.42
Insecticides	0.56	0.41	0.35
GE cotton			
Herbicide-tolerant	1.58	2.09	2.43
Bt transgenic	0.10	0.10	0.10

Across the three crops, HT varieties increased herbicide use, the two *Bt* transgenic crops reduced insecticide use and all GE crops planted since 1996 have increased corn, soybean, and cotton pesticide use.

GMO's in Europe

To date, the only type of GMO grown in the EU is *Bt* corn. *Bt* corn contains a gene from a bacterium (*Bacillus thuringiensis*) that produces a toxin (*Bt*-toxin) to defend it from the European corn borer (*Ostrinia nubilalis*). The insect pest is present primarily in southern and middle Europe, and is slowly making its way north.

Genetically-modified crops are grown in six countries of the European Union and their cultivation areas are increasing. Data on the last two years are shown in *Table 3*.

Table 3. Cultivation areas (hectares) of *Bt* corn in European countries

Country	2006	2007
Spain	53,700	75,150
France	5,000	21,200
Czech Republic	1,290	5,000
Portugal	1,250	4,199
Germany	950	2,685
Slovakia	30	900

In Spain, a significant amount of the corn production is genetically modified - an estimated 25% of the current production. *Bt* corn was first grown in 1998.

In France, biotech corn has gained strong support among the farmers, who stand to gain more from the crop than any other EU country.

Bt corn was first grown in the Czech Republic in 2005.

Portugal also began producing *Bt* corn in 2005.

Since the 2006 growing season, *Bt* corn cultivars have full approval in *Germany* and are now ready for commercial cultivation. All areas must be declared in a site register.
Slovakia became the newest country in 2006 to plant biotech crops.
In 2006, nearly 80% of Romania's soybean production consisted of herbicide-tolerant varieties. Romanian Government decided to discontinue cultivation of GM soybean upon joining the European Union in January 2007 (GMO COMPASS, 2008; ASEBIO WEBSITE).
Most of the European countries are against GMO. On the 5th of April 2006, the 'Vienna Declaration for a GMO-free Europe' was pronounced by the platform organizing the 'March for a GMO-free Europe' - prepared by the many NGO's (non-governmental organizations) like Global 2000, Greenpeace, and other environmental organizations -, saying: "Transgenic agriculture will have an unacceptable impact on the survival of conventional and organic agriculture in Europe. Without clear prohibition of genetic pollution, the quality of our agriculture cannot be guaranteed. We now face the challenge of protecting our natural and agricultural biodiversity." (…) "Coexistence must not mean contamination. The objective of any legislation on coexistence must be to ensure guaranteed GMO-free agriculture and food production. This means: Who applies genetically modified organisms must strive for zero-contamination. Coexistence measures have to be tailored in such a way that contaminations remain the absolute exception."
Regulations are strict for the authorization of GMO's in Europe. The main instrument is European Community Directive 90/220/EEC - prepared in April 1990, amended for several times (e.g. 2001/18/EC). It regulates the deliberate releases of GMO's for research and development and the placing on the market of genetically-modified products. It provides for an environmental evaluation and a step-by-step approval for the dissemination of GMO's. A case-by-case assessment of the risks to human health, animal health and the environment is carried out prior to a release and the placing of a GMO on the market. It also provides a framework that Member States must accomplish. A national authority in every Member State has to regulate the release of GMO's. Decision-makers have to find balance between interests and opinions of consumers, NGOs, producers, retailers and farmers who influence the authorization process. The consumer group has the most influence on the authorization procedure (BISOFA ET AL., 2001).
Labeling and traceability is among the very strict regulations in Europe. Regulations (EC) No. 1829/2003 and (EC) No. 1830/2003 of the European Parliament and of the Council concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms require the following:
- Consumers' safety has to be guaranteed as a result of the traceability of products consisting of or containing GMO's.
- All products are subject to compulsory labeling.
- Operators should transmit the following information in writing: (i) an indication that the products consist of or contain GMO's, (ii) the unique alphanumerical identifiers assigned to the GMO's contained in the products.
- Operators who place on the market a pre-packaged product consisting of or containing GMO's must, at all stages of the production and distribution chain, ensure that the words "This product contains genetically modified organisms" or "Product produced from GM (name of organism)" appear on a label affixed to or transmitted with the product.
- When placing a product on the market, the industrial operator must transmit the following information in writing to the operator receiving the product: (i) an indication of each food ingredient produced from GMO's, (ii) an indication of each raw material or additive for feeding stuffs produced from GMO's, (iii) if there is no list of ingredients, the product must nevertheless bear an indication that it is produced from GMO's.

- For food or feed products, including those intended directly for processing, traces of GMO's will continue to be exempt from the labeling obligation if they do not exceed the threshold of 0.9% and if their presence is adventitious and technically unavoidable (EUROPEAN UNION WEBSITE).

European consumer opinion is expressed and enhanced through NGO's activities. It is dominated by a negative attitude towards GM products. According to the results of several surveys the issue of genetic engineering ranks high up in the list of potential risks caused by food. Considering the above mentioned, the future of this field in Europe cannot be predicted. The resistance is very strong, so it seems that GM food will not spread the markets in the next years.

Figure 2 shows a comparison of people's opinion about different applications of biotechnology in Europe and the USA.

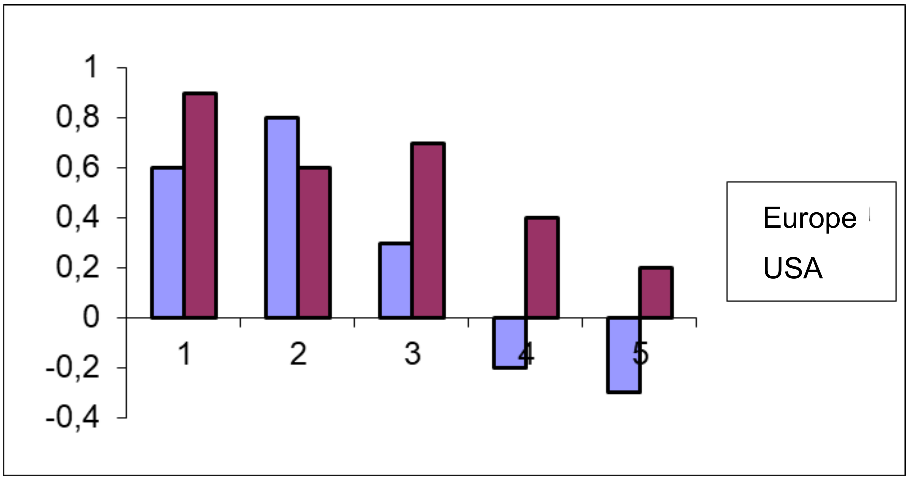

Figure 2. Approaches of the public to fields of biotechnology in Europe and the USA. 1. remedies, 2. genetic testing, 3. crops, 4. food, 5. organ transplant (acceptability of values: 1: acceptable, 0: neutral, -1: unacceptable)

GMO's in Hungary

Hungary joined the European Union on 1st May 2004. The country has moratorium in place for the commercial cultivation of GM crops that can be applied with reference to new scientific evidence for security risks. The Commissions motion to lift the Hungarian moratorium was outvoted by more than half of the Member States in September 2006. It is not easy to see the clear picture. On one side, there are opinions that most of Hungarian consumers (70-80%) do not want GMO's. These figures come from green movements and NGO's. Multinational biotechnological companies in the country state the opposite that almost three-fourth of farmers want to grow GMO's.

As it is seen, two sides are present opposite each other about the question. The 'pros' - academics interested in conducting research for multinationals and the big farmers' group both claim the right to choose - say that this kind of development in biotechnological research could place Hungarian agriculture on the top rank of the region in view of the application of the new technology. Other arguments are that energetic sector could profit from the new technology, it is environmentally friendly, high added value and many jobs could be created in regions where unemployment is a real serious problem. Their communication is a bit one-sided and neglects the resistance of consumers saying that consumers have no business defining what the product comes from.

The ‘contras’ are mostly politicians - there is a 5-party consensus in the Parliament -, consumers, environmental organizations, organic farmers, leading scientists from the fields of nutritional and ecological sciences. Farmers say that GMO-free status of the country would mean better prices on markets, while coexistence would result in the loss of markets; and since Hungary is an agricultural country, these losses would adversely affect its whole economy. Scientists emphasize the unnecessary and unpredictable risks of the technology.

The most debates were on the buffer zones - the separation of conventional and biotech crops. Finally, the buffer zones became 400 meters wide. This kind of strict restriction is exceptional in Europe. Not only crops but infrastructure for the two technologies would be needed to avoid contamination from treatments after harvests and the economical sources for this can be questionable (SIMONYI, 2007).

The opinion of consumers and professionals about gene technology is mostly negative and figures are a bit different but similar.

Professionals: 37.61% ‘rather negative than positive’, 17.95% ‘predominantly negative’.

Consumers: 35.04% ‘rather negative than positive’, 13.25% ‘predominantly negative’.

More than half (51%) of the consumers would refuse GM food even if it was cheaper, more tasty, had better appearance and longer shelf-life than the traditional one.

Labeling also seems to be very important for Hungarian consumers as mainly three-fourth of them (73%) thinks it compulsory to indicate GM content on the packages of foodstuffs.

Even if Hungarian consumers predominantly refuse GM products, this proportion is still much smaller than in Western Europe (BANATI AND SZABO, 2006).

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