CURRENT STATUS OF GENETICALLY MODIFIED PRODUCTS IN GLOBAL AGRICULTURE AND TRADE

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ABSTRACT

This Bulletin provides an overview of GM crops, and their impact on agriculture generally, and Asian agriculture in particular. It discusses the current situation, including the distribution of GM crop production, trade, and ownership of the technology. The response of the international community to GM crops and biotechnology is reviewed, including protocols and summit meetings aimed at producing consensus about these new organisms. The final section discusses the future prospects, particularly of small-scale farmers in Asia, and how they might benefit more from biotechnology.

INTRODUCTION

People around the world have developed and are using many kinds of biotechnology. Biotechnology can be classified into two major categories: traditional and modern. Traditional biotechnology applications have been around for millennia, including manipulating microorganisms in the fermentation process to make bread, beer, wine, soy sauce, cheese and many other food products.

The development of modern biotechnology is really a ground-breaking advance because of its enormous power to transform living things. New techniques such as tissue culture, cell culture and embryo transfer, as well as various techniques of molecular manipulation, have emerged. Most prominently, transgenic technologies such as genetically modified organisms (GMOs) are now being widely used in crop breeding and commercial production. Table 1 lists some examples of applications of this technology, and the different level of skills, know-how and hardware investment required for them to be useful. It is clear that both the skill requirements and hardware investment are very high for the modern application of biotechnology.

In this Bulletin, I shall be reviewing currently available information to provide a holistic picture, particularly of genetically modified organisms/products of agricultural biotechnology. The first section deals with the current situation, including production, ownership of technology and biosafety. This is followed by a discussion on the impact of agricultural biotechnology on trade, and several other key issues. The responses of international organizations is analyzed. Finally, a discussion of the future prospects, particularly of small-scale farmers in Asia, will be presented.

AREA PLANTED IN GM CROPS

There was an insignificant area planted in GM crops before 1992. Nowadays, the area is much larger. The estimated area of the commercial production of transgenic or GM crops for 2001 was approximately 52.6 million hectares. These were grown in 13 countries (United States, Argentina, Canada, China, South Africa, Australia, Mexico, Bulgaria, Uruguay, Romania, Spain, Indonesia and Germany). The commercial production of GM crops in India and Brazil began in 2002. The increase between 2000 and 2001, one year alone, was 9.4 million hectares and

Keywords: Cartagena Protocol, GM companies, GM crops, IPR (intellectual property rights), small-scale farmers, trade

Table 1. Application of Biotechnology

	Examples	Skill/know-how requirements	Hardware investment
Traditional uses	Composting, various fermentation processes, e.g. making bread, beer, wine, soy sauce and cheese	Low	Very low to sophisticated
New scientific breakthroughs	Cryopreservation, tissue culture, cell culture, plant propagation, DNA analysis, gene mapping	Increasingly sophisticated	Increasingly expensive
Advanced or modern applications	Propagation, genetic engineering (i.e. GMOs), improvement of plants/other organisms, production of enzymes and secondary metabolites, genomics, proteomics	High	High

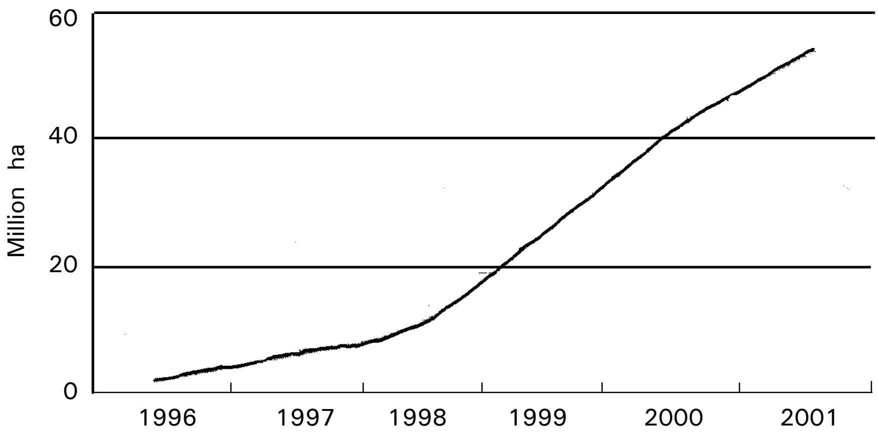

Fig. 1. Global area planted in GM crops

represents a 19% increase. Between 1996 and 2001, over only five years, the total area of GM crops grew about 30 times, as shown in Fig. 1.

The production of GM crops is currently concentrated in just a few countries, while more countries are still in the stage of experimenting. In 2001, 99% of GM crops were produced commercially in only four countries, namely United States (68%), Argentina (22%), Canada (6%) and China (3%). As for crops, GM soybean made up 63% of the global planting area, while GM corn accounted for 19%, followed by GM cotton (13%) and GM canola (5%).

Not only the commercial production of GM crops is expanding, but more impressively, experimentation and field trials. By the end of 2000, there were estimated to be more than 11,500 field trials of GM crops in 39 countries. As shown in Table 2, while the number of countries permitting field trial are evenly divided between developed and developing countries, the location of trials is clearly not. Far more trials take place in developed countries than in developing ones. The United States alone accounted for over 80% of all field trials in the world, while fewer than 20% were conducted in developing countries. Table 2 also shows that as of the end of 2000, 14 crops had been approved for commercial planting, feed or food use.

Table 2. Field trials of transgenic crops by the end of 2000

	Field trials		No. of
	No. countries	No. trials	approved crops
Developed countries	20	9,701	14
United States	1	6,337	14
Canada	1	1,233	4
All others	18	2,131	5
Developing countries	19	1,822	4
Argentina	1	393	3
China	1	45	4
All others	17	1,184	3
Total	39	11,523	14

Table 3. GM traits of major crops

- Herbicide tolerant 77% (Roundup Ready)
- Insect resistant 11% (Bt corn, Bt cotton)

- Delayed ripening
- Modified color or oil content (herbicide tolerant canola)
- Virus resistance (potato, yam in Africa)
- Nutrient enrichment (golden rice)

DESIRED TRAITS OF GM CROPS

In terms of traits, there are only two major GM traits that had so far been developed for commercial application up to the year 2001. These were herbicide tolerant crops, which accounted for 77% of all GM crops. Other traits of GM crops include delayed ripening, and modified color or oil content (as in the case of canola). GM potato and yam have been bred for virus resistance, and golden rice for nutrient enrichment. Crops with the last four traits have only limited commercial production. Bt maize accounted for 11%, while Bt cotton was an important crop in 2002.

Bt crops

Bt genes are taken from the soil bacterium *Bacillus thuringiensis* (Bt). The spores of this tiny bacterium contain a protein which breaks down in the guts of insects, releasing a toxin which eventually kills the insect. Farmers have been spraying Bt preparations on their crops for decades. The Bt on the leaves is eaten by pests, enters their gut and kills them. With biotechnology, the Bt becomes part of the plant, so all the plant is toxic to the pests which feed on it.

OWNERSHIP OF GM COMPANIES

Biotechnology has been one of the fastest-growing sectors of the world economy in recent years, especially in the United States. In 2001, 101 private biotech companies out of 1,800 companies (agro and non-agro) went public on stock exchanges, raising a total capital of over US$20 billion.

There is a very unusual situation with agricultural biotechnology, in that a few firms dominate the global market. In terms of technology ownership, 71% of all agro-biotechnology patents are owned by the top five companies, namely Pharmacia (21%, 287 patents), Dupont (20%, 279 patents), Syngenta (13%, 173 patents), Dow (11%, 157 patents), and Aventis (6%, 77 patents). This concentration of biotechnology research and development activities in a limited number of companies has raised a series of ethical questions.

There is widespread concern about the role of patents, and intellectual property rights in general, with regard to GM crops. In addition, the growing power of a few large companies in the seed and agrochemical industries, and the increasing prevalence of downstream vertically coordinated arrangements, are also a cause of concern among both farmers and consumer groups.

What is even more remarkable is that GM seed produced by only one company, Monsanto, accounted for around 90% of the area planted in herbicide-tolerant and Bt crops. It should be remembered that these two genetically engineered traits accounted for virtually all of the 52.6 million ha of commercial production of GM crops in 2001. Such a strong dominance of biotechnology by a single company is rarely seen in other industries.

This new type of agro-biotechnology industry is very different from traditional agriculture. The major difference lies in the structure of the sector. In traditional agriculture, farmers rely more on their own efforts to get seeds which they can sow. With GM crops, however, farmers must rely on purchased seeds every year for their production. This may be a very important feature of future agriculture. Farmers may have to face this change in farming practice all over the world, including in developing countries.

BUILDING A WORLD CONSENSUS ABOUT GM CROPS

The rapid expansion of GM crops all over the world has raised public concern. Producers tend to be optimistic about the potential benefits, and advocate the rapid development and mass production of such crops. Others, however, particularly those who consume the GM products, are concerned about the long-term uncertainty with respect to food safety and the environment.

Significant progress has been achieved in bridging the gaps among different opinions, with two specific major events. These are the conclusion of the Cartagena Protocol on Biosafety in 2000, and the recent World Food Summit held in Rome in June 2002.

The Cartagena Protocol on Biosafety

This Protocol represents the first major consensus building. All issues of biotechnology are no longer seen as philosophical or ideological, but deemed to be technical in nature. The main theme is how to ensure that the country-to-country movement of genetically modified organisms resulting from modern biotechnology are safe to mankind and the environment. This in itself is a great accomplishment, to be able to transform conflicting arguments into workable topics.

The key feature of the Cartagena Protocol on Biosafety is the prior notification and consent before GM crops are introduced into the environment. This will require exporters to notify the importing country about any first shipment of such crops. The importing country can then decide whether or not to accept such imports, using a science-based assessment of the environmental risk of such shipments. GM crops such as soybean, corn and canola are all covered by the Protocol, although processed foods such as vegetable oil are not. Full implementation of this Protocol will have a significant impact on trade in GM crops.

The 2002 World Food Summit

The 2002 World Food Summit was particularly concerned with the application of biotechnology in the development of agriculture, particularly in securing food security in a safe manner. It was also concerned with the use of biotechnology in the developing countries. These are very likely be the major users and beneficiaries of biotechnology in the future. Paragraph 25 of the Declaration from the Summit reads:

> "We call on the FAO, in conjunction with the CGIAR and other international research institutes, to advance agricultural research and research into new technologies, including biotechnology. The introduction of tried and tested new technologies, including biotechnology, should be accomplished in a safe manner and adapted to local conditions to help improve agricultural productivity in developing countries. We are committed

to study, share and facilitate the responsible use of biotechnology in addressing development needs."

Against this background, there are several issues surrounding the biosafety of biotechnology. The core issue is risk and uncertainty with regard to biosafety. An important international conference was held in Thailand in July 2001, entitled *"New Biotechnology Food and Crops: Science, Safety and Society"*. It was jointly organized by OECD, FAO, WHO, UNEP, CBD, and the governments of the United Kingdom and Thailand. A broad range of issues were discussed, including anticipating unintended effects, how to assess the risks and benefits, validation of information, public sector support for research, and a coordinated multilateral process. With continuous dialogues like this on a regional and international scale, the public sector will play an increasingly important role in biosafety risk management.

GM CROPS AND THE ENVIRONMENT

The environmental safety concerns derived from GM products are difficult to address, since the effects are not easily observed in the short term. Those who oppose this kind of biotechnology argue that GM species may crossbreed, cross-fertilize or pollinate with non-GM species. These hybrids may become the dominant species, thus changing the ecosystem. There are also concerns over the possibility of detrimental effects on other species, such as damage to butterflies from Bt crops, and soil flora and fauna. It is also fear that Bt crops may induce resistance in target pests.

To summarize: GM crops are a fact in modern agriculture, and are probably here to stay. Whether they are accepted or not is a matter of public reception and opinions, which politicians must take into account. Finally, while there are critics of GM crops, there are also supporters and perceived advantages.

Advantages and disadvantages of GM crops

There are a number of actual or potential benefits from GM crops. These include:

- Enhanced crop yield and productivity;
- More nutritious and higher quality products;
- Less need for pesticides and herbicides;
- Greater efficiency in resource management; *and*,
- Role as a bioreactor to produce raw materials for pharmaceuticals and other industries.

For critics, there are four main objections

- Consumers do not have sufficient information about GMOs;
- There may be potential detrimental effects from eating GM foods, while there have not yet been objective studies to identify such effects, if they exist.
- There may be unexpected environmental problems.
- GM crops may violate certain religious beliefs and traditions.

Given this degree of uncertainty, we may naturally be astonished by the rapid introduction of GM products into the market. It is interesting to see where GM products are being consumed, how many GM products are there in proportion to non-GM ones, and the international trade in GM products.

TRADE IN GM CROPS

Three leading GM commodities are discussed as examples: soybean, corn and cotton. A study we carried out for the year 2001 found that global production of non-GM soybeans in 2001 was about 92 million mt, compared to 83 million mt of GM soybeans. The trade in GM soybeans is estimated at 26 million mt, or 47.5% of the global soybean trade. For corn, the global production was 586 million mt in 2001. We estimated that out of the 75.4 million mt of corn traded globally, GM corn accounted for approximately 15 million mt, or 20% of the global corn trade.

The global trade volume of cotton for 2000/2001 was 26.4 million bales. The estimated yield differences between GM and non-GM cotton vary greatly. In order to cover all possibilities, we designed two scenarios in estimating the global trading of GM cotton: a 20% unit yield difference and 0% yield difference.

The 0% difference case estimated that around 12 million bales, or 26 million mt of

GM cotton, were traded globally in 2000/2001 seasons. For the 20% yield difference case, about 14 million bales or 31 million mt is the estimated global GM cotton trade.

INTERNATIONAL ORGANIZATIONS AND GM CROPS

A number of international organizations are involved in developing regulations and other aspects of GM crops.

One example is FAO. Apart from the international legal framework under WTO, the joint FAO/WHO standard, the *Codex Alimentarius*, is very influential in the process of standard development at a national level. FAO's *Codex Alimentarius* Commission is responsible for developing international food standards, codes of practice, guidelines and recommendations.

For biotechnology, a *Codex ad boc* Task Force on Food Derived from Biotechnology was established in 1999. The mandate of the Task Force is to develop guidelines for risk assessment of foods derived from biotechnology, and to prepare analytical tools for the detection and identification of food or food ingredients derived from biotechnology. The Task Force is expected to complete its work in 2003.

ACCESS TO GM TECHNOLOGY

As we all know, access to key technologies is essential to the successful applications of agro-biotechnology, particularly in the developing world. However, many of these key technologies are in the hands of the private sector, and dominated by a few companies. Also, dissemination of these technologies, from the relatively few places where they are being developed to the massive area of the developing world, is a real issue.

What effect will GM crops have on the problems of poor farmers and consumers in developing countries? For example, in fields cultivated with herbicide-resistant GM soybeans, post-emergent herbicides can be used. The greatest benefit of these crops, however, is the increase of yield that comes from the retention of soil moisture because of the reduced amount of soil disturbance. The use of transgenic modification could have substantial benefits for developing countries, providing they have access to GM technology and GM seeds at an affordable cost.

Biotechnology in the developing world

There are a number of issues to consider when it comes to biotechnology in the developing world. First of all, how can all developing countries afford the cost of biotechnology? Secondly, how can we work out proper arrangements for intellectual property rights (IPR) held by private companies so they can be transferred to public use? Thirdly, are the crop genetic improvements that are currently available suitable for developing countries? And finally, who will assist developing countries, and what type of assistance is appropriate and sufficient?

As yet we have no answers to these questions. However, even if we seek answers as actively as possible, it will take years for developing countries to catch up with developments in modern biotechnology. And if we do not seek to resolve these issues, developing countries may never catch up at all.

INTELLECTUAL PROPERTY RIGHTS AND GM CROPS

One of the most intriguing and important issues surrounding GM crops is perhaps the question of intellectual property rights (IPR), in relation to trade and technology transfer. I believe appropriate use of IPR is most important in the development of agro-biotechnology for the developing world. Today, key technologies of this most visible and controversial field of agricultural research are concentrated in the hands of a few large multinational corporations in North American and Western Europe.

The IPR that are associated with the surge of private research in biotechnology may, if not properly managed, block access to new developments by the public sector and non-profit research. This is particularly true for developing countries. Several world agreements of the World Trade Organization (WTO) are specifically relevant to considerations of issues surrounding GMOs. In this Bulletin, I shall discuss one of the most important, Trade-Related Intellectual Property Rights (TRIPS).

Intellectual property rights have been a subject of intense discussion at the General Agreement on Tariffs and Trade (GATT) negotiation before WTO. Within the WTO framework, IPR are included in discussions of TRIPS, with the goal of harmonizing and enlarging patent protection on a global scale.

TRIPS are essentially a set of minimum standards for government laws and regulations of all WTO members. Under TRIPS, members of WTO grant patents to inventions, and these patents become part of global trade. The rationale of TRIPS is to facilitate liberalization in the trade of goods and services, but there are certain exceptions.

In relation to biotechnology for agriculture, TRIPS allow patents to be granted for plant varieties, but not plants. Although WTO requires all members to comply with their commitments to TRIPS by 2005, in practice there seem to be difficulties in keeping to this timetable. The question of whether the status of plants or crops can be patented remains unclear and controversial.

TRIPS serves the legitimate purpose of protecting intellectual property rights, but agriculture involves a much wider spectrum of issues. As we observe the rapid expansion of GM crop production, it seems unavoidable that GM crops will dominate many markets in the future. Without a proper mechanism, key technology for the production of these GM crops may lie in the hands of a few private institutions. Access to the needed key technology may in the future require intervention from the public sector.

To realize the benefits of agricultural biotechnology, developing countries must address, not only IPR, but two other issues: biosafety regulations and capacity building for research and development (R&D). These three issues must be properly managed, no matter whether a country is importing biotechnology or developing its own research and initiatives.

Of these three issues, IPR represents the legal framework, to insure that the use of biotechnology is properly governed. A set of comprehensive biosafety regulations is being worked out by FAO, which will effectively protect the public, and therefore signifies sound consideration of social and ethical aspects during the decision-making process. Finally, R&D capacity is really the key if a country and its consumers are to make informed choices about the adoption and development of biotechnology. Regardless of whether national technology policies are oriented toward importation or internal generation, developing countries need the scientific ability to absorb the new technologies and adapt them to meet local conditions.

TAIWAN'S EXPERIENCE IN THE DEVELOPMENT OF BIOTECHNOLOGY

The government has made it a priority to maximize the application of biotechnology at a farm level. Public awareness, food safety and intellectual property rights are equally respected. Information about basic research into biotechnology is considered to belong to the public domain. The government takes the initiative in research and development related to biotechnology. Research findings with potential for further application are transferred to the private sector and farmers through various extension channels, either through government agencies or Farmers' Associations. So far, research findings on biotechnology developed by the public sector, particularly from the agricultural research institutes, have been applied to agricultural production in many ways. These include tissue culture for the production of healthy seedlings, breeding improvements, biopesticides, biofertilizers and vaccines.

Banana, citrus, horticultural crops, ornamentals, and aquaculture have benefited greatly. Biotechnology has helped orchid production, for example, create a market worth more than US$60 million each year. Biopesticides are another example. The mass production of biological control agents from microorganisms has been developing rapidly as an environmentally friendly and low-cost method of pest management.

CONCLUSION

The application of biotechnology to agriculture creates great challenges as well as opportunities. Agriculture is the foundation of many societies in the Asian and Pacific region. It serves, not only as a provider of food and livelihood, but also as a very important source of social and economic stability, and a dynamic interaction between human beings and the ecosystem.

A public-private partnership, and international and regional cooperation, would be favorable for the adoption process of biotechnology in the region's agriculture. It was good to see that in the year 2000, seven National Academies of Sciences in Brazil, China, India, Mexico, the United Kingdom and the United States, jointly published a report urging action to promote the use of biotechnology for alleviating world hunger and poverty. This is especially important for the Asian and Pacific region, because the region's agriculture is quite different from that of the countries where most biotechnology is being developed.

The majority of farmers in the Asian and Pacific region engage in small-scale farming. Their access to new information and technology is relatively poor. Production is labor-intensive. Given the trend towards globalization and trade liberalization, they need to be able to take advantage of new technical developments, since they are competing with farmers all over the world. Through such regional cooperative efforts, information about applicable biotechnology may be extended and transfered as needed to countries based on small-scale farming. Mechanisms such as technology transfer among National Agricultural Research Systems (NARS) can also create significant linkages with the farming community. Under such a framework, member countries will be able to exchange information on new agro-biotechnology and capacity building. Consumer concerns with food safety and environmental considerations must also be a basic part of the process.

It is essential that the negative impacts, if any, of products created by biotechnology are kept to a minimum, while the greatest benefits should be harnessed and equally shared by all. Biotechnology offers the potential to reduce uncertainty in the world's future food supply, in the face of a growing population and the limited carrying capacity of the Earth.

Population growth and food distribution will most likely remain the two most critical challenges which mankind must face for many years to come. Agriculture must shoulder the task of meeting the food needs of an additional 1.7 billion people over the next 20 years, most of whom will be living in the Asian and Pacific region. Since the area of agricultural land is limited, and much of it has become degraded by continuous intensive use, we must take good care of the agro-ecosystem and practice sustainable use of natural resources to maintain agricultural productivity. Biotechnology may perhaps offer a win-win solution which will benefit all stakeholders.

In conclusion, I should like to quote an FAO document:

> "As scientific progress presents us with ever-more powerful tools and seemingly boundless opportunities, we must exercise caution and ensure thorough ethical consideration of how these should be used. Countries producing genetically modified products must have a clear and responsive regulatory policy and authoritative body to ensure that scientific risk analysis is carried out and that all possible safety measures are taken through testing before the release of biotechnology products, and afterwards through close monitoring. More important, the human rights to adequate food and democratic participation in debate and eventual decisions concerning the new technologies must be respected, as must the right to informed choice".

Jacques Diouf, FAO Director General. Foreword, *Genetically Modified Organisms, Consumers, Food Safety and the Environment.* FAO Ethics Series No. 2, Rome 2001.