Perspectives

Agrobiotechnology in the Americas

Global challenges for food production

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Agrobiotechnology
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Given the growing demand for food and the steadily shrinking amount of available farmland, the world faces an ever-greater need to promote the conservation and management of genetic diversity. Agriculture is now being used as an alternative for the production of bioenergy, and at the same time, the world is facing new challenges of climate change. All these factors call for more efficient types of agriculture if the human race is to grow and develop economically on a sustainable, socially acceptable footing. One area of science and technology that may be able to promote truly advanced agriculture is agrobiotechnology (Cohen 2006 and Tsotsos 2007).

Some countries have recognized the potential of this alternative and adopted agrobiotechnology as a vehicle for knowledge-based economic development, together with an appropriate regulatory framework for biosafety compatible with international standards.

The term "biotechnology" refers to "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use" (Convention on Biological Diversity). More narrowly, it considers all the molecular technologies, such as gene manipulation and transfer, DNA typing and cloning of plants and animals (FAO 2000).

In some industrial processes, the use of biotechnology dates back centuries. It has also been used for studying the environment, medicine and the like. In the specific field of agriculture, agrobiotechnology has been seen as a tool for preserving genetic

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diversity, especially targeting those genetic resources that are endangered. Indeed, agrobiotechnology has provided the means to produce crops that exhibit economically important characteristics such as pest and disease resistance and higher-quality agricultural products. It has led to the development of animal-based pharmaceuticals such as bovine somatotropin (BST) and has even gone so far as to produce cloned animals. In most fields where it has been adopted to make the sector more competitive, major economic and environmental benefits have accrued in both developed and developing countries.

The question is, if agrobiotechnology has proved to be beneficial, why does it arouse so many diverging opinions? Why has it been so slow to develop and be adopted in Latin America and the Caribbean (LAC)? This article will discuss the problem areas where agrobiotechnology may be best equipped to contribute solutions. It will also describe research trends in this field in LAC, the development of genetically modified organisms (GMOs), and specific regulatory frameworks for biosafety that currently take the shape of international agreements and negotiations.

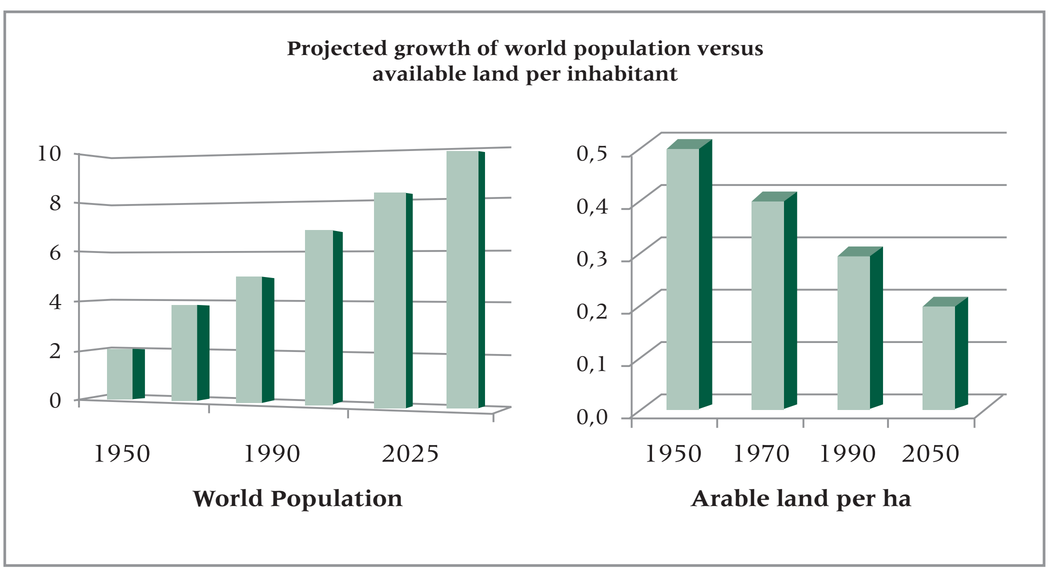
Agrobiotechnology and world challenges

Agriculture will be expected help cushion the impact of many of the problems facing the world over the next 30 to 40 years, including:

- Population growth, expected to reach 9 billion people by 2025, most of them in developing countries (**Chart 1**).
- Loss of farmland, leaving a projected total of less than 0.2 ha per inhabitant (**Chart 1)**.
- The effect of climate change on agriculture.
- The consequences of economic globalization.
- The demand for foods such as cereals will grow by 11% to 15% by 2050 (Cohen 2006, IFPRI 2004).

With the combination of all these projections, the outlook is clearly more complex. It means that the human race will need to develop technologies that yield greater productivity and more products.

Chart 1



Source: *CGIAR/FAO 2003*

Technologies must be both nutritious and safe, easily adapted to climate conditions such as drought or flooding, and amenable to changes in the physical and chemical qualities of soil. At the same time, new technologies will need to be environmentally friendly to ensure conservation and management of existing genetic diversity.

All these conditions and challenges clearly point to some of the biotechnological solutions that have already been accepted by the world scientific community. These include genetic improvement of orphan crops, increased tolerance to abiotic stress and acidic soil conditions, development of vaccine-producing crops, industrial crops grown on marginal lands and the promotion of bio- and phyto-medications.

Table 1 lists various types of abiotic stress that agrobiotechnology may be able to overcome.

Molecular biotechnology also holds potential for improving agricultural production systems, with a direct impact on livestock production systems and bioenergy (Trigo 2007). Similarly, genetic mapping or sequencing of animal genomes has contributed to the development of livestock products of high enough quality to meet consumer demands (Jones and Tewolde 2006; Casas 2005).

Biotechnology research trends and constraints in LAC

The private sector in LAC is investing very little in agrobiotechnology research. Most studies in this field are financed with public resources (Tewolde et al. 2006) to target disease resistance, genetic mapping of certain species, and improvement assisted with the use of molecular markers. Most of these studies are undertaken with the objective of making production systems more efficient, laying special emphasis on certain economically important characteristics.

Table 2 shows the direction of public sector crop research in various countries of LAC, where the main characteristics being studied are resistance to drought, salinity, cold, diseases, fungus, bacteria, lepidoptera and coleoptera (Sampaio 2006).

The countries currently developing research activities in agrobiotechnology are Argentina, Brazil, Colombia, Cuba, Costa Rica, Guatemala, Bolivia, Chile, Peru and Venezuela. They are studying both annual and perennial crops. Nevertheless, none of these countries has biotechnology products currently on the market, with a few exceptions in countries where research is taking place in collaboration with private companies.

Table 1. Types of abiotic stress potentially solved with agrobiotechnology.

	Facts
Drought	5000 Lt water per kg of whole rice. 70% of the word water used in agriculture.
Salinity	380 000 ha affected by high salinity.
Acidity	Affects 40% of all arable land. 380 000 ha are affected in South America alone.
Temperature	70% of total land in de Andes is used for potatoe production despite its vulnerability to cold stress.
Of the 13 billion hectares of land in the word, only around 10% is under cultivation. Added to the lost produced by pests and diseases, data suggest that more than 70% of lost potential yield was caused by abiotic stress.	

Source: *CGIAR/FAO 2003*

This is why the development of research activities in LAC needs to be covered by regulatory systems and intellectual property laws. According to Sampaio (2006), the countries have yet to develop comprehensive regulatory frameworks on biosafety to cover research, production, marketing, labeling and traceability in these countries. Thus, despite efforts underway in the hemisphere to continue making new discoveries and producing new knowledge, the countries still need to develop national policies and establish regulatory frameworks for each of the components of agrobiotechnology research.

Table 2. Targets of agrobiotechnology research in LAC.

Characteristic	*Crop*	*Country*
Drought resistance	Peanuts, soybeans, corn, rice, wheat	Brazil Colombia – CIAT Mexico – CIMMYT
Resistance to salinity	Tobacco	Argentina
Aluminum resistance	Corn, wheat	Brazil Mexico – CIMMYT
Resistance to cold	Potatoes	Bolivia
Disease resistance	Corn, sunflowers, wheat, cacao, banana, apples, grapes, rice, tomato, potatoes, papaya	Argentina Brazil Chile Colombia – CIAT Peru – CIP Venezuela Costa Rica
Fungus	Potatoes, banana, citrus, papaya, rice, sugar cane, tomato, melon, zucchini	Cuba Mexico
Bacteria	Potatoes, tomato, beans, sugar cane, papaya, passion fruit, melon, rice, banana-plantain, coffee, corn, citrus, zucchini	Argentina Brazil Chile Colombia – CIAT Peru – CIP Venezuela Costa Rica Cuba Mexico
Resistance to lepidoptera	Alfalfa, cotton, corn, soybeans, sunflower, sugar cane, cassava-manioc, potatoes, rice, coffee, pineapple, tomato, sweet potato-yams	Argentina Brazil Colombia – CIAT Peru – CIP Guatemala Costa Rica Cuba Mexico
Resistance to coleoptera	Potatoes, cotton	Argentina Brazil

Source: *Sampaio 2006*

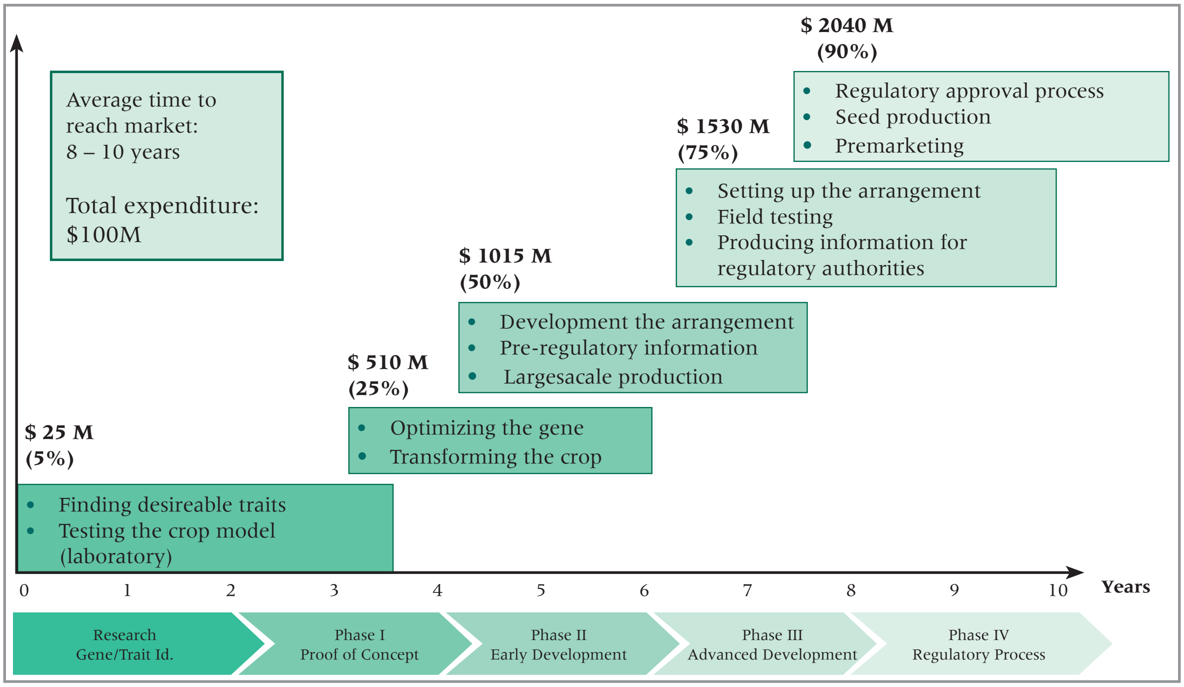


Fig. 1. *Costs and timetable for the stages in developing a GMO.*
Source: *CGIAR/FAO 2003*

Figure 1 outlines the various steps needed in development, technology transfer and marketing of biotechnology products.

Significantly, over 10 years are needed to take a biotechnology product such as a GMO to market, at an approximate cost of over $100 million (Tsotsos 2007). Because the countries have very limited resources available, they need to multiply their efforts at encouraging interested private companies to invest in the production of GMOs.

Agrobiotechnology, GMOs and biosafety regulatory frameworks

Over 10 years have elapsed since agrobiotechnology crops such as corn, soybeans, cotton and canola were developed and adopted for the first time. **Figure 2** shows the growth of GMO production (ISAAA 2006). At present, agrobiotechnology has been adopted in 22 countries where more than 100 million hectares of cropland have been planted to biotechnology products or genetically modified organisms. Of these 22 countries, nearly half (Canada, the United States, Mexico, Honduras, Brazil, Argentina, Uruguay, Paraguay, Chile, Colombia) are located in the Americas. This is why it is so important for the countries of the Americas to take a leading role, not only in technology development, but also in food production and marketing at the world level.

To date, biotechnology crops have brought economic benefit to consumers, producers, the industry and even governments by improving productivity and lessening the use of pesticides and insecticides (Traxler 2006; Trigo 2006). No scientifically proven evidence has yet shown that GMOs are having a negative impact on the environment, public health or genetic diversity (FAO 2004). Even in the centers of origin of certain species, no evidence has been found to substantiate claims of gene flow and its apparent consequences for genetic diversity. Nevertheless, more data will clearly be needed to verify the impact of each GMO that is developed or introduced in a country for direct consumption or processing.

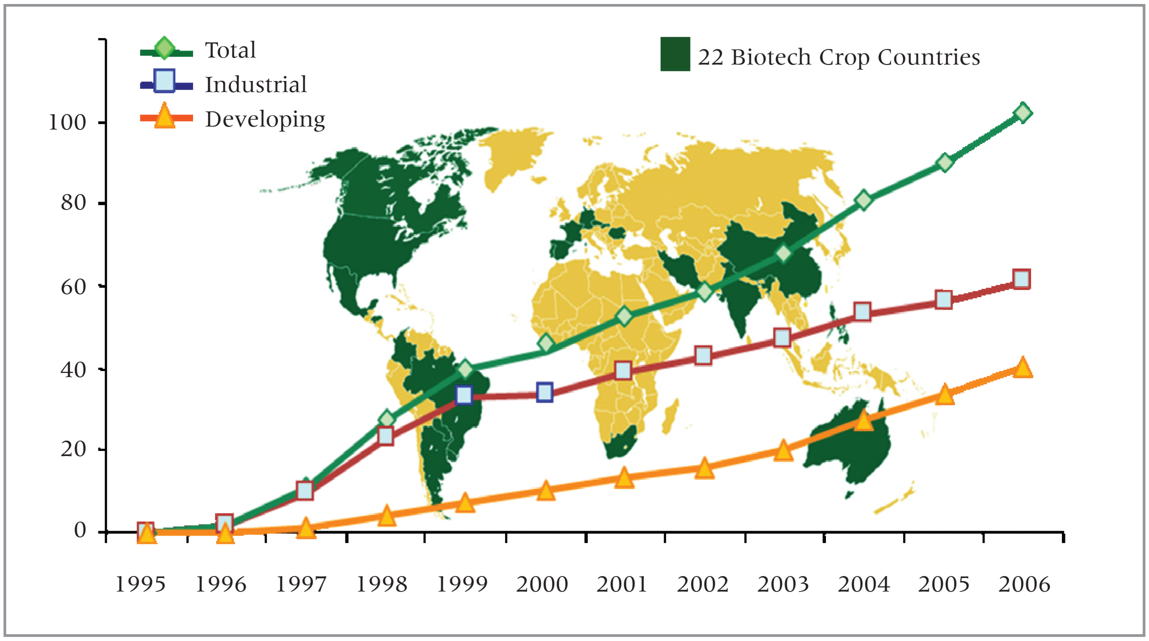


Fig. 2. *Area planted to biotechnology crops worldwide, in millions of hectares, 1996-2006.*

Source: *ISAAA 2006*

There is no question that GMOs have been developed with close attention to regulatory frameworks. Along these lines, the international community has developed agreements such as the Cartagena Protocol on Biosafety to prevent environmental damage, threats to public health, and genetic erosion of species. Nearly all the countries of the Americas, with a few exceptions, are parties to the Protocol, which obliges them to implement standards for the development or cross-border trade of these products.

Conclusions

As the world faces increasing difficulty to feed its people, agrobiotechnology emerges as a potential solution. It can serve as a useful production mechanism only if it is covered by effective regulatory frameworks on biosafety, currently translated into international agreements and negotiations.

Some countries of the Americas are already engaged in research in the field of agrobiotechnology. Studies have focused on certain characteristics of those plant and animal species that hold the greatest economic importance. Nevertheless, products developed by research projects in LAC are still far from winning healthy markets.

Nearly half the countries that have adopted agrobiotechnology are located in the Americas. Most of those that have failed to do so are held back primarily by the cost: it takes more than $100 million and nearly 10 years to develop, transfer, validate and market a GMO. This is why more work is needed for building private partnerships to carry out the development of GMOs, together with a regulatory framework on biosafety consistent with international standards.

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Resumen / Resumo / Résumé

Agrobiotecnología en las Américas: ante los desafíos globales para la producción de alimentos

Uno de los principales desafíos por resolver en el mundo en los siguientes 25-30 años es determinar la forma de satisfacer la demanda creciente de alimentos que se estima será del 11% a 15% de la actual y que deberá satisfacer a cerca de 9 mil millones de habitantes con reducidas tierras agrícolas per cápita. Esto se complica aún más cuando se toma en cuenta la crisis que enfrentan los componentes del medio ambiente, como el recurso hídrico y la tierra, además de los efectos del cambio climático. En el presente artículo se muestra este panorama y la ingerencia que ya ha tenido la agrobiotecnología como alternativa para el desarrollo y la competitividad agropecuaria de los países, junto a un marco regulatorio de bioseguridad de conformidad con los estándares internacionales. También se expone la tendencia de la agrobiotecnología en la región, sus limitantes e interés de los sectores público y privado para invertir en investigación acerca del tema.

Agrobiotecnologia nas Américas: desafios globais para a produção de alimentos

Um dos principais desafios que o mundo precisará enfrentar nos próximos 25-30 anos é saber como responder à demanda cada vez maior de alimentos, cuja previsão é de 11% a 15% da atual, e que deverá atender a cerca de 9 bilhões de habitantes com reduzidas áreas agrícolas per capita. Isso se torna ainda mais complexo quando se considera a urgência de conservar o meio ambiente, incluindo a água e a terra, além dos efeitos que acarretam as mudanças climáticas. Este artigo apresenta o panorama da situação e a ingerência que vem tendo a agrobiotecnologia como alternativa para o desenvolvimento e a competitividade agropecuária dos países, junto com um marco regulatório de biossegurança baseado em padrões internacionais. Também aponta as tendências da agrobiotecnologia na região, seus fatores limitantes e a necessidade de complementar os esforços dos setores público e privado para investir no desenvolvimento, adoção e transferência da agrobiotecnologia.

Agrobiotechnologie dans les Amériques Face aux défis mondiaux de la production alimentaire

L’un des principaux défis qui attendent le monde au cours des 25 à 30 prochaines années consiste à trouver le moyen de satisfaire la demande alimentaire croissante qui, selon les estimations, augmentera de 11 % à 15 % par rapport à la demande actuelle et devra satisfaire quelque 9 milliards d’habitants alors que, parallèlement, la superficie des terres agricoles par habitant ira en diminuant. Le problème devient encore plus complexe lorsqu’on tient compte de l’urgence de conserver l’environnement, notamment les ressources hydriques et la terre, sans oublier les effets du changement climatique. Le présent article brosse un tableau de la situation et montre la place prise par l’agrobiotechnologie en tant que solution de rechange pour le développement et la compétitivité agricole des pays, conjuguée à l’établissement d’un cadre réglementaire de biosécurité conforme aux normes internationales. L’article décrit également la tendance suivie par l’agrobiotechnologie dans la région, ses facteurs limitants et la nécessité de renforcer les efforts d’investissement des secteurs public et privé dans le développement, l’adoption et le transfert de l’agrobiotechnologie.