# PLANT BIOTECHNOLOGY : CURRENT SITUATION AND TRENDS

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## ABSTRACT

Since the late 1980's gene technology has been used in plants as an additional tool in crop improvement. Today several commercial GM crop varieties are widely used mainly on the American continents. The first traits developed were those lying in the main expertise of the Seed Industry: tolerance to non-selective herbicides, resistance to insects, pollination control. Moreover the first species genetically modified were plants largely used throughout the world in modern agriculture such as soybean, maize, oilseed rape and cotton. Today more or less all important plant species including cereals have been transformed and a wide range of traits from agronomic enhancement to plant-product quality improvement are being developed. In countries like USA, Canada, the European Union and Japan, consistent legislative systems regulating the marketing of such novel crops have been set up. All systems are based on the concept of substantial equivalence it must be demonstrated that the GM crop is at least as safe as its conventional counterpart. However the practicalities of trade in agricultural products throughout the world has raised the necessity for more harmonisation, improved transparency and safety evaluation capacity building. Several international initiatives are in process with this aim: Cartagena protocol, OECD, FAO/WHO, EU-US Forum etc. For the EU the revised directive 90/220 will be an important step.
**Key words:** Genetically Modified Crops, worldwide uses, GM legislation.

## *IZVLEČEK*

## *RASTLINSKA BIOTEHNOLOGIJA: TRENUTNO STANJE IN USMERITVE*

Genska tehnologija je kot dodatni pripomoček pri žlahtnjenju rastlin v uporabi od poznih osemdesetih let. Številne gensko spremenjene sorte se komercialno že na široko uporabljajo, v glavnem v Ameriki (Severni in Južni). Prve, tako razvite lastnosti izvirajo v glavnem iz potreb semenarske industrije: toleranca na selektivne herbicide, odpornost proti žuželkam, kontrola križanja.
Prve genetsko spremenjene rastline so bile tiste, ki se v sklopu sodobnega kmetovanja pridelujejo širom po svetu. To so: soja, koruza, oljna repica in bombaž. Danes so gensko spremenjene bolj ali manj vse pomembne rastlinske vrste, vključno z žiti. Skupaj z njimi je razvita tudi široka paleta lastnosti, ki z agronomskega stališča izboljšujejo proizvodno kakovost rastlin. V nekaterih državah kot so ZDA, Kanada, Japonska in države EU so bili vzpostavljeni dokaj dosledni zakonski sistemi, ki urejajo trženje s tovrstnimi novimi rastlinami. Vsi sistemi temeljijo na konceptu enakovrednosti, ki je zasnovan na dejstvu, da morajo biti gensko spremenjene sorte najmanj tako varne kot

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so konvencialne sorte. Ttrgovanje s kmetijskimi proizvodi širom po svetu je povečalo potrebo po večji usklajenosti, izboljšani preglednosti in izboljšanju vrednotenja varnosti. Številne mednarodne pobude potekajo v smeri teh ciljev preko: Cartagena protokola, OECD, FAO/WHO, EU-US Forum itd. Za EU bo pomemben korak v tej smeri revidirana direktiva 90/220.

**Ključne besede:** genetsko spremenljivi posevki, svetovna uporaba, zakonodaja o genetsko spremenjljivih rastlinah

## 1. INTRODUCTION

Since the first plant cell was transformed by using the genetic engineering in Ghent by Marc Van Montagu and Jeff Schell in the early eighties, tremendous progress have been achieved enabling the practical cultivation of genetically modified commercial varieties throughout the world today. The history of the development of the transgenic - or genetically modified (GM) – crops can be divided in three phases:

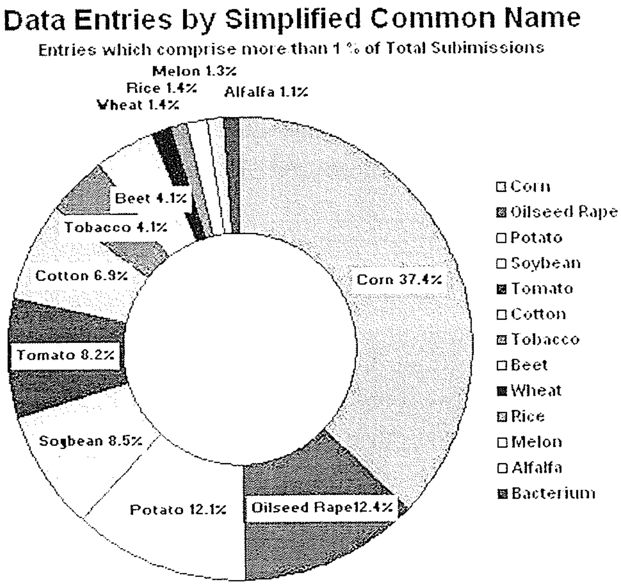
- The first phase, mainly during the eighties where the activities remained contained in the laboratories. During this phase the technology of transformation has been improved but the most remarkable achievement has been the improvement of the regeneration techniques that could allow applying the technology to more or less all the plant species.
- The second phase, beginning in the late 80s saw the first field trials being carried out with potentially commercial applications.
- The third phase, beginning in the mid 90s, was the development and commercial use of genetically modified commercial crops developed in the previous phases. In the same time the "second generation" of genetically modified products has been being in preparation in the laboratories.

## 2. CURRENT STATUS OF COMMERCIALISED TRANSGENIC CROPS

According to Clive James of the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), the estimated global area of transgenic crops for 2000 is 44.2 million hectares. 99% of those crops are grown in only four countries : USA (30,3 M ha – 68%), Argentina (10 M ha – 23%), Canada (3 M ha – 7%) and China (0.5 M ha – 1%). Nine other countries grow GM crops: Australia, South Africa, Mexico, Uruguay, France, Spain, Germany, Romania and Bulgaria. It is noteworthy that this ranking is far different from the figure of the development activities with field trials. As a matter of fact, according to the OECD database, if 71.1% and 9% of field trials have been respectively performed in USA and Canada, around 18 % of the development activities have been performed in the EU where nearly no commercial uses are found.
Similarly, only four crops constitute the large majority of that acreage : soybean (25.8 M ha), maize (10.3 M ha), cotton (5.3 M ha) and canola/rapeseed (2.8 M ha). Furthermore the major trait deployed in those crops are herbicide tolerance – in the four crops – and insect resistance in maize and cotton.

## 3. PROSPECTIVE OF FUTURE DEVELOPMENT

A good indication of the crops that are likely to be developed in the near future is given by the OECD database on the field trials.




As indicated in the figure, beside the four major crops we find specialised crops like potato and beet but also some vegetables, tomato and melon, and two other cereals, rice and wheat. Those plants have been transformed with the same traits as the four main ones but new traits are developed in addition, often called quality traits: modification of starch, delay of ripening, improved nutritional value, etc. Furthermore such high potential traits need to be carried by highly performing crops. So, yield enhancement traits are developed in parallel.

Recently FAO published a report on "Biotechnology developments and their potential impact on trade in cereals" that gives good indication on the potential traits. This report lists the different traits as follows:

Producer-oriented biotechnology: yield enhancing technologies:

- Creation of hybrids: by introduction of genes inhibiting the formation of pollen in a self-pollinated plant it is possible to render it only female and hence to enable cross pollination, allowing the production of hybrids thereof. This system has already been applied in commercial oilseed rape in Canada and by genetic engineering can be adapted to other species.
- Optimisation of photosynthesis by "architecture genes" (IRRI) that enable the plant to absorb more photosynthetic energy or genes that convert a larger portion of that energy into grain rather than in leaves or stems.
- Possibility to grow crops under unfavourable conditions by conferring resistance to stresses: resistance to drought, salt, toxic elements, frost.
- Reducing the growing season allowing more harvests per year.

End-user oriented technologies:

- There are many possibilities of improving the nutritional value of crops by enhancing the presence of certain elements like vitamin A, vitamin H (biotin) or modifying the protein balance in order to make them more nutritious.
- Another potentially important application is the improvement of the quality of feed crops so as to improve feeding efficiency and reduce pollutants (phosphorous) in animal waste.

- The modification of carbohydrates metabolism can be of important value for the industry using grain crops for sucrose, starch or fuel. By this mean it is possible to develop "tailor-made" genetically modified varieties for specific industrial uses. In the same field there are possibilities to have cellulose produced by genetically modified grains in addition to the traditional source.
- Finally we must not forget the possibility to modify crop plants for the production of proteins of pharmacological significance.

## 4. STATUS OF LEGISLATION RELATED TO THE USE OF GENETICALLY MODIFIED CROPS

In most of the developed countries, and at least where GM crops are grown, the use of genetically modified crops is strictly regulated. In general three types of uses are considered:

1. The contained use in laboratories,
2. The field releases for research and development purposes.
3. The marketing of GM crops.

For any use of GM crops a specific permit or clearance is required. This clearance is given by the Authority on the basis of the analysis of the risks connected with the use of the GM crop. Everywhere the basis of the risk assessment is the assessment of the consequences of the genetic modification by a clear description of the transgene and its product on one hand and on the comparison between the GM crop and the parent that has been modified, on the other hand. The general concept used in general is the concept of substantial equivalence that aims to demonstrate that the modified plant is not different from the parental line except for the expected changes.
On this common basis several systems have been established. The first ones were the North American (USA and Canada) and the EU set of legislation put in place in the early nineties. They define two types of approaches that were more or less followed by the other countries.

- In North America there is no specific legislation for GMOs but existing legislation have been adapted in the way to include specific assessment for GMOs. The use of GMOs is specifically regulated until it is demonstrated that they are not more harmful than their non-GM counterpart.
- On the opposite, in the EU two directives, 90/219 and 90/220, regulate specifically the use of the GMOs: specific approvals are given by specific Competent Authorities. At the end of the authorisation procedure the GMO receives a permit with specified conditions of uses but the product still keeps its specific status of genetically modified organism.

Such differences in the approach generated conflictual situations that emphasized the necessity to harmonise the legislation on GMOs throughout the world. In June 1999, the G8 requested OECD to carry out an analysis on Food safety and Biotechnology. The Working Group on Harmonisation of Regulatory oversight of Biotechnology gave its report in the summit of Okinawa in July 2000. According to the communiqué it "represents a useful step in this direction".
In the same way the discussions on the Biosafety Protocol (Cartagena protocol) will enable the establishment of a consistent basis for such an harmonisation.
Similarly the EU-US Biotechnology Consultation Forum issued in December 2000 a useful and interesting report. One of the important aspects of this forum is that, beside the scientists, for the first time, other types of experts have been involved. As a consequence the socio-economic and cultural aspects have been identified as critical factors in the decision making that takes place in the risk management step of the risk analysis.

## 5. CONCLUSIONS

The spectacular development of genetically modified crops within the last five years could lead to the conclusion that we are assisting to a matter of revolution. But when we look more thoroughly at the figures we must admit that this expansion is not really widespread.
As a matter of fact, first, that affects mainly the developed countries and more particularly the North America. Second, some non negligible parts of the world, like the Europe, albeit important research and development activities have been carried out there, are still lagging far behind the leaders. Third, most of the developing countries have not access to this technology yet. There is no doubt that as long as we will not develop GM crops that will meet really the expectations of the users, including the end users, with obvious benefits for all and that would enable to restore the confidence of the public in the Europe, this revolution will still remain partial.
Therefore it is crucial that the intergovernmental and international discussions going on in organisations like FAO/WHO (Codex Alimentarius), OECD, Biosafety Protocol etc. set up a consistent framework where the researchers from both the public and private sector will work in a sound way towards the right direction for the common benefits of all. In that way the recent revision of the EU directive 90/220/EEC on the deliberate release of the GMOs is an important step forward.

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