ISAAA

INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

## ISAAA Briefs

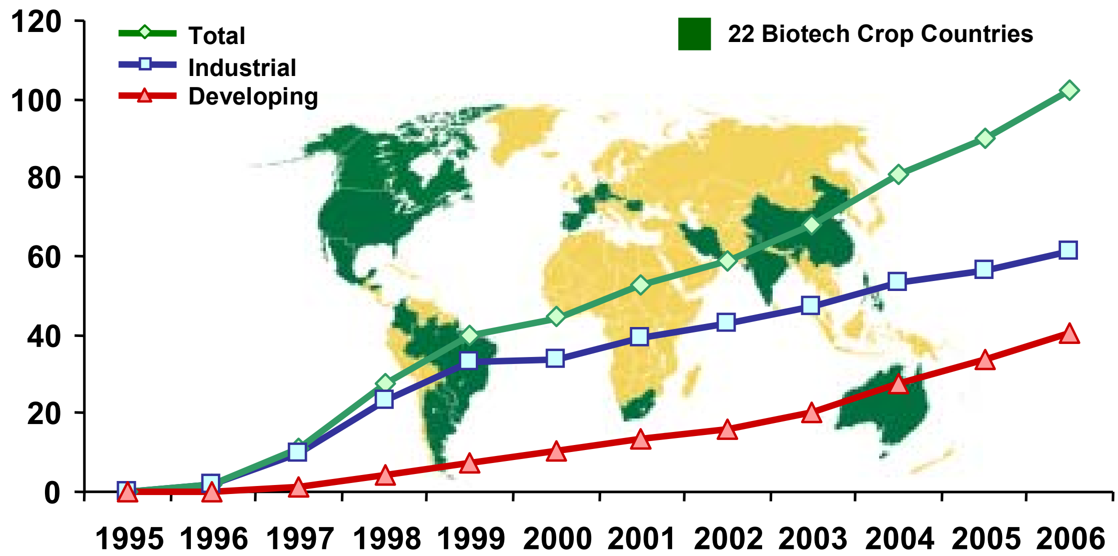
BRIEF 35

# Global Status of Commercialized Biotech/GM Crops: 2006

by


Clive James
Chair, ISAAA Board of Directors


**GLOBAL AREA OF BIOTECH CROPS**
**Million Hectares (1996 to 2006)**




*Increase of 13%, 12 million hectares (30 million acres) between 2005 and 2006.*

Source: Clive James, 2006.


No. 35 - 2006

# BRIEF 35

# Global Status of Commercialized Biotech/GM Crops: 2006

by

**Clive James**
Chair, ISAAA Board of Directors

**No. 35 - 2006**

**Cosponsors:** Ibercaja, Spain
The Rockefeller Foundation, USA
ISAAA

ISAAA gratefully acknowledges grants from Ibercaja and the Rockefeller Foundation to support the preparation of this Brief and its free distribution to developing countries. The objective is to provide information and knowledge to the scientific community and society re biotech/GM crops to facilitate a more informed and transparent discussion re their potential role in contributing to global food, feed, fiber and fuel security, and a more sustainable agriculture. The author, not the cosponsors, takes full responsibility for the views expressed in this publication and for any errors of omission or misinterpretation.

**Published by:** The International Service for the Acquisition of Agri-biotech Applications (ISAAA).



**Citation:** James, Clive. 2006. Global Status of Commercialized Biotech/GM Crops: 2006. *ISAAA Brief* No. 35. ISAAA: Ithaca, NY.

**ISBN:** 1-892456-40-0

**Publication Orders and Price:** Please contact the ISAAA *SEAsia*Center for your copy at publications@isaaa.org. Purchase a copy on-line at http://www.isaaa.org for US$50. For a hard copy of the full version of Brief 35 and Executive Summary, cost is US$50 including express delivery by courier. The publication is available free of charge to eligible nationals of developing countries.

ISAAA *SEAsia*Center
c/o IRRI
DAPO Box 7777
Metro Manila, Philippines

**Info on ISAAA:** For information about ISAAA, please contact the Center nearest you:

ISAAA *Ameri*Center
417 Bradfield Hall
Cornell University
Ithaca NY 14853, U.S.A.

ISAAA *Afri*Center
c/o CIP
PO 25171
Nairobi
Kenya

ISAAA *SEAsia*Center
c/o IRRI
DAPO Box 7777
Metro Manila
Philippines

or email to info@isaaa.org

**Electronically:** For Executive Summaries of all *ISAAA Briefs,* please visit http://www.isaaa.org

## CONTENTS

## LIST OF TABLES AND FIGURES

### *Tables*



### *Figures*

## Global Status of Commercialized Biotech/GM Crops: 2006

- In 2006, the first year of the second decade of commercialization of biotech crops 2006-2015, the global area of biotech crops continued to climb for the tenth consecutive year at a sustained double-digit growth rate of 13%, or 12 million hectares (30 million acres), reaching 102 million hectares (252 million acres). This is a historical landmark in that it is the first time for more than 100 million hectares of biotech crops to be grown in any one year. In order to appropriately account for the use of two or three "stacked traits", that confer multiple benefits in a single biotech variety, the 102 million hectares expressed as "trait hectares" is 117.7 million, which is 15% higher than the estimate of 102 million hectares.

- Biotech crops achieved several milestones in 2006: annual hectarage of biotech crops exceeded 100 million hectares (250 million acres); for the first time, the number of farmers growing biotech crops (10.3 million) exceeded 10 million; the accumulated hectarage from 1996 to 2006 exceeded half a billion hectares at 577 million hectares (1.4 billion acres), with an unprecedented 60-fold increase between 1996 and 2006, making it the fastest adopted crop technology in recent history.

- It is notable that the year-to-year increase of 12 million hectares in 2006 is the second highest in the last five years in absolute area, despite the fact that the adoption rates in the US, the principal grower of biotech crops, are already over 80% for soybean and cotton. It is also noteworthy that in 2006, India, the largest cotton growing country in the world, registered the highest proportional increase with an impressive gain that almost tripled its Bt cotton area to 3.8 million hectares.

- In 2006, the number of countries planting biotech crops increased from 21 to 22 with the EU country Slovakia, planting Bt maize for the first time and bringing the total number of countries planting biotech crops in the EU to six out of 25. Spain continued to be the lead country in Europe planting 60,000 hectares in 2006. Importantly, the collective Bt maize hectarage in the other five countries (France, Czech Republic, Portugal, Germany, and Slovakia) increased over 5-fold from approximately 1,500 hectares in 2005 to approximately 8,500 hectares, albeit on small hectarages, and growth in these five countries is expected to continue in 2007.

- 10.3 million farmers from 22 countries planted biotech crops in 2006, up from 8.5 million farmers in 2005. Of the 10.3 million, 90% or 9.3 million (up significantly from 7.7 million in 2005) were small, resource-poor farmers from developing countries whose increased income from biotech crops contributed to their poverty alleviation. Of the 9.3 million small farmers, most of whom were Bt cotton farmers, 6.8 million were in China, 2.3 million in India, 100,000 in the Philippines, several thousand in South Africa, with the balance in the other seven developing countries which grew biotech crops in 2006. This initial modest contribution of biotech crops to the Millennium Development Goal of reducing poverty by 50% by 2015 is an important development, which has enormous potential in the second decade of commercialization from 2006 to 2015.

- A new biotech crop, herbicide tolerant alfalfa, was commercialized for the first time in the US in 2006. RR® alfalfa has the distinction of being the first perennial biotech crop to be commercialized and was seeded on 80,000 hectares, or 5% of the 1.3 million hectares of alfalfa probably seeded in the US in 2006. RR® Flex herbicide tolerant cotton was launched in 2006 occupying a substantial area of over 800,000 hectares in its first year and was planted as a single trait and as a stacked product with Bt, with the latter occupying the majority of the hectarage. The plantings were principally in the US with a smaller hectarage in Australia. Notably in China, a locally developed virus resistant papaya, a fruit/food crop, was recommended for commercialization in late 2006.

- In 2006, the 22 countries growing biotech crops comprised 11 developing countries and 11 industrial countries; they were, in order of hectarage, USA, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Romania, Mexico, Spain, Colombia, France, Iran, Honduras, Czech Republic, Portugal, Germany, and Slovakia. Notably, the first eight of these countries grew more than 1 million hectares each - this provides a broad and stable foundation for future global growth of biotech crops.

- For the first time, India grew more Bt cotton (3.8 million hectares) than China (3.5 million hectares) and moved up the world ranking by two places to number 5 in the world, overtaking both China and Paraguay.

- It is noteworthy that more than half (55% or 3.6 billion people) of the global population of 6.5 billion live in the 22 countries where biotech crops were grown in 2006 and generated significant and multiple benefits. Also, more than half (52% or 776 million hectares) of the 1.5 billion hectares of cropland in the world is in the 22 countries where approved biotech crops were grown in 2006.

- In 2006, the US, followed by Argentina, Brazil, Canada, India and China continued to be the principal adopters of biotech crops globally, with 54.6 million hectares planted in the US (53% of global biotech area) of which approximately 28% were stacked products containing two or three traits. The stacked products, currently deployed in the US, Canada, Australia, Mexico, South Africa and the Philippines, are an important and growing future trend, which meets the multiple yield constraints of farmers.

- The largest absolute increase in biotech crop area in any country in 2006 was in the US estimated at 4.8 million hectares, followed by India at 2.5 million hectares, Brazil with 2.1 million hectares, with Argentina and South Africa tying at 0.9 million hectares each. The largest proportional or percentage increase was in India at 192% (almost a three-fold increase from 1.3 million hectares in 2005 to 3.8 million hectares in 2006) followed closely by South Africa at 180% with an impressive increase in its biotech white and yellow maize area, and the Philippines at 100% increase, also due to a significant increase in its biotech maize area.

- Biotech soybean continued to be the principal biotech crop in 2006, occupying 58.6 million hectares (57% of global biotech area), followed by maize (25.2 million hectares at 25%), cotton (13.4 million hectares at 13%) and canola (4.8 million hectares at 5% of global biotech crop area).

- From the genesis of commercialization in 1996, to 2006, herbicide tolerance has consistently been the dominant trait followed by insect resistance and stacked genes for the two traits. In 2006, herbicide tolerance, deployed in soybean, maize, canola, cotton and alfalfa occupied 68% or 69.9 million hectares of the global biotech 102 million hectares, with 19.0 million hectares (19%) planted to Bt crops and 13.1 million hectares (13%) to the stacked traits of Bt and herbicide tolerance. The stacked product was the fastest growing trait group between 2005 and 2006 at 30% growth, compared with 17% for insect resistance and 10% for herbicide tolerance.

- During the period 1996 to 2006, the proportion of the global area of biotech crops grown by developing countries has increased consistently every year. Forty percent of the global biotech crop area in 2006, equivalent to 40.9 million hectares, was grown in developing countries where growth between 2005 and 2006 was substantially higher (7.0 million hectares or 21% growth) than industrial countries (5.0 million hectares or 9% growth). The increasing collective impact of the five principal developing countries (India, China, Argentina, Brazil and South Africa) representing all three continents of the South (Asia, Latin America and Africa), is an important continuing trend with implications for the future adoption and acceptance of biotech crops worldwide.

- In the first 11 years, the accumulated global biotech crop area was 577 million hectares or 1.4 billion acres, equivalent to over half of the total land area of the USA or China, or 25 times the total land area of the UK. High adoption rates reflect farmer satisfaction with the products that offer substantial benefits ranging from more convenient and flexible crop management, lower cost of production, higher productivity and/or net returns per hectare, health and social benefits, and a cleaner environment through decreased use of conventional pesticides, which collectively contribute to a more sustainable agriculture. The continuing rapid adoption of biotech crops reflects the substantial and consistent improvements for both large and small farmers, consumers and society in both industrial and developing countries.

- The most recent survey[1] of the global impact of biotech crops for the decade 1996 to 2005, estimates that the global net economic benefits to biotech crop farmers in 2005 was $5.6 billion, and $27 billion ($13 billion for developing countries and $14 billion for industrial countries) for the accumulated benefits during the period 1996 to 2005; these estimates include the benefits associated with the double cropping of biotech soybean in Argentina. The accumulative reduction in pesticides

[1] *GM Crops: The First Ten Years - Global Socio-economic and Environmental Impacts by Graham Brookes and Peter Barfoot, P.G. Economics. 2006.*

for the decade 1996 to 2005 was estimated at 224,300 MT of active ingredient, which is equivalent to a 15% reduction in the associated environmental impact of pesticide use on these crops, as measured by the Environmental Impact Quotient (EIQ) - a composite measure based on the various factors contributing to the net environmental impact of an individual active ingredient.

- The serious and urgent concerns about the environment highlighted in the 2006 Stern Report on Climate Change[2], have implications for biotech crops which can potentially contribute to reduction of greenhouse gases and climate change in three principal ways. First, permanent savings in carbon dioxide emissions through reduced use of fossil-based fuels, associated with fewer insecticide and herbicide sprays; in 2005 this was an estimated saving of 962 million kg of carbon dioxide ($CO_2$), equivalent to reducing the number of cars on the roads by 0.43 million. Secondly, conservation tillage (need for less or no ploughing with herbicide tolerant biotech crops) for biotech food, feed and fiber crops, led to an additional soil carbon sequestration equivalent in 2005 to 8,053 million kg of $CO_2$, or removing 3.6 million cars off the road. Thus, in 2005 the combined permanent and additional savings through sequestration was equivalent to a saving of 9,000 million kg of $CO_2$ or removing 4 million cars from the road. Thirdly, in the future cultivation of a significant additional area of biotech-based energy crops to produce ethanol and biodiesel will, on the one-hand, substitute for fossil fuels and on the other, will recycle and sequester carbon. Recent research indicates that biofuels could result in net savings of 65% in energy resource depletion. Given that energy crops will likely occupy a significant additional crop hectarage in the future, the contribution of biotech-based energy crops to climate change could be significant.

- While 22 countries planted commercialized biotech crops in 2006, an additional 29 countries, totaling 51, have granted regulatory approvals for biotech crops for import for food and feed use and for release into the environment since 1996. A total of 539 approvals has been granted for 107 events for 21 crops. Thus, biotech crops are accepted for import for food and feed use and for release into the environment in 29 countries, including major food importing countries like Japan, which do not plant biotech crops. Of the 51 countries that have granted approvals for biotech crops, the US tops the list followed by Japan, Canada, South Korea, Australia, the Philippines, Mexico, New Zealand, the European Union and China. Maize has the most events approved (35) followed by cotton (19), canola (14), and soybean (7). The event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 21 approvals (EU=25 counted as 1 approval only), followed by insect resistant maize (MON 810) and herbicide tolerant maize (NK603) both with 18 approvals, and insect resistant cotton (MON 531/757/1076) with 16 approvals worldwide.

- The overview of biofuels in this Brief serves to introduce the subject, and is focused on the implications of the growing interest and investments in biofuels in relation to two specific topics: crop

[2] *Stern Review on the Economics of Climate Change, UK 2006 (http://www.sternreview.org.uk).*

biotechnology and developing countries. It is evident that biotechnology offers very significant advantages for increasing efficiency of biofuel production in both industrial and developing countries. It is expected that biotechnology and other improvements will allow industrial countries, like the US, to continue to produce surplus supplies of food, feed and fiber and coincidentally achieve ambitious goals for biofuels in the near-term. Any investment in food crops for biofuels in food insecure developing countries must not compete, but complement the programs in place for food, feed and fiber security. Any program developed in biofuels must be sustainable in terms of agricultural practice and forest management, the environment, and the ecosystem, particularly the responsible and efficient use of water. Most developing countries, with the exception of countries like Brazil which is a world leader in biofuels, would benefit significantly from forging strategic partnerships with public and private sector organizations from both industrial countries and the advanced developing countries, which are knowledgeable and experienced in the production, distribution and consumption of biofuels. Biofuels should not only benefit the national economy of a developing country but also benefit the poorest people in the country, who are mainly in the rural areas, most of whom are small resource-poor subsistence farmers and the landless rural labor who are entirely dependent on agriculture and forestry for their livelihoods.

- The future for biotech crops looks encouraging with the number of countries adopting the four current major biotech crops expected to grow, and their global hectarage and number of farmers planting biotech crops expected to increase as the first generation of biotech crops is more widely adopted and the second generation of new applications for both input and output traits becomes available. The outlook for the next decade of commercialization, 2006 to 2015, points to continued growth in the global hectarage of biotech crops, up to 200 million hectares, with at least 20 million farmers growing biotech crops in up to 40 countries, or more, by 2015. Genes conferring a degree of drought tolerance, expected to become available around 2010-2011, are projected to have substantial impact relative to current input traits and will be particularly important for developing countries which suffer more from drought, the most prevalent and important constraint to increased crop productivity worldwide. The second decade of commercialization, 2006-2015, is likely to feature significantly more growth in Asia compared with the first decade, which was the decade of the Americas, where there will be continued growth in stacked traits in North America and strong growth in Brazil. The mix of crop traits will become richer with quality traits making their long awaited debut with implications for acceptance, particularly in Europe. A 2006 study by the International Food Information Council (IFIC)[3] in the US confirmed that the vast majority are confident in the safety of the US food supply and express little to no concern about food and agricultural biotechnology, and would selectively buy biotech-based products with high omega-3 oil content. Other products including pharmaceutical products, oral vaccines, and specialty products will also feature. By far, the most important potential contribution of biotech crops will be their contribution

[3] *International Food Information Council. 2006. Food Biotechnology: A Study of U.S. Consumer Attitudinal Trends, 2006 Report.*

to the humanitarian Millennium Development Goals (MDG) of reducing poverty and hunger by 50% by 2015. The use of biotechnology to increase efficiency of first generation food/feed crops and second-generation energy crops for biofuels will have high impact and present both opportunities and challenges. Injudicious use of the food/feed crops, sugarcane, cassava and maize for biofuels in food insecure developing countries could jeopardize food security goals if the efficiency of these crops cannot be increased through biotechnology and other means, so that food, feed and fuel goals can all be met. Adherence to good farming practices with biotech crops, such as rotations and resistance management, will remain critical as it has been during the first decade. Continued responsible stewardship must be practiced, particularly by the countries of the South, which will be the major new deployers of biotech crops in the second decade of commercialization of biotech crops, 2006 to 2015.

- In 2006, the global market value of biotech crops, estimated by Cropnosis, was $6.15 billion representing 16% of the $38.5 billion global crop protection market in 2006 and 21% of the ~$30 billion 2006 global commercial seed market. The $6.15 billion biotech crop market comprised of $2.68 billion for biotech soybean (equivalent to 44% of global biotech crop market), $2.39 billion for biotech maize (39%), $0.87 billion for biotech cotton (14%), and $0.21 billion for biotech canola (3%). The market value of the global biotech crop market is based on the sale price of biotech seed plus any technology fees that apply. The accumulated global value for the eleven-year period, since biotech crops were first commercialized in 1996, is estimated at $35.5 billion. The global value of the biotech crop market is projected at over $6.8 billion for 2007.

**Global Status of Commercialized Biotech/GM Crops: 2006**

by

**Clive James**
Chair, ISAAA Board of Directors

## Introduction

2006 marks the first year of the second decade of commercialization, 2006-2015, of biotech crops, also known as genetically modified (GM) or transgenic crops, now more often called **biotech crops** as referred to in this Brief. The experience of the first decade of commercialization, 1996 to 2005, during which a cumulative total of 475 million hectares (approximately 1.175 million acres) of biotech crops were planted globally in 24 countries, has confirmed that the early promise of crop biotechnology has been fulfilled. Biotech crops deliver substantial agronomic, environmental, economic, health and social benefits to farmers and, increasingly, to society at large. The rapid adoption of biotech crops, during the initial decade of commercialization, 1996 to 2005, reflects the substantial multiple benefits realized by both large and small farmers in industrial and developing countries, which have grown biotech crops commercially. Between 1996 and 2005, a total of 24 countries, 12 developing and 12 industrial countries, contributed to over a 50-fold increase in the global area of biotech crops from 1.7 million hectares in 1996 to 90.0 million hectares in 2005. Adoption rates for biotech crops during the period 1996 to 2005 are unprecedented and, by recent agricultural industry standards, they are the highest adoption rates for improved crops; for example, significantly higher than the adoption of hybrid maize in its heyday in the mid-west of the USA. High adoption rates reflect farmer satisfaction with the products that offer substantial benefits ranging from more convenient and flexible crop management, lower cost of production, higher productivity and/or net returns per hectare, health and social benefits, and a cleaner environment through decreased use of conventional pesticides, which collectively contribute to a more sustainable agriculture. There is a growing body of consistent evidence across years, countries, crops and traits generated by public sector institutions that clearly demonstrates the benefits from biotech crops. These benefits include: improved weed and insect pest control with biotech herbicide tolerant and insect resistant Bt crops, that also benefit from lower input and production costs; biotech crops also offer substantial economic advantages to farmers compared with corresponding conventional crops. The severity of weed and insect pests and diseases varies from year-to-year and country to country and hence will directly impact pest control costs and the economic advantages of biotech crops in any given time or place.

Despite the continuing debate on biotech crops, particularly in countries of the European Union (EU), millions of large and small farmers in both industrial and developing countries have continued to increase their plantings of biotech crops by double-digit adoption growth rates every year since 1996, because of the significant multiple benefits that biotech crops offer. This high rate of adoption is a strong vote of confidence in biotech crops, reflecting farmer satisfaction in both industrial and developing countries. About 8.5 million farmers grew biotech crops in 2005 and derived multiple benefits that included significant agronomic, environmental, health, social and economic advantages. ISAAA's 2005 Global Review predicted that the number of farmers planting biotech crops, as well as the global area of biotech crops, would continue to grow in 2006. Global population was 6.5 billion in 2005 and is expected to reach approximately 9.2 billion by 2050, when around 90% of the global population will reside in Asia, Africa and Latin America. Today, 852 million people in the developing countries suffer from hunger and malnutrition and 1.3 billion are afflicted by poverty. Biotech crops represent promising technologies that can make a vital contribution, but not a total solution, to global food, feed and fiber security and can also make a critically important contribution to the alleviation of poverty, the most formidable challenge facing global society which has made a Millennium Development Goal pledge to decrease poverty, hunger and malnutrition by half by 2015, which will also mark the completion of the second decade of commercialization of biotech crops 2006-2015.

The most compelling case for biotechnology, and more specifically biotech crops, is their capability to contribute to:

- **increasing crop productivity**, and thus contributing to global food, feed and fiber security, **with benefits for producers, consumers and society at large**;

- **conserving biodiversity**, as a land-saving technology capable of higher productivity on the current 1.5 billion hectares of arable land, and thereby precluding deforestation and protecting biodiversity in forests and in other *in-situ* biodiversity sanctuaries;

- **more efficient use of external inputs, thereby contributing to a safer environment and more sustainable agriculture systems;**

- **increasing stability of productivity** and production to lessen suffering during famines due to biotic and abiotic stresses particularly drought which is the major constraint to increased productivity on the 1.5 billion hectares of arable land in the world;

- **the improvement of economic, health and social benefits, food, feed, and fiber security and the alleviation of abject poverty, hunger and malnutrition for the rural population dependent on agriculture in developing countries;**

- **the production of renewable resource-based biofuels, which will reduce dependency on fossil fuels, and therefore contribute to a cleaner and safer environment with lower levels of greenhouse gases that will mitigate global warming;**

- **and thus provide significant and important multiple and mutual benefits to producers, consumers and global society.**

The most promising technological option for increasing global food, feed and fiber production is to combine the best of the old and the best of the new by integrating the best of conventional technology (adapted germplasm) and the best of biotechnology applications (novel traits). This integrated product must be incorporated as the technology component in a global food, feed and fiber security strategy that must also address other critical issues including population control and improved food, feed and fiber distribution. Adoption of such a holistic strategy will allow society to continue to benefit from the vital contribution that both conventional and modern plant breeding offers the global population.

The author has published global reviews of biotech crops annually since 1996 as ISAAA Briefs. This publication provides the latest information on the global status of commercialized biotech crops. A detailed global data set on the adoption of commercialized biotech crops is presented for the year 2006 and the changes that have occurred between 2005 and 2006 are highlighted. The global adoption trends during the last 11 years from 1996 to 2006 are also illustrated. Following the resumption of approval of biotech crops in Europe, after the 1998 moratorium, there is cautious optimism that their acceptance in Europe will parallel their increased global acceptance, initially as those imported products already approved for fiber, feed and food use and increasingly as cultivated crops following the leadership of Spain which has now grown and benefited from Bt maize for eight years. In 2005, Spain and Germany were joined by three other EU countries France, Portugal, and the Czech Republic, all growing Bt maize, bringing the total of EU countries growing biotech crops in 2005 up to 5, equivalent to 20% of the total of 25 EU countries. The area of Bt maize in EU countries like France and Portugal was expected to increase in 2006 following farmer satisfaction with the technology in 2005. Notably, Iran commercialized biotech rice in 2005, albeit on a modest area of 4,000 hectares. This was a very important development because rice is the most important food crop in the world and also the most important food crop of the world's 1.3 billion poor people, of which resource-poor farmers are a significant proportion.

This Brief documents the global database on the adoption and distribution of biotech crops in 2006, and there is an introductory section on biofuels which are being assigned priority by many countries and where biotechnology is likely to become an increasingly important element for increasing the efficiency and volume of ethanol and biodiesel. It also contains a comprehensive listing of biotech crop products that have received regulatory approvals for import for food and feed use and for release into the environment, including planting, in specific countries (Appendix 1).

Note that the words, rapeseed, canola, and Argentine canola as well as transgenic, genetically modified crops, GM crops and biotech crops, are used synonymously, reflecting the usage of these words in different regions of the world, with biotech crops being used exclusively in this text because of its growing usage worldwide. Similarly, the words corn, used in North America, and maize, used more commonly elsewhere in the world, are synonymous, with maize being used consistently in this Brief, except for common names like corn rootworm where global usage dictates the use of the word corn. Global figures and hectares planted commercially with biotech crops have been rounded off to the nearest 100,000 hectares and in some cases this leads to insignificant approximations, and there may be minor variances in some figures, totals, and percentage estimates. It is also important to note that countries in the Southern Hemisphere plant their crops in the last quarter of the calendar year. The biotech crop areas reported in this publication are planted, not necessarily harvested, hectarage in the year stated. Thus, for example, the 2006 information for Argentina, Brazil, Australia, South Africa, and Uruguay is hectares usually planted in the last quarter of 2006 and harvested in the first quarter of 2007 with some countries like the Philippines planting more than one season per year.

Over the last 10 years, ISAAA has devoted considerable effort to consolidate all the available data on officially approved biotech crop adoption globally; the database does not include plantings of biotech crops that are not officially approved. The database draws on a large number of sources of approved biotech crops from both the public and private sectors in many countries throughout the world. Data sources vary by country and include, where available, government statistics, independent surveys, and estimates from commodity groups, seed associations and other groups, plus a range of proprietary databases. Published ISAAA estimates are, wherever possible, based on more than one source of information and thus are usually not attributable to one specific source. Multiple sources of information for the same data point greatly facilitate assessment, verification and validation of a specific estimate. The "proprietary" ISAAA database on biotech crops is unique in that it is global in nature, and provides continuity from the genesis of the commercialization of biotech crops in 1996, to the present. The database has gained acceptance internationally as a benchmark for the global status of biotech crops and is widely cited in the scientific literature and the international press.

## Global Area of Biotech Crops in 2006

In 2006, the global area of biotech crops continued to grow for the tenth consecutive year at a sustained double-digit growth rate of 13% reaching 102 million hectares (252 million acres), a historical landmark in that this is the first time for more than 100 million hectares of biotech crops to be planted in any one year. It is also the first time that the accumulated hectarage from 1996 to 2006, 577 million hectares (1.4 billion acres), has exceeded 500 million hectares. Biotech crops have also set a precedent in that the biotech area has grown by double-digit rates every single year for the last 11 years, since commercialization first began in 1996. Also, the number of farmers growing biotech crops in 2006, reached 10 million for the first time at 10.3 million of which 90% or 9.3 million, (up from 7.7 million in 2005), were small resource-poor farmers from developing countries.

**Table 1. Global Area of Biotech Crops, 1996 to 2006**

| | **Hectares** (million) | **Acres** (million) |
|---|---|---|
| 1996 | 1.7 | 4.3 |
| 1997 | 11.0 | 27.5 |
| 1998 | 27.8 | 69.5 |
| 1999 | 39.9 | 98.6 |
| 2000 | 44.2 | 109.2 |
| 2001 | 52.6 | 130.0 |
| 2002 | 58.7 | 145.0 |
| 2003 | 67.7 | 167.2 |
| 2004 | 81.0 | 200.0 |
| 2005 | 90.0 | 222.0 |
| **2006** | **102.0** | **252.0** |
| TOTAL | **576.6** | **1,425.3** |

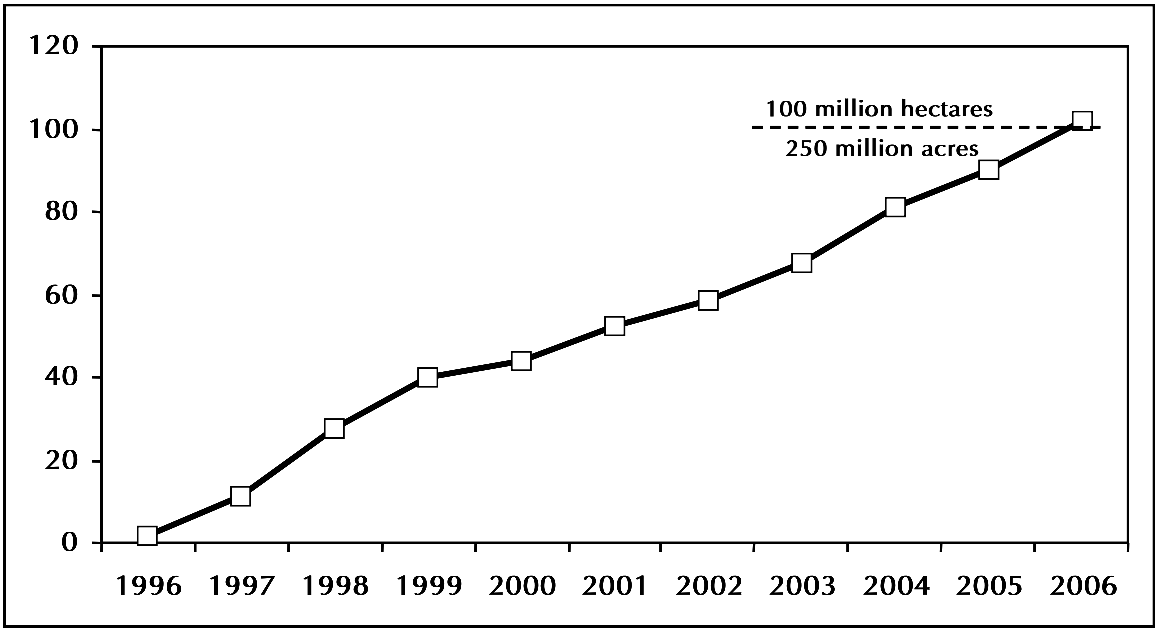
**Increase of 13%, 12 million hectares (30 million acres) between 2005 and 2006.**
**Source: Clive James, 2006.**

Thus, in 2006, 102 million hectares of biotech crops were planted by 10.3 million farmers in 22 countries, compared with 90 million hectares grown by 8.5 million farmers in 21 countries in 2005. It is notable that the year-to-year increase of 12 million hectares in 2006 is the second highest in the last five years in absolute area, and is equivalent to a growth of 13 %. One additional country, Slovakia, has been added to the global list of biotech countries in 2006, bringing the total to 22, compared with 21 in 2005. Thus, the total number of EU countries now growing biotech crops is six and includes Spain, France, Czech Republic, Portugal, Germany and Slovakia.

To put the 2006 global area of biotech crops into context, 102 million hectares of biotech crops is equivalent to more then 10% of the total land area of China (956 million hectares) or the USA (981 million hectares) and more than four times the land area of the United Kingdom (24.4 million hectares). The increase in area between 2005 and 2006 of 13 % is equivalent to 12 million hectares or 30 million acres.

During the first 11 years of commercialization 1996 to 2006, the global area of biotech crops increased sixty-fold, from 1.7 million hectares in 1996 to 102 million hectares in 2006 (Figure 1). This rate of adoption is the highest rate of crop technology adoption for any crop technology and reflects the growing acceptance of biotech crops by farmers in both large and small farmers in industrial and developing countries. In the same period, the number of countries growing biotech crops tripled, increasing from 6 in 1996 to 12 countries in 1999, 17 in 2004, reaching a historical milestone of 21 countries in 2005, and 22 in 2006. This year was also the first time that more than

**Figure 1. Global Area of Biotech Crops, 1996 to 2006 (Million Hectares)**




**Source: Clive James, 2006**

10 million farmers grew biotech crops, and when the area in the six EU countries reached approximately 70,000 hectares with countries like France increasing its area of Bt maize five-fold, from 1,000 to 5,000 hectares between 2005 and 2006. We are likely to see an even bigger change in biotech maize hectarage in France, and some other EU countries in 2007.

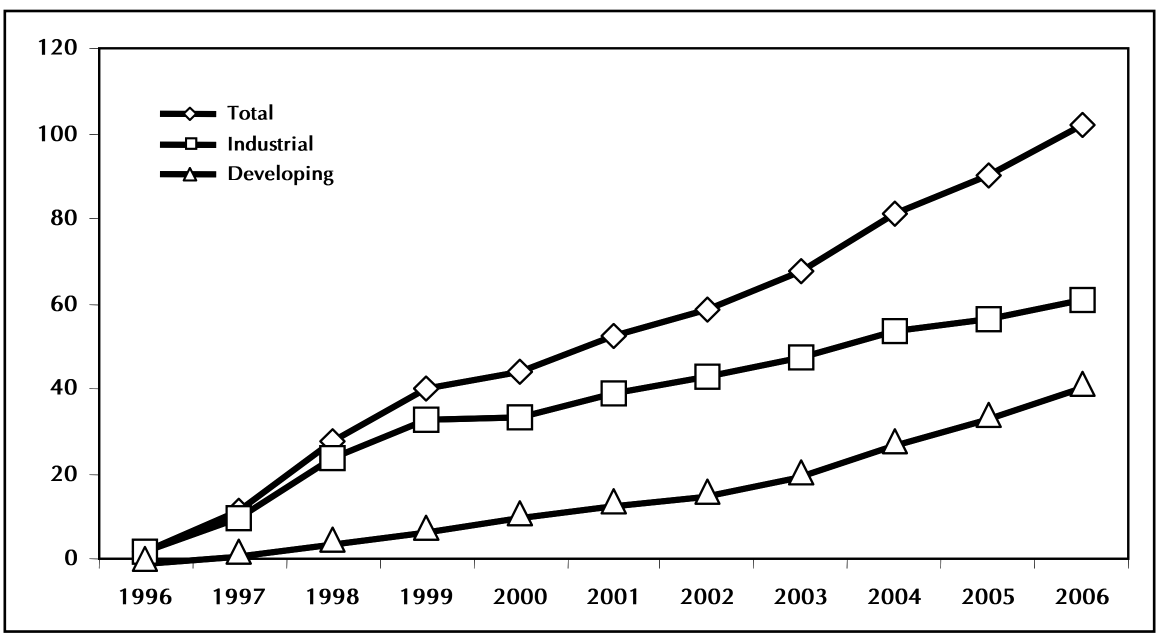
Whereas the US reported the largest absolute increase in biotech crops at 4.8 million hectares, India registered the largest proportional increase with almost a three-fold increase (192% increase) in Bt cotton area from 1.3 million hectares in 2005 to 3.8 million hectares in 2006; as a result India moved from number 7 in the world ranking to number 5, overtaking both China and Paraguay. Notably, large proportional increases in biotech crops were also reported by South Africa (180% increase, equivalent to 0.9 million hectares), the Philippines (100% increase and 0.1 million hectares), Uruguay (33% increase and 0.1 million hectares and Brazil (22% increase, equivalent to a significant 2.1 million hectares in absolute hectarage). In fact, the only two countries to register a decrease were Australia because of the severe drought and Mexico due to import problems which led to a shortage of biotech cotton seed for the first planting season.

In summary, during the period 1996 to 2006, an accumulated total of 577 million hectares or 1.4 billion acres of biotech crops have been successfully grown, accumulatively since 1996, as a result of approximately 45 million repeat decisions by farmers to plant biotech crops (Table 1 and Figure 1). Farmers have signaled their strong vote of confidence in crop biotechnology by consistently increasing their plantings of biotech crops by double-digit growth rates every single year since biotech crops were first commercialized in 1996, with the number of biotech countries increasing from 6 to 22 in the same 11-year period. However, the significant hectarage of 102 million hectares does not fully capture the biotech crop hectarage planted with stacked traits, which are masked when biotech crop hectarage is expressed simply as biotech hectares rather than biotech "trait hectares". Taking into account that 15% of the 102 million hectares planted primarily in the US, but also increasingly in Canada, Australia, Mexico, South Africa and the Philippines had two or three traits, the true global area of biotech crops in 2006 expressed as "trait hectares" was 117.7 million compared with 102 million hectares.

## Distribution of Biotech Crops in Industrial and Developing Countries

Figure 2 shows the relative hectarage of biotech crops in industrial and developing countries during the period 1996 to 2006. It clearly illustrates that whereas the substantial but consistently declining share (60% in 2006 compared with 62% in 2005) of biotech crops continued to be grown in industrial countries in 2006, the proportion of biotech crops grown in developing countries has increased consistently every single year from 14% in 1997, to 16% in 1998, to 18% in 1999, 24% in 2000, 26% in 2001, 27% in 2002, 30% in 2003, 34% in 2004, 38% in 2005 and 40% in 2006. Thus, in

**Figure 2. Global Area of Biotech Crops, 1996 to 2006: Industrial and Developing Countries (Million Hectares)**




Source: Clive James, 2006

**Table 2. Global Area of Biotech Crops, 2005 and 2006: Industrial and Developing Countries (Million Hectares)**

| | 2005 | % | 2006 | % | +/- | % |
|---|---|---|---|---|---|---|
| Industrial countries | 56.1 | 62 | 61.1 | 60 | 5.0 | +9 |
| Developing countries | 33.9 | 38 | 40.9 | 40 | 7.0 | +21 |
| **Total** | **90.0** | **100** | **102.0** | **100** | **12.0** | **+13** |

**Source: Clive James, 2006.**

2006, more than one third (40%), of the global biotech crop area of 102 million hectares, equivalent to 41.0 million hectares, was grown in 11 developing countries where growth continued to be strong, compared with the 11 industrial countries growing biotech crops (Table 2). Developing countries that exhibited exceptionally strong proportional growth, included India and the Philippines in Asia, Uruguay and Brazil, in Latin America, and South Africa on the African continent. It is noteworthy that for the second year in succession, the absolute growth in the biotech crop area between 2005 and 2006 was almost 1.5 times higher in the developing countries (7.0 million hectares) than in industrial countries (5.0 million hectares). Equally important to note is that the percentage growth was almost three times higher (21%) in the developing countries of the South, compared to 9% in the industrial countries of the North.

## Distribution of Biotech Crops, by Country

The eight principal countries that grew biotech crops on 1 million hectares or more in 2006, listed by hectarage, were the USA which grew 54.6 million hectares, (53% of global total), Argentina with 18.0 million hectares (18%), Brazil 11.5 million hectares (11%), Canada 6.1 million hectares (6%), India 3.8 million hectares (4%), China 3.5 million hectares (3%), Paraguay with 2.0 million hectares (2%), and South Africa with 1.4 million hectares (1%). An additional 14 countries grew a total of 1 million hectares in 2006 (Table 3 and Figure 3). It should be noted that of the top eight countries, each growing 1.0 million hectares or more of biotech crops, the majority (6 out of 8) are developing countries, Argentina, Brazil, India, China, Paraguay, and South Africa, compared with only two industrial countries, USA and Canada. The number of biotech mega-countries (countries which grow 50,000 hectares, or more, of biotech crops) numbered 14 in 2006, the same as in 2005. Notably, 10 of the 14 mega-countries are developing countries from Latin America, Asia and Africa. The high proportion of biotech mega-countries in 2006, 14 out of 22, equivalent to two thirds, reflects the significant broadening, deepening and stabilizing in biotech crop adoption that has occurred within the group of more progressive countries adopting more than 50,000 hectares of biotech crops, on all six continents in the last 11 years.

It is noteworthy that, compared with 2006, there was one additional country, which grew biotech crops in 2006. Slovakia grew 30 hectares of Bt maize for the first time bringing the total number of EU countries to six. Slovakia joins Spain, by far the largest grower of Bt maize in the EU, along with France, Czech Republic, Germany and Portugal, which collectively grew approximately 70,000 hectares of biotech maize in 2006.

The five countries with the largest increase in absolute area of biotech crops of 0.5 million hectares or more, between 2005 and 2006 were the US with a 4.8 million hectare increase, India with a 2.5 million hectare increase, Brazil with 2.1 million hectares, Argentina 0.9 million hectares, and South Africa with an increase of over 0.9 million hectares. Modest growth in crop biotech area was reported in Canada, the Philippines, China and Uruguay. In fact, Australia and Mexico were the only countries to report negative growth of biotech crops, due to the continuing severe drought which drastically decreased cotton plantings in Australia, and seed import problems in Mexico.

Based on proportional year-to-year annual growth in biotech crop area, three countries (notably, all mega-biotech developing countries), India, South Africa and the Philippines had exceptionally high rates of growth, resulting in the doubling or more of biotech crop area. India, for the second consecutive year, had the highest year-on-year proportional growth of all countries in 2006, with almost a three-fold increase of 192% in Bt cotton area over 2005. Notably, South Africa increased its 2006 hectarage 2.8 fold, or 180% increase due mainly to more than a doubling of biotech white maize used for food and biotech yellow maize used for animal feed. The Philippines, which is the only country in Asia to grow a biotech feed crop, more than doubled its biotech maize hectarage to 200,000 hectares featuring all three classes of biotech maize, Bt maize, herbicide tolerant maize, and the stacked traits of Bt and herbicide tolerance.

The six principal countries that have gained the most economically from biotech crops, during the first decade of commercialization of biotech crops, 1996 to 2005 are, in descending order of magnitude, the US ($12.9 billion), Argentina ($5.4 billion), China ($5.2 billion), Brazil ($1.4 billion), Canada ($1.0 billion), India ($0.5 billion), Paraguay ($0.1 billion) and others ($0.5 billion) for a total of $27 billion, $13 billion for developing countries and $14 billion for industrial countries.

The 22 countries that grew biotech crops in 2006 are listed in descending order of their biotech crop areas in Table 3. There were 11 developing countries, and 11 industrial countries including Romania and the Czech Republic and Slovakia from Eastern Europe and Iran from the Middle East. In 2006, biotech crops were grown commercially in all six continents of the world - North America, Latin America, Asia, Oceania, Europe (Eastern and Western), and Africa. The top eight countries, each growing 1.0 million hectares, or more, of biotech crops in 2006, are listed in order of crop biotech hectarage in Table 3 and include the USA, Argentina, Brazil, Canada, India, China, Paraguay and South Africa. These top eight biotech countries accounted for approximately 98% of

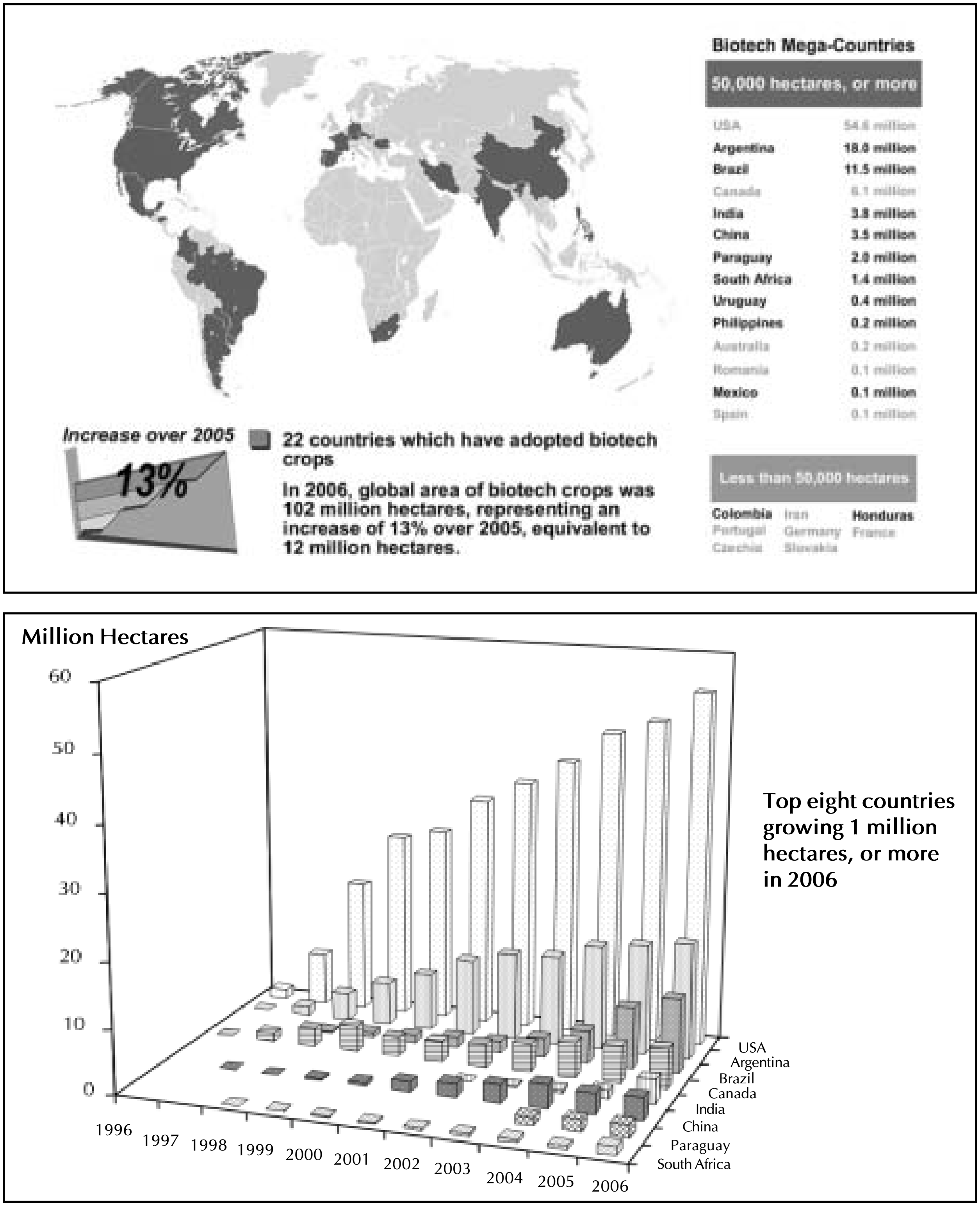
**Table 3. Global Area of Biotech Crops in 2005 and 2006: by Country (Million Hectares)**

| Country | 2005 | % | 2006 | % | +/- | % Increase |
|---|---|---|---|---|---|---|
| 1. USA* | 49.8 | 55 | 54.6 | 53 | +4.8 | +10 |
| 2. Argentina* | 17.1 | 19 | 18.0 | 18 | +0.9 | +5 |
| 3. Brazil* | 9.4 | 10 | 11.5 | 11 | +2.1 | +22 |
| 4. Canada* | 5.8 | 6 | 6.1 | 6 | +0.3 | +5 |
| 5. India* | 1.3 | 1 | 3.8 | 4 | +2.5 | +192 |
| 6. China* | 3.3 | 4 | 3.5 | 3 | +0.2 | +6 |
| 7. Paraguay* | 1.8 | 2 | 2.0 | 2 | +0.2 | +11 |
| 8. South Africa* | 0.5 | 1 | 1.4 | 1 | +0.9 | +180 |
| 9. Uruguay* | 0.3 | <1 | 0.4 | <1 | +0.1 | +33 |
| 10. Philippines* | 0.1 | <1 | 0.2 | <1 | +0.1 | +100 |
| 11. Australia* | 0.3 | <1 | 0.2 | <1 | -0.1 | -33 |
| 12. Romania* | 0.1 | <1 | 0.1 | <1 | <0.1 | - - |
| 13. Mexico* | 0.1 | <1 | 0.1 | <1 | <0.1 | - - |
| 14. Spain* | 0.1 | <1 | 0.1 | <1 | <0.1 | - - |
| 15. Colombia | <0.1 | <1 | <0.1 | <1 | <0.1 | - - |
| 16. France | <0.1 | <1 | <0.1 | <1 | <0.1 | - - |
| 17. Iran | <0.1 | <1 | <0.1 | <1 | - - | - - |
| 18. Honduras | <0.1 | <1 | <0.1 | <1 | <0.1 | - - |
| 19. Czech Republic | <0.1 | <1 | <0.1 | <1 | <0.1 | - - |
| 20. Portugal | <0.1 | <1 | <0.1 | <1 | <0.1 | - - |
| 21. Germany | <0.1 | <1 | <0.1 | <1 | <0.1 | - - |
| 22. Slovakia | -- | -- | <0.1 | <1 | <0.1 | - - |
| **TOTAL** | **90.0** | **100** | **102.0** | **100** | **+12.0** | **+13** |

*** Mega-biotech countries growing 50,000 hectares, or more, of biotech crops.**
**Source: Clive James, 2006.**

the global biotech crop hectarage with the balance of 2% growing in the other 14 countries listed in decreasing order of biotech crop hectarage - Uruguay, Philippines, Australia, Romania, Mexico, Spain, Colombia, France, Iran, Honduras, Czech Republic, Portugal, Germany, and Slovakia. The following paragraphs provide a more detailed analysis of the biotech crop situation in each of the 22 biotech crop countries, with more detail provided for the 14 mega-biotech countries growing 50,000 hectares, or more, of biotech crops.

Figure 3. Global Area (Million Hectares) of Biotech Crops, 1996 to 2006, by Country, and Mega-Countries, and for the Top Eight Countries.



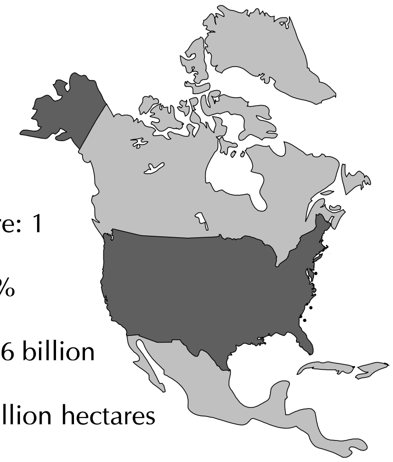

Source: Clive James, 2006

*USA*

The US is one of the six "founder biotech crop countries", having commercialized biotech maize, soybean, cotton and potato in 1996, the first year of global commercialization of biotech crops. The US continued to be the lead biotech country in 2006 with impressive continued growth that was the second highest in absolute area increase in the last five years. The total hectarage planted to biotech soybean, maize, cotton, canola, alfalfa (grown for the first time in 2006), squash, and papaya was 54.6 million hectares, up 4.8 million hectares or 10% from the 49.8 million hectares planted in 2005. This is the largest increase in absolute terms for any country in 2006.

Total plantings of maize in the US in 2006 were 32.2 million hectares (the sixth highest in 20 years), down 3% from the 2005 area of 33.0 million hectares. Planting started slowly in the Great Plains as rain delayed progress until April when it warmed and the hot dry conditions that followed in May and June favored further planting and emergence but with moisture shortages in some areas. Total plantings of soybean at 30.3 million hectares (the second highest on record), were up 3% from the 29.6 million hectares in 2005. Record high soybean yields in 2005 followed by higher input costs in 2006 resulted in some farmers shifting from high input cost crops like maize to lower input cost crops like soybeans. Soybean hectarage in North Dakota and Illinois showed record gains compared with 2005 and there was a significant shift from maize to soybeans in Illinois. Total plantings of upland cotton at 6.0 million hectares in 2006 (the fourth highest in 30 years) were up 7 percent on last year's 5.63 million hectares with growers increasing their hectarage of cotton in Mississippi, New Mexico, Arizona and California. Canola hectarage was down significantly by 12% at 412,000 hectares compared with 469,000 hectares in 2005. The two major canola States were North Dakota with 365,000 hectares and Minnesota with 47,000 hectares. Estimates of alfalfa seedings for 2006 will not be available from USDA until January 2007, but they are not likely to be very different from 2005 seedings. In 2005, total hectarage seeded for alfalfa

**USA**



Population: 296.4 million

GDP: $12,456 billion

% employed in agriculture: 1

Agriculture as % GDP: 1%

Agricultural GDP: $124.56 billion

Arable Land (AL): 178 million hectares

Ratio of AL/Population*: 2.6

Major crops:
- Maize
- Soybean
- Wheat
- Sugarcane
- Sugar beet
- Cotton

Commercialized Biotech Crops:
- HT/Bt/HT-Bt Maize
- HT Soybean
- Bt/HT/Bt-HT Cotton
- HT Canola
- VR Squash
- VR Papaya
- HT Alfalfa

Total area under biotech crops and (% increase in 2006):
54.6 Million Hectares (+10% in 2006)

Farm income gain from biotech, 1996-2005: $12.9 billion

*Ratio: % global arable land / % global population

forage (includes alfalfa harvested as hay and alfalfa haylage and green chop) was 1.3 million hectares which was seeded in both spring and fall. Alfalfa is seeded as a forage crop and grazed or harvested and fed to animals.

In 2006, the US continued to grow more biotech crops (54.6 million hectares) than any other country in the world, equivalent to 53% of global biotech crop hectarage. Compared to 2005, when the gain was 2.2 million hectares, the gain in 2006 was more than double at 4.8 million hectares equivalent to a 10% year-over-year growth. The increase is higher than in the past for several reasons. Firstly, there was a substantial increase in biotech maize, reflecting strong growth in the stacked traits, and herbicide tolerance, with less hectarage of the single gene Bt maize. Secondly, there were significant increases in total plantings of soybean and cotton, and the % adoption of biotech crops for both crops are now at very high levels of adoption of approximately 90% adoption. RR® Flex cotton was also launched in a significant introduction in 2006 and contributed to the overall increase in the US. RR® Flex provides flexibility in weed control and provides a larger window for weed control. Thirdly, biotech alfalfa contributed 80,000 hectares in its first year launch. However, even the significant growth of 4.8 million hectares in 2006 does not fully reflect the increased biotech crop hectarage planted with stacked traits, which are masked when biotech crops hectarage is expressed simply as biotech "hectares" rather than biotech "trait hectares" - the same concept as expressing air travel as "passenger miles" rather than "miles". Thus, of the 54.6 million hectares of biotech crops planted in the US in 2006, 15.3 million hectares, equivalent to 28% had either two stacked traits for two different insect resistant genes (for European corn borer and corn root worm control) or two stacked traits for insect resistance and the other for herbicide tolerance in the same variety, or three stacked traits, two for insect control and one for herbicide tolerance. Accordingly, the adjusted "trait hectares" total for the US in 2006 was 69.9 million hectares compared with 54.6 million "hectares" of biotech crops.

It is noteworthy that the first triple stacked construct in maize, which the US introduced in 2005 on approximately half a million hectares, increased to over 2 million hectares in 2006. Given that the US has proportionally much more stacked traits than any other country, the masking effect leading to apparent lower adoption affects the US more than other countries. In fact, Canada, Australia, Mexico, South Africa and the Philippines are the only five other countries that have deployed stacked traits at this time, albeit at much lower proportions than the US, but this is a trend that will increasingly affect other countries. The total stacked trait hectarage in Canada, Australia, South Africa, Mexico and the Philippines was only approximately 400,000 hectares, thus global "trait hectares" in 2006 was approximately 117.7 million compared with 102 million hectares, a 15% variance.

The biggest increase in US biotech crops was for maize with a gain of almost 15%, compared to 2005 equivalent to approximately 2.5 million hectares. In 2006, the area of biotech soybean increased by 1.5 million hectares which now has the highest adoption rate of any US biotech crops at 92%, the highest ever. The increase in biotech cotton was 675,000 hectares equivalent to a 15% increase and now occupies 88% of upland cotton in the US. Total canola plantings in the US were down by 12% in 2006 compared with 2005 and the area of biotech canola also decreased in line by approximately 30,000 hectares in 2006.

It is noteworthy that a new biotech crop, herbicide tolerant RR®alfalfa, was approved for commercialization in the US in June 2005. The first pre-commercial plantings (20,000 hectares) were actually sown in the fall of 2005, followed by larger commercial plantings (40,000 hectares) in the spring of 2006. Another planting of 20,000 hectares in the fall of 2006 resulted in a total of 80,000 hectares seeded in the 2006 launch of RR®alfalfa in the US. Whereas there is approximately 11 million hectares of the perennial alfalfa crop in the US, only 1.3 million hectares were probably seeded in 2006. Thus, the 60,000 to 80,000 hectares of RR®alfalfa represent approximately 5% of all the alfalfa seeded in 2006. RR®alfalfa enjoys the distinction of being the first ever perennial biotech crop to be approved worldwide, and herbicide tolerance is expected to be the first of several traits to be incorporated into this important forage crop. RR®alfalfa was well received by farmers in the US with all available seed sold in 2006 and demand is expected to grow over time. Benefits include improved and more convenient weed control resulting in significant increases in quantity and quality of forage alfalfa as well as the crop and feed safety advantages that the product offers. Gene flow has been studied and 300 meters provides adequate isolation between conventional and biotech alfalfa and 500 meters for seed crops. RR®alfalfa plants were first produced in 1997 and field trials were initiated in 1999 followed with multiple location trials to determine the best performing varieties. Import approvals have already been secured for RR®alfalfa in major US export markets for alfalfa hay including Mexico, Canada, Japan and the Philippines and are pending in South Korea, and Australia- these countries represent greater than 90% of the US alfalfa hay export market. Japan is the major market for alfalfa hay exports, mainly from California and the west coast states. The US is a major producer of alfalfa hay which occupies approximately 9 million hectares with an average yield of 7.59 metric tons per hectare of dry hay valued at $105 per ton, worth $7 billion per year. In addition, there is approximately 2 million hectares of alfalfa used for haylage/green chop with a yield of approximately 14.19 metric tons per hectare. The crop is sown in both the spring and the fall, with 1 to 4 cuttings per season, depending on location. Over 90% of the alfalfa in the US is used for animal feed with about 7% used as sprouts for human consumption. Monsanto developed the biotech alfalfa in partnership with Forage Genetics International. RR®alfalfa is likely to be more of a niche biotech crop than the other row biotech crops.

In addition to the four major biotech crops, soybean, maize, cotton and canola, and the newly introduced alfalfa, small areas of virus resistant squash and virus resistant papaya continued to be grown in the US in 2006.

The most recent report from the National Center for Food and Agricultural Policy (NCFAP) estimated that increased farmer income was $2.0 billion for 2005[4].

The 2006 Global Impact Study by Brookes and Barfoot estimated that biotech crops enhanced US farm income by $12.9 billion in the first decade of commercialization, 1996 to 2005. Another study by the University of Arizona[5] examined the impact of Bt cotton in the US and China in 2001. The two countries increased total world cotton production by 0.7% and reduced world cotton price by $0.31 per kg. Net global economic effects were $838 million worldwide with consumers benefiting $63 million. Chinese cotton farmers gained $428 million and US farmers gained $179 million whereas cotton farmers in the rest of the world lost $69 million because of the reduced price of cotton.

**ARGENTINA**

Population: 39.1 million

GDP: $183.2 billion

% employed in agriculture: 1

Agriculture as % GDP: 11%

Agricultural GDP: $20.15 billion

Arable Land (AL): 33.2 million hectares

Ratio of AL/Population*: 3.7

Major crops:
- Soybean
- Sugarcane
- Wheat
- Maize
- Sunflower seed

Commercialized Biotech Crops:
- HT Soybean
- Bt/HT Cotton
- Bt/HT Maize

Total area under biotech crops and (% increase in 2006):
18.0 Million Hectares (+5% in 2006)

Farm income gain from biotech, 1996-2005: $5.4 billion

*Ratio: % global arable land / % global population

### *Argentina*

Argentina is also one of the six "founder biotech crop countries", having commercialized RR® soybean and Bt cotton in 1996, the first year of global commercialization of biotech crops. Argentina remained the second largest grower of biotech crops (18.0 million hectares) in 2006 comprising 18% of global crop biotech hectarage. In 2006, the year-over-year increase, compared with 2005, was 0.9 million hectares, equivalent to an annual growth rate of 5%. Of the 18.0 million hectares of biotech crops in Argentina in 2006/07, 15.8 million hectares were planted to biotech soybean,

[4] *Sankula, S. 2006. Quantification of the impacts on US agriculture of biotechnology-derived crops planted in 2005. Available at www.ncfap.org/whatwedo*

[5] *Frisvold, G.B., Reeves, Jeanne M., and Tronstad, R. Bt Cotton Adoption in The United States and China: International Trade and Welfare Effects. Agbioforum 9(2): 69-78. 2006.*

an increase of 0.4 million hectares in biotech soybean area over 2005. Virtually all (98 to 99%) of the soybean crop in Argentina is herbicide tolerant soybeans. Total plantings of maize in Argentina in 2006 increased significantly from 2.5 million hectares in 2005 by 0.6 to a total of 3.1 million hectares, of which 2.8 million hectares were hybrid. The higher hectarage of national maize plantings in 2006 resulted in approximately 250,000 hectares more biotech maize. Of the 2.8 million hectares of hybrid maize, 1.7 million hectares were planted to Bt maize and 150,000 to herbicide tolerant maize. The adoption rate in the 2.8 million hectares of hybrid maize was approximately 62% for Bt and 5% for herbicide tolerant maize. It is notable that Argentina increased its reported area of biotech cotton in 2006 significantly to approximately 360,000 hectares of which over 270,000 hectares was Bt cotton and 90,000 hectares was herbicide tolerant cotton. The increase in biotech cotton is related to various factors including the availability of better adapted biotech varieties, improved returns and more awareness by farmers of the benefits associated with the technology, and improved reporting. Farmer saved seed which is prevalent in Argentina can lead to problems with Bt cotton if the purity drops to a point where larvae can establish on non-Bt cotton plants and start an infestation which can compromise insect resistant management strategies.

Argentina is estimated to have enhanced farm income from biotech crops by $5.4 billion in the first decade of commercialization of biotech crops 1996 to 2005. Biotech crops are also credited with creating 200,000 jobs, which has made a very important contribution to decreasing the high rate of national unemployment. Another analysis[6] by Eduardo Trigo and Eugenio Cap, estimated that the benefits to Argentina from RR® soybean to be $19.7 billion for the decade 1996 to 2005. The study estimates benefits on the basis of production increases which could be identified as resulting from the adoption of the new technologies, including the impact of increased productivity in animal production related to RR® soybean.

### *Brazil*

Following two Presidential decrees in 2003 and 2004 to approve the planting of farmer-saved biotech soybean seed for the 2003/04 and 2004/05 seasons, the Brazilian Congress passed a Biosafety Bill (Law #11,105) in March 2005 that provided for the first time a legal framework to facilitate the approval and adoption of biotech crops in Brazil. The Bill allowed, for the first time, sale of commercial certified RR® soybean seed and also for the first time, the approved use of Bt cotton (event BC 531) in the first registered variety DP9B. However, the latter was not planted as officially approved registered seed in 2005, because of unavailability of seed.

Projecting the adoption rate for RR® soybean in Brazil for 2006/07 continues to be a difficult task and the challenge is unrelated to biotech crops per se. The major uncertainties are due to the significant debt accumulated from losses in soybean production in the 2004/05 and 2005/06 seasons

[6] *Personal Communication, Eduardo Trigo, 2006.*

for soybean, estimated at approximately $2 billion, and as a result the total national plantings of soybean is likely to decrease again in 2006, as it did in 2005. Lack of credit and the strength of the Real against the US dollar exacerbate these uncertainties. The situation in the state of Matto Grosso is pivotal because it is the swing state in terms of soybean production that reacts strongly to both positive and negative financial developments. Whereas there is little doubt that Brazil offers more potential for biotech crops than possibly any other country in the world in the long term, short term constraints related to credit, the price of soybean and the strength of the Real impacted significantly on the adoption level of RR® soybean in 2006/07. RR® soybean is attractive to farmers in Brazil because cost of production is less than for conventional soybeans hence less credit for inputs is required. Also, RR® soybean is less prone to economic losses from Asian Soybean Rust because effective weed control allows more air to enter between the rows, resulting in decreased humidity which in turn delays the development of the disease to epidemic levels that result in severe losses. Soybean Rust is a major economic constraint in important states like Matto Grosso requiring up to 6 applications of fungicide at $25 per application which can make soybean production unprofitable.

**BRAZIL**

Population: 184.2 million

GDP: $795.7 billion

% employed in agriculture: 20

Agriculture as % GDP: 9.9%

Agricultural GDP: $78.77 billion

Arable Land (AL): 59.6 million hectares

Ratio of AL/Population*: 1.4

Major crops:
- Sugarcane
- Soybean
- Maize
- Cassava
- Oranges
- Cotton

Commercialized Biotech Crops:
- HT Soybean
- Bt Cotton

Total area under biotech crops and (% increase in 2006):
11.5 Million Hectares (+22% in 2006)

Farm income gain from biotech, 2003-2005: $1.4 billion

*Ratio: % global arable land / % global population

Many farmers expressed a strong intent to plant much more RR® soybean in 2006/07 than 2005/06. Paul Pinto, a soybean farmer who produces soybean seed in Parana, planted 50% of his hectarage to RR® soybean in 2005/06 but intended to plant his entire crop to RR® soybean in 2006/07 - his farmer friends also planned to double their RR® soybean in 2006/07. It is estimated that there are now more than 100,000 farmers growing soybean in Brazil. After Matto Grosso, the state of Parana is the second biggest state for soybeans in Brazil. In the past, Parana attempted to ban the planting of RR® soybean and its export from its state port of Paranagua. However, in 2006 Parana is expected to plant more than 50% of its 3.9 million hectares of soybean to RR® soybean and the port of Paranagua is now exporting significant tonnages of RR® soybean.

In March 2006 there was a significant event when Brazilian authorities confirmed that China had authorized importation of Brazilian soybeans for the next five years, as opposed to the usual annual authorization. This was an important development and provides Brazil with the assurance of longer term future markets and stable supply for China. Soybean exports now account for 25% of Brazil's total exports to China worth $1.7 billion in 2005 and according to China, Brazilian soybean accounts for 30% of total soybean imports.

In 2006, some hectarage of RR® soybean was planted in virtually all of the states in Brazil with the largest plantings in the states of Rio Grande do Sul, Parana, Matto Grosso, Goias, and Matto Grosso do Sul. Despite the various constraints related to the supply of soybean seed, given farmer options and profitability of alternate crops, total planting of soybean in Brazil in 2006/07 is expected to be approximately 20.6 million hectares, about 1 million hectares less than the 21.6 million hectares planted in 2005. Planting of soybean in Brazil starts in the northern provinces in September and finishes in the southern provinces by mid-to late December. At the time when this Brief went to press in November 2006, approximately two-thirds of the soybean crop had been planted in Brazil.

It is provisionally projected that biotech soybean will occupy approximately 11.4 million hectares of the 20.1 to 20.6 million hectare crop in the 2006/07 season, equivalent to about 55% of the area planted to soybean in 2006/07 - this is over 20% more than the 9.4 million hectares of RR® soybean planted in Brazil in 2005/06. This estimate is in line with the estimates of EMBRAPA, Brazil's national agricultural research organization, which estimates an increase of 2 million hectares of RR® soybean in Brazil in 2006. This is the first year when a significant quantity of certified RR® soybean has been available, including a scheme in the south of the country that allowed farmers to exchange uncertified seed for certified seed. The major constraint that impacted on RR® soybean planting in 2006 were the high agricultural debts and the severe shortage of credit. Other constraints included limited supplies of varieties adapted to areas outside the south and the very high cost of transportation from production areas distal from ports. In the past, the majority of RR® soybean has been grown in the southern state of Rio Grande do Sul and increases in this state are expected to continue in 2006/07. A total of 57 varieties were approved for use in Brazil in 2006. Lack of adapted approved varieties for states outside the south limited adoption to some extent in 2006/07 but approved varieties are now becoming increasingly available.

The approval in 2005 of one biotech cotton event (BCE 531) in the variety DP9B allowed cotton growers in Brazil to legally plant Bt cotton for the first time in the 2006/07 season. This variety underwent field-testing in Brazil prior to the events that delayed registration due to legal considerations. In July 2006, another Bt cotton variety NuOpal was registered, thus two varieties were available in 2006. Input costs on cotton production in Brazil are very high with insecticides comprising up to 40% of total production costs and involving up to 14 sprays per season. Benefits from Bt cotton are estimated at up to $130 per hectare and accordingly Bt cotton is expected to offer significant benefits to Brazil, particularly for the large cotton growing states of Matto Grosso and Bahia. Brazil is expected to grow approximately 1.2 million hectares of cotton in 2006 making it the sixth largest grower of cotton, by area, in the world after India, US, China, Pakistan and Uzbekistan. The adoption of biotech cotton in Brazil in 2006/07 was rapid and is expected to reach high adoption rates in the near term as more adapted varieties of cotton become available and are approved for registration. Cotton is grown by both large and small farmers, and Bt cotton offers the poor small farmers in Brazil significant socio-economic benefits, similar to those experienced in China and increasingly in India. The potential for biotech Bt cotton in Brazil is significant because economic losses from insect pests have resulted in a reduction in cotton area from 4 million hectares to the current 1 million hectares. Thus, there is the potential for reversing the decline in cotton area in Brazil with the adoption of Bt cotton. The area of cotton in Brazil in 2005 was 857,000 hectares and increased to 1.2 million hectares in 2006, of which 120,000 hectares were planted to Bt cotton.

In 2006, Brazil retained its position as the third largest hectarage of biotech crops in the world, provisionally estimated at 11.5 million hectares, of which 11.4 million hectares were planted to RR® soybean and 120,000 hectares planted with Bt cotton, grown officially for the first time in 2006. The year-over-year growth between 2005 (9.4 million hectares) and 2006 (11.5 million hectares) is 22%. Brazil is the second largest producer of soybeans in the world after the USA, the third largest producer of maize, the sixth largest producer of cotton, the tenth largest grower of rice and the only major producer of rice outside Asia (3.7 million hectares). Brazil is also the largest sugarcane producer in the world with 6.2 million hectares and in 2005 used approximately half of the production of 31.3 million tons of sugar for the production of 16 billion liters of the biofuel ethanol. Bloomberg (November 2006) projected that sugarcane hectarage and output will increase 55% in the next six years with ethanol exports climbing from the current 3.1 billion liters to 7 billion liters.

The re-enstatement of CTNBio's authority to approve RR® soybean and Bt cotton in March of 2005, was by far the most important recent development in Brazil. CTNBio's challenge now is to deal with an extensive backlog of applications that has accumulated whilst the long debate over its authority delayed all decisions related to approval of biotech crops. The maize area in Brazil is the third largest in the world at 13 million hectares and applications are pending for both Bt maize and herbicide tolerant maize which have the potential to increase productivity significantly. Long delays in the approval of pending applications could result in Brazil losing out on the benefits of first generation technology and having to delay deployment until the second generation of technologies becomes available. Pending applications for field trials at CTNBio include new varieties of herbicide tolerant soybean, Bt and herbicide tolerant maize, four biotech sugarcanes, virus resistant potatoes from EMBRAPA, and low lignin Eucalyptus.

Brazil is, by far, the largest grower of sugarcane in the world and it is also the world leader in the production of ethanol from sugarcane with ambitious plans to significantly increase production of biofuels in the future. Brazil has approximately 350 sugar mills/distilleries, another 46 under construction and yet another 46 being considered for construction. Brazil produces 13% of the 157.6 million tons of sugar produced globally, and based on value, sugar and ethanol are the third and eighth most important exports, from the country. Brazil has significant investments in sugarcane biotechnology and completed sequencing the crop genome in 2003 which involved more than 200 scientists from 22 institutes in Brazil. This development opens up important new opportunities for improving the biofuel yield of sugarcane through biotech applications. The phasing out of EU subsidies for sugar processors provides Brazil with an opportunity to become the dominant leader in the global sugar market where it already exports sugar worth more than $2 billion per year. The potential of biofuels in the next decades, and the role of biotechnology are discussed elsewhere in this Review.

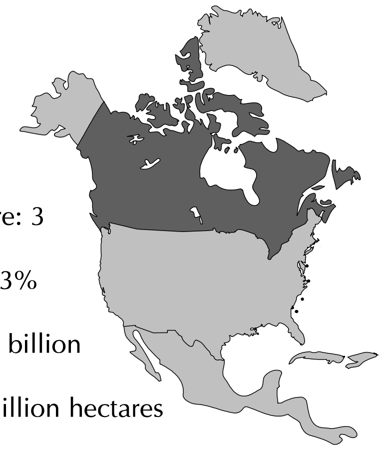
In summary, Brazil is poised to become a world leader in the adoption of biotech crops in the near-term with continued significant growth in RR® soybean hectarage, rapid expansion in Bt cotton supplemented with herbicide tolerance, substantial opportunities on the 13 million hectares of maize and its 3.7 million hectares of rice, as well as the deployment of virus resistant beans and papaya being developed by EMBRAPA, a strong national agricultural research organization, with public sector investments in crop biotechnology.

Brazil is estimated to have enhanced farm income from biotech soybeans by $1.4 billion in the three-year period 2003/04/05 since it first commercialized biotech crops officially in 2003/04. More generally, agribusiness in Brazil is riding the crest of a strong wave of growth financed increasingly by the private sector, rather than the traditional public sector. Brazil is the largest producer of sugarcane and oranges in the world, has the largest commercial cattle herd on the globe, and is the world leader in beef exports. It is the second biggest producer of soybean and ethanol in the world and agricultural exports are likely to reach $34 billion in 2006, comprising a substantial 38% of total exports. Brazil has several factors in its favor that will likely stimulate strong growth in the agricultural sector in the next decade. These include an enormous area of new land with an adequate water supply, strong domestic and export markets for grain and oil seeds for feed and poultry and pork production, large productivity gaps in crops such as maize, cotton and rice with entrepreneur farmers that will quickly adopt innovative technology like biotech to close those gaps. The challenges are the lack of infrastructure in transportation and marketing and the increasing dependency on Asian markets which could suffer in a recession. Adoption of technologies such as biotech crops will allow Brazil to remain competitive in more challenging economic circumstances and provide Brazil with the comparative advantage at the time when it is needed the most.

### *Canada*

Canada is another member of the six "founder biotech crop countries", having commercialized herbicide tolerant canola in 1996, the first year of commercialization of biotech crops. In 2006 Canada retained its number four ranking worldwide in terms of biotech crop area. Growth in biotech crop area continued in Canada in 2006 with a net gain of 300,000 hectares, approximately the same as last year and equivalent to a 5% year-over-year growth, with a total biotech crop area of 6.1 million hectares for the three biotech crops of canola, maize and soybean. The largest biotech crop, by far, is herbicide tolerant canola, most of which is grown in the west where adoption rates are very high. In 2006, the national adoption rate for biotech canola was 84%, up from 82% in 2005 and 77% in 2004, and equivalent to 4.5 million hectares; this compares with a biotech canola area of 4.2 million hectares in 2005. In Ontario and Quebec, the major provinces for maize and soybean hectarage, biotech maize was up by 70,000 to 850,000 hectares and soybean was almost constant at 750,000 hectares.

**CANADA**



Population: 32.3 million

GDP: $1,129.5 billion

% employed in agriculture: 3

Agriculture as % GDP: 2.3%

Agricultural GDP: $25.98 billion

Arable Land (AL): 49.9 million hectares

Ratio of AL/Population*: 6.6

Major crops:
- Wheat
- Barley
- Maize
- Rapeseed
- Potato

Commercialized Biotech Crops:
- HT Canola
- HT/Bt/HT-Bt Maize
- HT Soybean

Total area under biotech crops and (% increase in 2006):
6.1 Million Hectares (+5% in 2006)

Farm income gain from biotech, 1996-2005: $1 billion

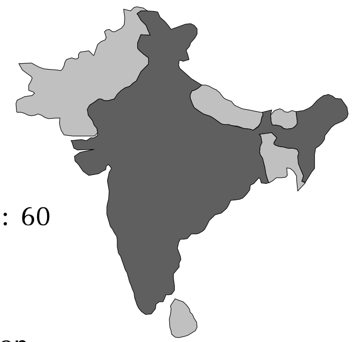
*Ratio: % global arable land / % global population

Canada is one of only three countries (the others are the USA and the Philippines) which grows maize with stacked traits for herbicide tolerance and Bt for insect resistance. The stacked trait maize hectarage in Canada in 2006 was approximately 200,000 hectares compared with over 2 million hectares of stacked maize in the US. The continued growth of biotech crops in Canada in 2006 occurred with slightly lower total plantings of canola (5.3 million hectares), and slightly higher plantings of maize (1.1 million hectares) and soybean (1.2 million hectares).

Canada is a major producer of wheat, and biotech varieties have been field-tested but not approved and adopted. Several of the current principal wheat varieties have been developed through mutagenesis and the development of biotech wheat varieties resistant to *Fusarium* could be an important future development for Canada. Maize with higher levels of lysine is undergoing field tests. The recently approved RR® alfalfa in the US has been approved for import to Canada.

Canada is estimated to have enhanced farm income from biotech crops by $1.0 billion in the first decade of commercialization 1996 to 2005.

**INDIA**



Population: 1.09 billion

GDP: $719.8 billion

% employed in agriculture: 60

Agriculture as % GDP: 22%

Agricultural GDP: $158 billion

Arable Land (AL): 177.5 million hectares

Ratio of AL/Population*: 0.7

Major crops:
- Sugarcane
- Rice, paddy
- Wheat
- Vegetables, fresh
- Potato
- Cotton

Commercialized Biotech Crop: Bt Cotton

Total area under biotech crops and (% increase in 2006):
3.8 Million Hectares (+192% in 2006)

Farm income gain from biotech, 2002-2005: $463 million

*Ratio: % global arable land / % global population

### *India*

India, the largest democracy in the world, is highly dependent on agriculture which generates almost one quarter of its GDP and provides two thirds of its people with their means of survival. India is a nation of small resource-poor farmers, most of whom do not make enough income to cover their meager basic needs and expenditures. The National Sample Survey[7] last conducted in 2003, reported that 60.4% of rural households were engaged in farming indicating that there are 89.4 million farmer households in India. Sixty percent of the farming households own less than 1 hectare of land, and only 5% own more than 4 hectares. Only the 5 million farming households (5% of 90 million) have an income that is greater than their expenditures. The average income of farm households in India (based on 45 Rupees per US Dollar) was $46 per month and the average consumption expenditures was $62. Thus, of the 90 million farmer households in India, approximately 85 million, which represent about 95% of all farmers, are small resource-poor farmers who do not make enough money from the land to make ends meet - in the past, these included the vast majority of the 5 million or more, Indian cotton farmers. India has a larger area of cotton than any country in the world - 9 million hectares cultivated by approximately 5 to 5.5 million farmers. Whereas, India's cotton area represents 25% of the global area of cotton, in the past it produced only 12% of world production because Indian cotton yields were some of the lowest in the world.

[7] *National Sample Survey, Organization's Situation Assessment Survey of Farmers (NSS, 59th Round), India, 2003.*

**Table 4. Adoption of Bt Cotton in India, by Major State, in 2004, 2005, and 2006 (‘000 hectares)**

| State | 2004 | 2005 | 2006 |
|---|---|---|---|
| Maharashtra | 200 | 607 | 1,840 |
| Andhra Pradesh | 75 | 280 | 830 |
| Gujarat | 122 | 150 | 470 |
| Madhya Pradesh | 80 | 146 | 310 |
| Northern Zone* | - - | 60 | 215 |
| Karnataka | 18 | 30 | 85 |
| Tamil Nadu | 5 | 27 | 45 |
| Other | - - | - - | 5 |
| **Total** | **500** | **1,300** | **3,800** |

* Punjab, Haryana, Rajasthan
**Source: ISAAA, 2006.**

Approximately 65% of India’s cotton is produced on dryland and 35% on irrigated lands. Hybrids occupy 70% (6.3 million hectares) of the cotton area and 30% (2.7 million hectares) are varieties. The percentage devoted to hybrids has increased significantly over the last few years, a trend that has been accentuated by the introduction in 2002 of high performance Bt cotton hybrids out-performing conventional hybrids. Cotton is the major cash crop of India and accounts for 75% of the fiber used in the textile industry which has 1,063 spinning mills and accounts for 4% of GDP. Cotton impacts the lives of an estimated 60 million people in India, including farmers who cultivate the crop, and a legion of workers involved in the cotton industry from processing to trading.

India is the only country to grow all four species of cultivated cotton *Gossypium arboreum* and *herbaceum* (Asian cotton), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American Upland cotton). *Gossypium hirsutum* represents 90% of the hybrid cotton production in India and all the current Bt cotton hybrids are *G.hirsutum*.

Bt cotton, which confers resistance to important insect pests of cotton was first adopted in India as hybrids in 2002. India grew approximately 50,000 hectares of officially approved Bt cotton hybrids for the first time in 2002, and doubled its Bt cotton area to approximately 100,000 hectares in 2003. The Bt cotton area increased again four-fold in 2004 to reach half a million hectares. In 2005, the area planted to Bt cotton in India continued to climb reaching 1.3 million hectares, an increase of 160% over 2004.

In 2006, the record increases in adoption continued with almost a tripling of area of Bt cotton to 3.8 million hectares. In 2006, this tripling in area was the highest year-on-year growth for any country in the world. Notably, India's Bt cotton area in 2006 (3.8 million hectares) exceeded for the first time, that of China's (3.5 million hectares), the third largest cotton producer in the world. Of the 6.3 million hectares of hybrid cotton in India in 2006, which represents 70% of all the cotton area in India, 60% or 3.8 million hectares was Bt cotton - a remarkably high proportion in a fairly short period of five years. Of the 3.8 million hectares of hybrid Bt cotton grown in India in 2006, 34% was under irrigation and 66% rainfed. A total of 62 Bt cotton hybrids were approved for planting in 2006 compared with 20 in 2005 and 4 in 2004. The distribution of Bt cotton in the major growing states in 2004, 2005 and 2006 is shown in Table 4. The major states growing Bt cotton in 2006, listed in order of hectarage, are Maharashtra (1.840 million hectares representing almost half, 48% of all Bt cotton in India in 2006) followed by Andhra Pradesh (830,000 hectares or 22%), Gujarat (470,000 hectares or 12%), Madhya Pradesh (310,000 hectares or 8%), and 215,000 hectares (6%) in the Northern Zone and the balance in Karnataka and Tamil Nadu and other states.

It is estimated that approximately 2.3 million small farmers planted on average 1.65 hectares of Bt cotton in 2006. The number of farmers growing Bt cotton hybrids in India has increased from 300,000 small farmers in 2004 to 1 million in 2005, with over a two-fold increase in 2006, to 2.3 million farmers in 2006, who are reaping significant benefits from the technology. Coincidental with the steep increased adoption of Bt cotton between 2002 and 2005, the average yield of cotton in India, which had one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02 to 450 kg per hectare in 2005- 2006, with most of the increase in yield of up to 50%, or more, attributed to Bt cotton. At a national level, this is a major factor in higher cotton production increasing from 15.8 million bales in 2001-02 to 24.4 million bales in 2005-06, which is a record cotton crop for India[8]. The work of Bennett et al.[9] confirmed that the principal gain from Bt cotton in India is the significant yield gains estimated at 45% in 2002, and 63% in 2001, for an average of 54% over the two years. Taking into account the decrease in application of insecticides for bollworm control, which translates into a saving of 2.5 sprays, and the increased cost of Bt cotton seed, Brookes and Barfoot estimate that the net economic benefits for Bt cotton farmers in India were $139 per hectare in 2002, $324 per hectare in 2003, $171 per hectare in 2004, and $260 per hectare in 2005, for a four year average of approximately $225 per hectare. The benefits at the farmer level translated to a national gain of $339 million in 2005 and accumulatively $463 million for the period 2002 to 2005. Other studies report results in the same range, acknowledging that benefits will vary from year to year due to varying levels of bollworm infestations. The most recent study[10] by Gandhi and Namboodiri report a yield

[8] *Minutes of the third meeting of the Cotton Advisory Board (CAB) for the cotton year 2005-06, Office of the Textile Commissioner, Ministry of Textile, Govt of India held on 1 November 2006 at Mumbai, India and the National Cotton Scenario 2005-06, the Cotton Corporation of India (CCI), Govt of India at http://www.cotcorp.com/NATIONAL2.HTML*

[9] *Bennett R, Ismael Y, Kambhampati U, and Morse S (2004) Economic Impact of Genetically Modified Cotton in India, Agbioforum Vol 7, No 3, Article 1.*

[10] *Gandhi V and Namboodiri N.V., "The Adoption and Economics of Bt Cotton in India: Preliminary Results from a Study", IIMA Working Paper No. 2006-09-04, pp 1-27, Sept 2006.*

gain of 31%, a significant reduction in the number of pesticide sprays by 39%, and an 88% increase in profit or an increase of $250 per hectare for the 2004 cotton growing season.

In 2006, the Government of Andhra Pradesh approached the Monopolies and Restrictive Trade Practices Commission (MRTPC) of the Government of India, petitioning for lower prices for cotton seed. The case was contested and is now waiting judgment of the Supreme Court. In the interim, the price for cotton seed for the 2006 season was lower than in 2005 as the market for seed increased significantly in 2006. Given the significant and multiple benefits that farmers derive from Bt cotton in India the adoption of approved Bt cotton hybrids in India is expected to continue to increase significantly in 2007 and it is projected that the adoption rate will plateau at 80% or more, similar to the US which was 87% in 2006. Despite unprecedented high adoption of Bt cotton by millions of farmers, who have first-hand experience of the significant benefits it offers, anti-biotech groups continue to vigorously campaign against biotech in India, using all means to try and discredit the technology, including filing public interest writ petitions in the Supreme Court contesting the biosafety of biotech products.

### *Approval of events[11] and Bt cotton hybrids in India*

The number of events, as well as the number of Bt cotton hybrids and companies marketing approved hybrids increased from one event and 20 hybrids in 2005 by more than three-fold in 2006 to four events and 62 hybrids. This has provided much more choice than previous years to farmers in the North, Central and Southern regions where specific hybrids were approved for cultivation in specific regions (see Figure 4).

In 2006, a total of four events, of which three were new in 2006, were approved for incorporation in a total of 62 hybrids offered for sale in 2006. The first event known as Bollgard I (BG-I), featuring the *cry1Ac* gene was developed by Maharashtra Hybrid Seed Company Ltd. (MAHYCO), sourced from Monsanto, and approved for sale for the sixth consecutive year in a total of 48 hybrids for use in the North, Central and South zones (see Table 5).

The second event, Bollgard II (BG-II with event MON 15985) also developed by MAHYCO and sourced from Monsanto, featured the stacked genes *cry1Ac* and *cry2Ab*, was approved for sale for the first time in a total of seven hybrids for use in the Central and South regions.

The third event, known as Event 1 was developed by JK Seeds featuring the *cry1Ac* gene, sourced from IIT Kharagpur, India and approved for sale for the first time in a total of four hybrids for use in the North, Central and South regions.

[11] *An event refers to the unique DNA recombination event that took place in one plant cell, which was then used to generate entire transgenic plants. Every cell that successfully incorporates the gene of interest represents a unique "event".*

**Table 5. Deployment of Approved Bt Cotton Events/Hybrids by Region in India in 2006**

| Event | North (N) | Central (C) | South (S) | Central/North (C/N) | Central/South (C/S) | N/C/S | Total Hybrids |
|---|---|---|---|---|---|---|---|
| Bollgard[1]-I | 9 | 11 | 10 | 2 | 15 | 1 | 48 |
| Bollgard[2]-II | - | 5 | 2 | - | - | - | 7 |
| Event 1[3] | 1 | 1 | 2 | - | - | - | 4 |
| GFM Event[4] | 1 | 1 | 1 | - | - | - | 3 |
| **Total** | **11** | **18** | **15** | **2** | **15** | **1** | **62** |

[1,2] Mahyco [3] JK Seeds [4] Nath Seeds
**Source: ISAAA**

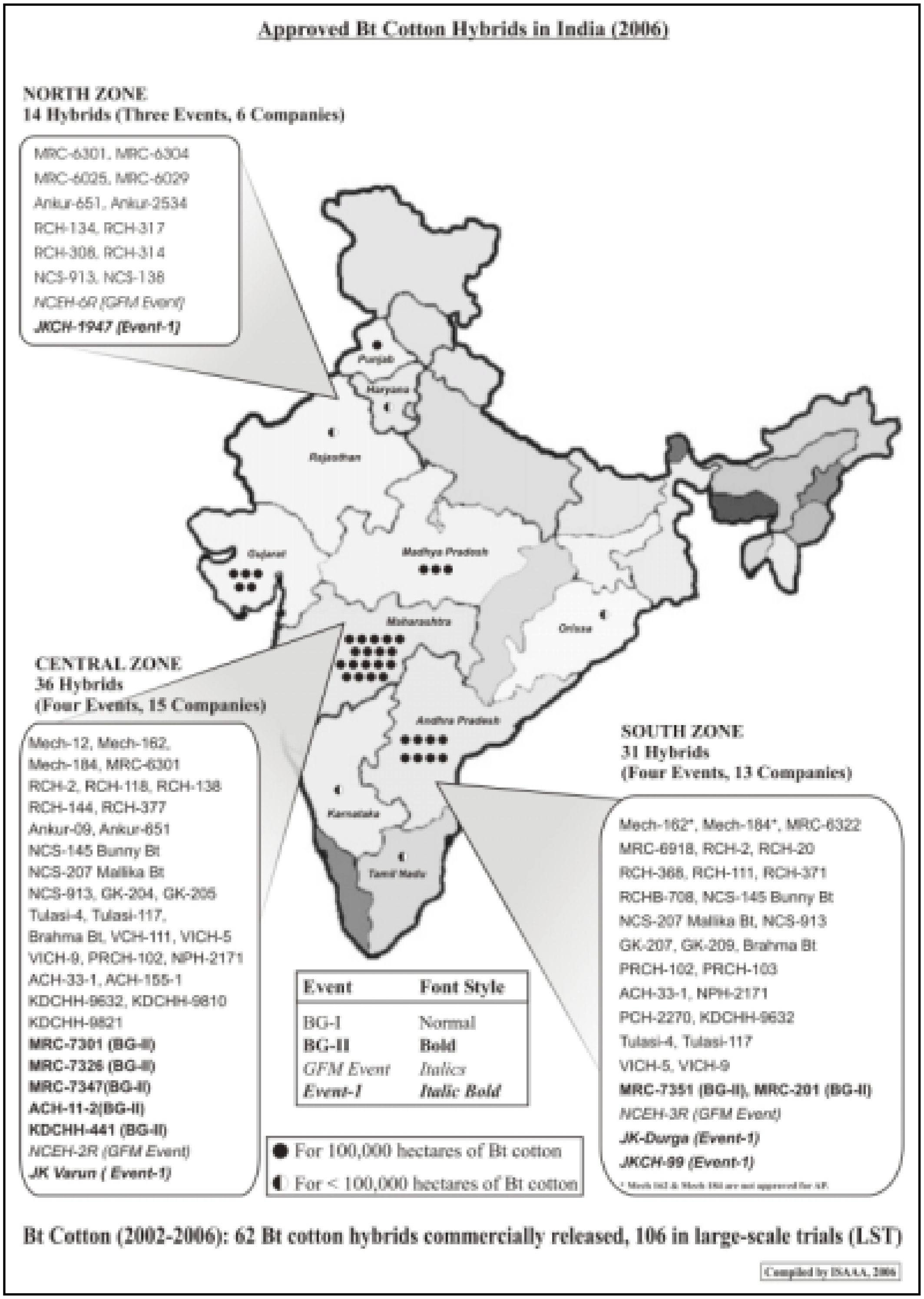
The fourth and last event, the GFM event was developed by Nath Seeds, sourced from China, featured the fused genes *cry1Ab* and *cry1Ac* and approved for sale for the first time in a total of three hybrids, one in each of the three regions of India. The deployment of these four events is summarized in Table 5.

In 2006, the 62 approved hybrids were marketed by the following seed companies from India; MAHYCO (MECH, MRC), Rasi (RCH), Ankur Seeds (Ankur), Nuziveedu Seed (NSC), JK Seeds (JKCH), Nath Seeds (NCEH), Ganga Kaveri Seeds (GK), Tulasi Seeds (Tulsi), Ajeet Seeds (ACH), Emergent Genetics (Brahma), Vikki Agrotech (VCH), Pravardhan Seeds (PRCH), Krishidhan (KDCHH), Prabhat (PCH & NPH) and Vikram Seeds (VICH).

The deployment of the four events in 62 hybrids in 2006 is summarized in Table 6 as well as their corresponding distribution in 2002, 2003, 2004 and 2005. In 2006, the Genetic Engineering Approval Committee (GEAC) approved 42 new varieties of Bt cotton hybrids for commercial cultivation for the 2006 season in addition to the 20 Bt cotton hybrids approved for sale in 2005 for a total of 62 hybrids. This gave farmers in India's three cotton-growing zones significantly more choice of hybrids to cultivate in 2006. Of the 62 Bt cotton hybrids approved for commercial cultivation, 14 hybrids featuring three events were sold by six companies in the Northern zone, 36 hybrids featuring four events were sold by 15 companies in the Central Zone, and 31 hybrids featuring four events were sold by 13 companies in Southern zones.

Similarly, the distribution of the 20 hybrids approved for 2005 is summarized in Table 6 as well as the four hybrids offered for sale in 2004 and the three hybrids approved for both 2003 and 2002. In 2002, MAHYCO was the first to receive approval for three Bt cotton hybrids, i.e. MECH 12, MECH 162 and MECH 184, for commercial cultivation in the Central and Southern cotton growing zones in India. For the convenience of the reader the deployment of the 62 Bt cotton hybrids in 2006 as

Figure 4. Approval of Events and Bt Cotton Hybrids in India, 2006*




* For map in full color, visit http://www.isaaa.org

**Table 6. Deployment of Approved Bt Cotton Events/Hybrids by Companies in India, 2002 to 2006**

| Zone | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| **NORTH ZONE** | | | | 6 Hybrids | 14 Hybrids |
| Haryana | | | | 1 Event | 3 Events |
| Punjab | | | | 3 Companies | 6 Companies |
| Rajasthan | | | | | |
| **CENTRAL ZONE** | 3 Hybrids | 3 Hybrids | 4 Hybrids | 12 Hybrids | 36 Hybrids |
| Gujarat | | | | 1 Event | 4 Events |
| Madhya Pradesh | | | | 4 Companies | 15 Companies |
| Maharashtra | | | | | |
| **SOUTH ZONE** | 3 Hybrids | 3 Hybrids | 4 Hybrids | 9 Hybrids | 31 Hybrids |
| Andhra Pradesh | | | | 1 Event | 4 Events |
| Karnataka | | | | 3 Companies | 13 Companies |
| Tamil Nadu | | | | | |
| **Summary** | | | | | |
| **Total no. of hybrids** | **3** | **3** | **4** | **20** | **62*** |
| **Total no. of events** | **1** | **1** | **1** | **1** | **4** |
| **Total no. of companies** | **1** | **1** | **1** | **3** | **15** |

*** Some of the 62 hybrids are being grown in multiple regions (see Table 5)**
**Source: ISAAA, 2006**

well as their respective events in the three regions is summarized and illustrated in the map in Figure 4.

The approval and adoption of Bt cotton by the two most populous countries in the world, India (1.1 billion people) and China (1.3 billion people), can greatly influence the approval, adoption and acceptance of biotech crops in countries throughout the world, particularly in developing countries. It is noteworthy that both countries elected to pursue a similar strategy by first exploring the potential benefits of crop biotechnology with a fiber crop, Bt cotton, which has already generated significant and consistent benefits in China, with the same pattern emerging in India, the largest grower of cotton in the world. India is estimated to have enhanced farm income from Bt cotton by $463 million in the period 2002 to 2005.

India is a country with first-hand experience of the life-saving benefits of the Green Revolution in wheat and rice. In 2006, India exported rice and imported wheat. Yields in both wheat and rice are now plateauing and the conventional technology currently used in wheat and rice and other crops will need to be supplemented to feed a growing population that will increase by 50% to 1.5 billion people by 2050. Accordingly, the Government of India, through the Department of Biotechnology (DBT) in the Ministry of Science and Technology, established six centers of plant molecular biology in 1990 and subsequently established a new institute, the National Center for Plant Genome Research, to focus on genomics and strengthen plant biotechnology research in the country. The increased public sector investments in crop biotechnology in India are complemented by private sector investments from indigenous Indian seed companies and subsidiaries of multinationals involved in biotech crops.

Crop biotech investments, from both the public and private sectors in India, estimated at $25 million per annum in 2001, are focused on the development of biotech food, feed and fiber crops that can contribute to higher and more stable yields and also enhanced nutrition. Given that rice production in India is vital for food security, much emphasis has been assigned to genomics in rice and the development of improved varieties tolerant to the abiotic stresses of salinity and drought, and the biotic stresses associated with pests. Reduction of postharvest losses, particularly in fruits and vegetables, through delayed ripening genes, is also a major thrust. Reflecting the emphasis on improved crop nutrition, two international collaborative projects involve Golden™ rice, and mustard with enhanced levels of beta-carotene plus an initiative to enhance the nutritional value of potatoes with the ama1 gene. Research in Germany by Stein *et al.*[12] in 2006 predict positive impact of Golden Rice 2 in India. Under an optimistic scenario, the burden of disability adjusted life years (DALYs) would be reduced by a significant 59% and by 9% under a pessimistic scenario.

Several public institutions and private companies in India have projects to develop improved varieties of the drought tolerant and important perennial eggplant, known locally as brinjal; it occupies more than 0.5 million hectares, is the main source of cash, and supplies 25% of calories to many resource-poor farmers. The goal of the projects is to improve resistance to shoot and fruit borer which are very important pests that require intensive insecticide applications, every other day in some cases, costing $40 to $100 per season's worth of insecticides, with environmental and health implications as eggplant is a food crop. These eggplant projects are all geared to deliver biotech products for evaluation and approval by the government in the near-term, representing India's first biotech food product. MAHYCO has developed an eggplant in which the *cry1Ac* gene confers resistance to the fruit and shoot borer. The product has been tested in field trials with good results, and the request to conduct larger scale multiple location field trials is currently being studied by a special committee commissioned by GEAC. ABSPII, the agri-biotechnology program of USAID executed by Cornell University, is supporting MAHYCO's request for approval and working with public institutions in India, Bangladesh and the Philippines to develop the technology in varieties that would complement MAHYCO's activities in hybrids. It is noteworthy that this private-public

[12] *Alexander J. Stein, H.P.S. Sachdev, and Matin Qaim. 2006. Potential Impact and Cost-Effectiveness of Golden Rice. Nature Biotechnology.*

partnership aims to generate affordable seed for resource-poor farmers which will substantially reduce the applications of insecticides required, with positive and significant implications for the environment and the health of farmers. Given that the Bt eggplant will significantly reduce application of insecticides, this in turn will reduce insecticide residues in soil and groundwater. Similarly, reducing insecticides which typically kill both bad and good insects, will contribute to a greater diversity of beneficial insects. Studies on gene flow have not detected any negative effects on wild species of eggplant and this monitoring will continue.

The average small resource-poor farmer cultivating eggplant in India has a farm of 1.67 hectares and cultivates 0.26 hectares of eggplant. The potential benefits that the technology offers resource-poor farmers in India are significant and include the following: a 45% reduction in the number of insecticides, applied usually by hand sometimes every other day, with positive implications for health, the environment and a significant reduction in production costs; a 117% increase in yield with implications for more affordable vegetables; an estimated US$411 million per annum increase in net benefits to Indian eggplant producers and consumers at the national level which could make a contribution to the alleviation of poverty by increasing the income of resource-poor farmers growing eggplant and providing a more affordable source of vegetables for poor consumers. Studies[13] have shown that the commercialization of Bt eggplant has the potential to benefit 700,000 farmers in the three countries of India (510,000 hectares), Bangladesh (64,208 hectares) and the Philippines (20,000 hectares); the collective area of eggplant represents a quarter of the total vegetable area in these three countries and therefore the potential impact of this project is significant. Eggplant is grown all the year round and supplies 25 calories per serving, and its "meaty" texture makes eggplant a perfect staple for vegetarians.

It is evident that Bt eggplant will be a very important new biotech crop for India and will complement the Bt cotton hybrids that are already approved and other Bt cotton varieties being developed by both the public and private sectors in India. Biotech crops in development by the public sector include the following 16 crops: banana, blackgram, brassica, cabbage, cauliflower, chickpea, coffee, cotton, eggplant, muskmelon, mustard/rapeseed, potato, rice (including basmati), tobacco, tomato and wheat. In addition, the private sector in India has the following nine biotech crops under development: brassica, cabbage, cauliflower, cotton, maize, mustard/rapeseed, pigeonpea, rice, and tomato.

In summary, India's increased public and private sector investments and particularly its government support for crop biotechnology is progressive. Prime Minister Manmohan Singh at the opening of the International Rice Congress in New Delhi in October 2006 directly addressed the issues related to any possible health and environmental changes related to biotech rice and stated that "we need

[13] *http://www.absp2.cornell.edu/projects/project.cfm?productid=2*

to strike a balance between using the potential of biotechnology to meet the requirements of hungry people while addressing concerns about interfering with nature". Shri Sharad Pawar, the Indian Minister of Agriculture, at the September 2006 ILSI conference on biotechnology referred to the need to strengthen and streamline the transgenic program and testing of transgenic crops. As part of the efforts to streamline India's regulatory framework for transgenic crops, the Genetic Engineering Approval Committee (GEAC) decided in its 69th meeting held on 30th June 2006 to adopt an "Event Based Approval System" for biotech crops. The new system has been directly applicable to Bt cotton hybrids expressing the *cry1Ac* gene (MON 531 event) as this event has cleared the three-year post release period and GEAC has renewed their approval for commercial release. The new system is also applicable to any other new events after their performance has been monitored post release for a period of three years. This will speed up the introduction of new biotech crops to the country without compromising biosafety and environmental safety. Coincidentally, developments in biotech crops in China and other progressive countries in Asia, such as the Philippines, particularly related to biotech rice and golden rice provide a stimulus and have a significant impact in India, and indeed in all rice-growing countries throughout Asia, and the world.

### *China*

Like the US, Argentina, and Canada, China is a member of the group of six "founder biotech crop countries", having commercialized Bt cotton in 1996, the first year of global commercialization of biotech crops. The national area planted to cotton in China increased from 5.1 million hectares in 2005 to 5.3 million hectares in 2006. This increase of 5% in total plantings resulted in a parallel increase in area of Bt cotton from 3.3 million hectares in 2005 to 3.5 in 2006, with percentage adoption of Bt at 66% the same as in 2005. An estimated 6.8 million small farmers grew Bt cotton in China in 2006, compared with 6.4 million in 2005 (an increase of around 5% over 2005, in line with the 5% increase in total cotton plantings in 2006). The level of Bt cotton adoption in China seems to have plateaued at around 66%. The plateauing may be in part due to the fact

**CHINA**

Population: 1.3 billion

GDP: $2,224.9 billion

% employed in agriculture: 49

Agriculture as % GDP: 15%

Agricultural GDP: $333.7 billion

Arable Land (AL): 143.4 million hectares

Ratio of AL/Population*: 0.5

Major crops:
- Rice, paddy
- Sugarcane
- Sweet potato
- Maize
- Vegetables, fresh
- Cotton

Commercialized Biotech Crop: Bt Cotton

Total area under biotech crops and (%increase in 2006):
3.5 Million Hectares (+6% in 2006)

Increased farm income for 1997-2005: $5.2 billion

*Ratio: % global arable land / % global population

that the large cotton areas in the province of Xing Xang are subject to much less pest pressure than eastern provinces such as Hubei where pest pressure is high and where adoption rates are well above the national average. No further information has become available in 2006 subsequent to the report in September 2005 by Guo Sandui of the Chinese Academy of Agricultural Sciences (CAAS) that new Bt cotton hybrids could yield up to 25% more than the current Bt cotton varieties. If confirmed, this could spur a renewed wave of increased adoption that would significantly exceed current adoption rates of around two-thirds of national cotton hectarage. In 2005, approval was granted to grow one of the new hybrids, Yinmian 2 on about 700 hectares in the Yellow River region, in 2006. However, information is not available at this time about Yinmian 2 plantings in 2006 and its performance and planned expansion in 2007. These new Bt cotton hybrids, like Yinmian 2, could boost farmer income by $1.2 billion per year, making China the second country after India to profit from Bt cotton hybrids which, unlike varieties, offer an incentive for developers of the hybrids which have a built-in value capture system not found in varieties. Use of non-conventional hybrids is already widespread (70% adoption) in the Yangtze River Valley but less prevalent in the Yellow River Valley. These non-conventional Bt hybrids are bred by crossing two varieties, rather than the normal inbred lines, which optimize hybrid vigor. The use of these non-conventional Bt hybrids can pave the way for the new hybrids like Yinmian 2 with higher yield potential. China, with its track record of having already developed successful Bt cotton varieties that compete with products developed by the private sector, has gained a rich experience in crop biotechnology which will serve China well in the development of future biotech crops in the near-term.

In September 2006, it was gleaned that China's National Biosafety Committee had recommended for commercialization a locally developed biotech papaya resistant to papaya ringspot virus (PRSV). This could be a significant development in that papaya is a fruit/food crop which is widely consumed throughout the country.

It is evident that Chinese policymakers view agricultural biotechnology as a strategic element for increasing productivity, improving national food security and ensuring competitiveness in the international market place. There is little doubt that China intends to be one of the world leaders in biotechnology since Chinese policymakers have concluded that there are unacceptable risks of being dependent on imported technologies for food security. China has over a dozen biotech crops being field-tested, including the three major staples - rice, maize, and wheat, as well as cotton, potato, tomato, soybean, cabbage, peanut, melon, papaya, sweet pepper, chili, rapeseed and tobacco.

China is cognizant of the need for biosafety management in order to ensure protection of the environment and consumers, and this is a consideration in the pending approval of Bt rice. Given the paramount importance of rice as the principal food crop in China, approximately 20% of the government's investment in crop biotechnology has been devoted to rice. This is equivalent to a current annual investment of $24 million at official exchange rates, or $115 million per year at a purchasing power parity rate, which undoubtedly makes China's investment in rice biotechnology, by far, the largest in the world. Three insect resistant hybrid rice varieties, two featuring the Bt gene and the other with the CpTi trypsin gene, entered pre-production field trials in 2001, plus a rice variety carrying the Xa 21 gene that confers resistance to the important bacterial blight disease of rice. Annual and extensive large-scale pre-production trials of these new biotech hybrids of rice, starting in 2001, confirmed yield increases of approximately 4 to 8%, plus a saving of 17 kg per hectare in pesticides, with positive health implications, along with a labor saving of 8 days per hectare, resulting in an overall increase in net income per hectare of $80 to $100. It is projected that with full adoption, the new biotech rice hybrids could result in a national benefit to China of $4 billion in 2010; insect borers, which can be controlled by Bt, are prevalent on up to 75% of approximately 30 million hectares of rice in China.

It is estimated that China has enhanced its farm income from biotech cotton by $5.2 billion in the period 1997 to 2005. It is evident that China could enjoy significant and multiple benefits from biotech hybrid rice that has already been extensively tested in environmental and pre-production 2001/03 trials at many locations and has been subjected to regulatory evaluation, including food and biosafety. The approval of biotech rice in China will not only have major implications for China but for the rest of the world, because rice is the major food crop of the world. Iran has already set a precedent in 2005 by growing a modest area of a variety of biotech rice whereas the pending Bt rice from China is a hybrid and not a variety.

With the approval of biotech rice this would leave wheat, as the only one of the three major world staples, - maize, rice and wheat - to be denied the significant advantages offered by biotechnology. The adoption of biotech maize, in Asia will, in due course, greatly facilitate the adoption of biotech wheat, probably with improved resistance to *Fusarium* and thus lower levels of mycotoxin, followed by quality traits and in the longer term, after 2010, improved drought resistance.

The near-term food and feed needs of China, and more broadly Asia, are not limited to rice, but also apply to maize for feed, and also more, and better quality, wheat for food. China's priority-trait needs include disease and insect resistance, herbicide tolerance as well as quality traits. China has its own portfolio of biotech crops with various traits that can be complemented with products developed by the public and private sectors for the global crop biotech market. China can derive significant benefits from biotech cotton and rice projected at $5 billion per year by 2010, and can complement these gains by applying biotechnology to the other staples of maize and wheat, and a dozen other crops. At the opening ceremony of the International High-level Forum on Biotechnology held in Beijing in September 2005, the Minister of Science and Technology Xu Guanhhua commented that "biotechnology could become the fastest growing industry in China in the next 15 years" and that "biotechnology will be put high on the country's mid- and long-term scientific and technological development strategy." He further predicted that eventually the advancement in R &D will lead to a bio-economy boom. China currently has 200 government funded biotech labs and 500 companies active in biotechnology.

In summary, there is little doubt that China aims to further enhance its role as a world leader in crop biotechnology, having already approved biotech cotton, pepper and tomato in the 1990s. The substantial economic, environmental and social benefits from Bt cotton have provided China with its first-hand experience of biotech crops. The rich experience with Bt cotton will serve China well in its consideration of biotech rice, which is expected in the next year or two following the issuance of biosafety certificates and verification of field safety data, some of which have already been generated thus expediting the final approval for commercialization.

One of the interesting aspects to observe is the growing relationship between China and Latin America, particularly Argentina and Brazil, in terms of agricultural trade in which biotech crops like soybean and maize will play an increasingly important role. It is noteworthy that all three countries are already significant players in growing and benefiting from biotech crops. China is now the world's fourth largest economy and is fast trying to regain its former number one position in GDP in the world which it has enjoyed for most of history. Indeed, even in the early 19th century China, the Middle Kingdom, controlled 30% of global GDP compared with 5% today, but China is expected to equal the US GDP in 2040. To fuel China's growth, it will require commodities, including biotech soybean and maize, and Latin America is likely to be an increasingly important source of those supplies as well as other industrial commodities such as copper. With a population twice as large as the whole of Latin America, China views Latin America as an ideal trading partner and vice-versa. Indeed trade between the two partners has already ballooned to $47 billion from only $200 million in 1975, and is expected to reach $100 billion by 2010 with biotech crop commodities playing an increasingly important role - this compares with trade of $180 billion between the two neighbors of US and Latin America. During President Hu's 2004 visit to Latin America he pledged to invest $100 billion in Latin America in the next 10 years. The increasing demands of China for products like soybean and other commodities from Latin America is partly responsible for both Argentina and Brazil being able to retire their respective debts to the International Money Fund (IMF) in 2006. The challenge will be to build a trading arrangement that fully exploits expanding trade opportunities without building a dependency that would result in over-exposure in more constrained economic times. The expanding demand and trade in commodities for the feed/food biotech-based crops of soybean, maize, and sugarcane, for both feed and biofuel/ethanol, could impact significantly on the global usage and trade in biotech crops. Given the high profile and increasing influence of the three countries involved, China, Brazil and Argentina, which collectively represent 25% of the world population, this could also have a significant impact on the general acceptance of biotech crops globally, whether they are used for food, feed, fiber or fuel.

***Paraguay***

Paraguay is the world's number four exporter of soybeans and grew biotech soybean unofficially for several years until it approved four herbicide tolerant soybean varieties in 2004. In 2006, Paraguay is expected to increase its biotech soybean area by another 10% to 2 million hectares from 1.8 million hectares in 2005. The percentage adoption also increased from 85% on the 2.1 million hectares in 2005 to 90% of the national soybean crop of 2.2 million hectares in 2006. Paraguay is one of nine countries that have successfully grown biotech soybeans; the nine countries, listed in order of biotech soybean hectarage are the USA, Argentina, Brazil, Paraguay, Canada, Uruguay, Romania, South Africa and Mexico.

**PARAGUAY**

Population: 6.5 million

GDP: $7.281 billion

% employed in agriculture: 45

Agriculture as % GDP: 22.4%

Agricultural GDP: $1.63 billion

Arable Land (AL): 3.04 million hectares

Ratio of AL/Population*: 2.0

Major crops:
- Cassava
- Soybean
- Sugar cane
- Maize
- Wheat

Commercialized Biotech Crop: HT Soybean

Total area under biotech crops and (% increase in 2006):
2 Million Hectares (+11% in 2006)

Farm income gain from biotech, 2004-2005: $132 million

*Ratio: % global arable land / % global population

Biotech maize and cotton have not been officially approved to-date in Paraguay but its neighboring countries are growing both crops successfully. Paraguay grew approximately 450,000 hectares of maize in 2006 and there is probably a potential for utilizing biotech maize for economic, environmental and social benefits because its neighbor Argentina, is already benefiting from Bt and herbicide tolerant maize. Paraguay also grows 320,000 hectares of cotton, which probably could benefit significantly from the biotech traits used in cotton in the neighboring countries of Argentina and Brazil.

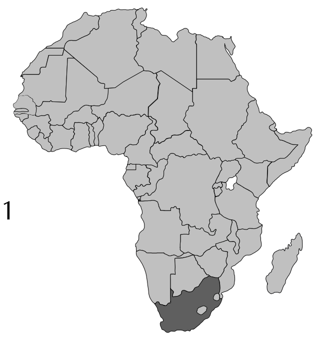
Paraguay is estimated to have enhanced farm income from biotech soybean by $132 million in 2004 and 2005 when it grew herbicide tolerant soybean.

### *South Africa*

South Africa maintained its number seven position in the world ranking for most of the first decade of commercialization of biotech crops, 1996-2005, but relinquished this position to India in 2004. In 2006, South Africa is still ranked eighth with a total biotech crop hectarage of 1.4 million hectares, more than double the biotech crop area of 0.5 million hectares in 2005 - an impressive 2.8 fold increase. The major increase was in biotech maize. Total plantings of maize in South Africa in 2006 were expected to increase by approximately 1.0 million hectares from 1.6 million hectares in 2005 to 2.7 million hectares in 2006, an increase of almost 60%. The higher hectarage of national maize plantings in 2006 resulted in parallel higher hectarage of both white and yellow biotech maize. In 2006, of the estimated 2.7 million hectares of white and yellow maize, 1.2 million hectares was biotech maize, equivalent to 44% of the total maize area (Table 7). Thus, the adoption rate for all biotech maize in 2006 was almost twice as high at 46% compared with only 27% in 2005. Of the total 1.2 million hectares of biotech maize 77% equivalent to 943,000 hectares was Bt and 23% or 189,000 hectares estimated to be herbicide tolerant.

White maize was expected to comprise 60% or 1.59 million hectares of the total maize area of 2.7 million hectares in 2006. Of the 1.59 million hectares of white maize, 44% was biotech made up of 552,000 hectares of Bt maize and 152,000 hectares of herbicide tolerant maize. Yellow maize was expected to comprise 40% or 1.1 million hectares of

## SOUTH AFRICA



Population: 45 million

GDP: $159.9 billion

% employed in agriculture: 11

Agriculture as % GDP: 4%

Agricultural GDP: $6.4 billion

Arable Land (AL): 14.7 million hectares

Ratio of AL/Population*: 1.4

Major crops:
- Sugarcane
- Maize
- Wheat
- Soybean
- Potato
- Cotton

Commercialized Biotech Crops:
- HT/Bt/HT-Bt Cotton
- HT/Bt Maize
- HT Soybean

Total area under biotech crops and (% increase in 2006):
1.4 Million Hectares (+180% in 2006)

Farm income gain from biotech, 1998-2005: $76 million

*Ratio: % global arable land / % global population

**Table 7. Adoption of Biotech Crops in South Africa, 2001 to 2006 ('000 hectares)**

| Year | Total area of biotech crops (maize, soybean, cotton) | Total area of biotech maize | Total area of biotech white maize (% of total white maize area) |
|---|---|---|---|
| 2001 | 197 | 166 | 6 (<1 %) |
| 2002 | 273 | 236 | 60 (3 %) |
| 2003 | 404 | 341 | 144 (8 %) |
| 2004 | 573 | 410 | 147 (8 %) |
| 2005 | 610 | 456 | 281 (29 %) |
| 2006 | 1,412 | 1,232 | 704 (44 %) |
| **Total** | **3,469** | **2,841** | **1,342** |

Source: ISAAA, 2006.

the total maize area of 2.7 million hectares. Of the 1.1 million hectares of yellow maize 50% was biotech maize made up of 391,000 hectares Bt maize and 137,000 hectares of herbicide tolerant maize.

In 2006, total plantings of soybean, at 214,000 hectares were down slightly from previous years with maize substituting for soybean. It is estimated that the area under herbicide tolerant soybean in 2006 was 160,000 hectares, equivalent to 75% adoption, compared with about 60% last year. Total cotton plantings in 2006 were estimated at 22,000 hectares, similar to last year, of which 20,000 hectares or 92% were biotech cotton. Of the 20,000 hectares of biotech cotton, 13,000 hectares ( 65% of biotech cotton hectares) had stacked traits for both Bt and herbicide tolerance, 5,000 hectares (25% of biotech cotton hectares) were the single Bt and 2,000 hectares (10% of biotech cotton hectares) were herbicide tolerant, used mostly as refugia in Bt fields. Currently, South Africa grows biotech maize and soybean only as single trait herbicide tolerant and single Bt, and not as stacked products. The approval of the stacked traits is an important policy decision that would allow South Africa to retain its leadership role in biotech crops. South Africa is estimated to have enhanced farm income from biotech crops by $76 million in the period 1998 to 2005. A 1998-2000 extensive study on Bt cotton reported substantial benefits for small holders. A 2001-2002 study on Bt maize showed an average benefit of $35/ha for dry land farmers and $117/ha for irrigated land, based on yield increases of 10.6% and 11.0% respectively, adjusted for pesticide reductions and the extra cost of biotech seed. The estimated annual average loss due to stalk borers is 10% equivalent to a national loss of $120 million, based on a 10 million MT harvest.

The progressive and steady increase in adoption of biotech crops in South Africa is captured in Table 7 which shows that the total hectarage of biotech crops increased consistently from 197,000 hectares in 2001 to 573,000 hectares in 2004 and reaching 1.4 million hectares in 2006. Of the three biotech crops, maize has always occupied the largest area with 166,000 hectares in 2001 (84% of the total biotech crop area) and 1.2 million hectares in 2006, (87% of all biotech crops). It is noteworthy that white biotech maize used for food is well accepted in South Africa occupying 6,000 hectares in 2001 (<1% of the white maize area) and increasing to 704,000 hectares in 2006 equivalent to 44% of the total white maize area of 1.59 million hectares.

South Africa plays a pivotal role in sharing its rich experience with other countries in Africa interested in exploring the potential that biotech crops offer. It is encouraging to note that South Africa already participates in technology transfer programs with other African countries and is engaged in training and human development programs with its neighboring African countries. Given South Africa's rich experience with biotech crops, it can also play an important role as the key partner country on the continent of Africa that can collaborate and cooperate with its counterparts in Asia, China and India, and Argentina and Brazil in Latin America. The Governments of India, Brazil and South Africa have established a platform for cooperation (IBSA) that includes research collaboration on crop biotech.

South Africa has the necessary resource base and experience in biotech crops that allows it to exert leadership in international networking with both public and private sector institutions in industrial countries to develop innovative and creative new modes of cooperation and technology transfer that can be shared with other crop biotech aspiring countries in Africa. South Africa plays a critical role as an African and global hub in the sharing of knowledge and experience about biotech crops. South Africa is estimated to have enhanced farm income from biotech crops by $76 million in the period 1998 to 2005.

**URUGUAY**

Population: 3.4 million

GDP: $13.24 billion

% employed in agriculture: 14

Agriculture as % GDP: 9.3%

Agricultural GDP: $1.23 billion

Arable Land (AL): 1.4 million hectares

Ratio of AL/Population*: 1.8

Major crops:
- Rice
- Maize
- Soybean
- Wheat
- Barley

Commercialized Biotech Crop:
- HT Soybean
- Bt Maize

Total area under biotech crops and (% increase in 2006):
0.4 Million Hectares (+33% in 2006)

*Ratio: % global arable land / % global population

### *Uruguay*

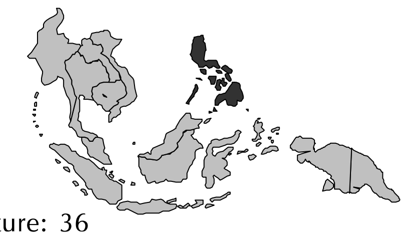
Uruguay, which introduced biotech soybean in 2000, increased its biotech crop area again in 2006 to reach approximately 350,000 hectares, with most of the gain coming from a modest increase in the hectarage of herbicide tolerant soybean that now occupies 100% of the 350,000 hectares of national soybean hectarage. The adoption of Bt maize, which Uruguay first approved in 2003, continued to grow modestly to about 35,000 hectares and occupied almost half of the 80,000 hectares of maize planted in Uruguay in 2006.

### *Philippines*

The Philippines, which grew Bt maize for the first time in 2003, is projected to significantly increase its total hectarage in the wet and dry seasons in 2006 to approximately 200,000 hectares, up from 70,000 hectares in 2005. The year-on-year three-fold increase of close to 150,000 hectares was due to significant increases which resulted in the following hectarages: Bt maize (125,000 hectares), herbicide tolerant maize (50,000 hectares) and importantly, the stacked traits for Bt and herbicide tolerance (25,000 hectares) grown for the first time in 2006. The number of small farmers, growing on average 2 hectares of biotech maize, is estimated at 100,000. The increase in value of farm income for farmers planting biotech maize the Philippines in the period 2003 to 2005 is estimated at $8 million. A total of four events of biotech maize have now been approved for commercial planting in the Philippines: MON 810 for insect resistance (2002), NK 603 for herbicide tolerance

(2005), Bt 11 for insect resistance (2005) and the stacked gene product of MON810/NK 603 (2005). The future acceptance prospects for biotech crops in the Philippines looks very promising with products also being developed by national institutes. These are Golden™ Rice, fortified rice resistant to Tungro virus and bacterial blight being developed by the Philippine Rice Research Institute (PhilRice) and virus resistant biotech papaya being developed by the Institute of Plant Breeding at the University of the Philippines at Los Baños.

**PHILIPPINES**



Population: 87.9 million

GDP: $98.4 billion

% employed in agriculture: 36

Agriculture as % GDP: 14.8%

Agricultural GDP: $14.56 billion

Arable Land (AL): 5.7 million hectares

Ratio of AL/Population*: 0.3

Major crops:

- Sugarcane
- Coconuts
- Rice
- Maize
- Bananas
- Cassavas
- Pineapples
- Mangoes

Commercialized Biotech Crop: Bt/Bt-HT Maize

Total area under biotech crops and (% increase in 2006):
0.2 Million Hectares (+100% in 2006)

Increased farm income for 2003-2005: $8 million

*Ratio: % global arable land / % global population

The Philippines passed its first regulation to deal with transgenic crops as early as October 1990, well before its neighboring countries in the region. The Philippines, which grows approximately 2.5 million hectares of maize is the only country in Asia to grow a major biotech feed crop, Bt maize, and moreover has achieved a biotech mega-country status with biotech maize, i.e. 50,000 hectares or more. Asia grows 30% of the global 140 million hectares of maize with China itself growing 25 million hectares, plus significant production in India (7 million hectares), Indonesia (3.3 million hectares), Philippines (2.5 million hectares), Thailand (1.1 million hectares) and Vietnam (1 million hectares).

### *Australia*

Australia is the fifth member of the six "founder biotech crop countries", having commercialized Bt cotton in 1996, the first year of global commercialization of biotech crops. Australia is expected to plant only 200,000 hectares of cotton in 2006 because of continuing severe droughts. As a result irrigators have been allocated limited volumes of water for cotton production and dryland growers will be completely dependent on late rains for planting. Assuming 200,000 hectares of cotton in 2006, the overall percentage adoption of biotech cotton in 2006 is expected to be over 90%, slightly higher than 2005. It is projected that in 2006 about 66% of all cotton in Australia will feature the stacked genes for herbicide tolerance and insect resistance (the dual RR® and Bt gene Bollgard®

II - this will include a small area of RR Flex®; 17% with the dual Bt gene on its own, compared with 10% in 2005; 8% with a single gene for herbicide tolerance including some of the newly introduced RR® Flex cotton, and the remaining 8% in conventional cotton, compared with 10% in 2005.

It is to the credit of Australia that it achieved the complete substitution of the single Bt gene product (Bollgard® I) with the dual Bt gene varieties (Bollgard® II) in only two years 2002/03, thereby greatly accelerating and enhancing the stability of Bt resistance management, and simultaneously benefiting from better and more reliable protection against the major insect pests. In 2002-2003, there was a limitation in place on the percentage of Bt cotton allowed to be planted in Australia. In 2003-2004, the single Bt gene product was restricted to 15% on any farm in Australia and the combined area of the single and dual gene Bt products was restricted to a maximum of 40%. With the introduction of the dual Bt gene product (Bollgard® II) in Australia, these deployment limitations that applied to the single gene product because of concern related to the deployment of resistance to the single Bt gene, were lifted.

**AUSTRALIA**

Population: 20.3 million

GDP: $612.8 billion

% employed in agriculture: 3.6

Agriculture as % GDP: 3.8%

Agricultural GDP: $23.29 billion

Arable Land (AL): 46.1 million hectares

Ratio of AL/Population*: 10.3

Major crops:
- Wheat
- Barley
- Sugarcane
- Fruits
- Cotton

Commercialized Biotech Crop: Bt/Bt-HT Cotton

Total area under biotech crops and (increase in 2006):
0.2 Million Hectares (-33% in 2006)

Farm income gain from biotech, 1996-2005: $154 million

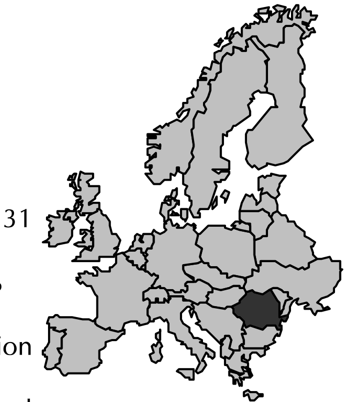
*Ratio: % global arable land / % global population

Australia is estimated to have enhanced farm income from biotech cotton by $154 million in the period 1996 to 2005.

To date, Australia, through the Office of the Gene Technology Regulator (OGTR), has approved three crops for commercial planting; cotton, carnations and canola with only one of these crops, biotech cotton, grown widely at this time. Despite a success story with biotech cotton in Australia, there is a vigorous debate over herbicide tolerant canola which was approved by the federal OGTR in 2003 but in the interim has been banned from cultivation by all the major canola growing states in Australia through the implementation of moratoria by state governments. These bans by the states have been instituted because of perceived potential market access restrictions for exports of biotech canola from Australia. However, most farmer groups oppose the ban because they believe it disadvantages them and that Australian canola exports will suffer with long-term negative consequences. The results of a federal study released in September 2005 by the Australian Bureau of Agricultural and Resource Economics (ABARE)[14] is consistent with the views of some farmers, and estimates that a ban on biotech crops in Australia over the next 10 years could cost Australian farmers $3 billion.

Detection of low levels of biotech canola in conventional crops of canola in September 2005 in Australia refueled the debate amongst parties. The ban on biotech canola in Australia could have negative implications for Australia in the US-Australian Free Trade Agreement, signed in 2004. This trade agreement opens markets for Australian exports to the US for manufactured products and services of $270 billion, including a modest potential for agricultural products and services. In September 2006, the Federal Government initiated a campaign to try and convince the states to reconsider their decisions on banning canola because of the risk of Australia becoming non-competitive in canola. Elsewhere in the world, canola benefits from current biotech traits and will continue to do so when new traits become available in the future. Of particular concern for Australia, as a drought prone country, is the significant advantage that competitors would gain when genes for drought tolerance are expected to become available in biotech crops around 2010 and beyond.

**ROMANIA**



Population: 22.3 million

GDP: $97.1 billion

% employed in agriculture: 31

Agriculture as % GDP: 13.1%

Agricultural GDP: $12.72 billion

Arable Land (AL): 9.7 million hectares

Ratio of AL/Population*: 2.0

Major crops:

| | | |
|---|---|---|
| • Wheat | • Sugar beets | • Grapes |
| • Maize | • Sunflower seed | • Soybean |
| • Barley | • Potatoes | |

Commercialized Biotech Crop: HT Soybean

Total area under biotech crops and (increase in 2006):
0.1 Million Hectares (+5% in 2006)

*Ratio: % global arable land / % global population

### *Romania*

Romania is the third largest producer of soybean in Europe after Italy and Serbia Montenegro and ranks equal third with France with approximately 145,000 hectares of soybean planted in 2006. Romania first grew herbicide tolerant soybean in 2001 when it planted 14,250 hectares of RR® soybean of its national soybean hectarage of approximately 100,000 hectares - a 15% adoption

[14] *Apted, S., McDonald, D., and Rodgers, H. September 2005. Transgenic Crops: Welfare Implications for Australia. ABARE.*

rate. In 2006, of its national soybean hectarage of 145,000 hectares, 115,000 hectares were planted with RR® soybean, equivalent to a 79% adoption rate. The very high adoption rate of 79% reflects the confidence of farmers in RR® soybean, which has delivered unprecedented benefits compared with RR® soybean in other countries, particularly in terms of yield gains. A study by PG Economics in 2003 estimated that the average yield gain was plus 31% equivalent to an increase in gross margins ranging from +127% to +185% or an average a gain of $239 per hectare that translates to an annual economic gain at the national level of between $10 and $20 million. Given that RR® soybean technology is usually yield-neutral in other countries such as the US and Argentina which have embraced the technology at high adoption rates, the yield increases in Romania are quite unprecedented. The high yield increases that range from +15% to +50% with an average of +31% reflect past low usage of herbicides and ineffective weed management, particularly of Johnson grass, which is very difficult to control.

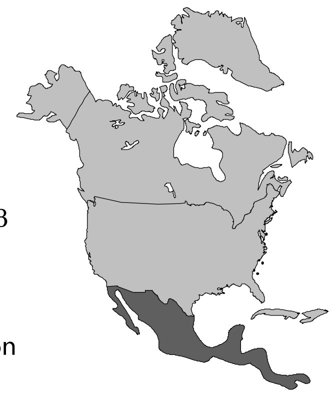
Despite the above significant and unique advantages, a decision has been taken by the Romanian Government, prompted by the European Union, to discontinue cultivation of biotech soybean as of January 2007 to facilitate membership in the EU, where RR® soybean has not been approved for planting. Many observers and Romanian farmers believe there are several compelling reasons for Romania to continue to grow RR® soybean after joining the EU, through a derogation. First, if farmers are denied the right to plant RR® soybean they will not be able to achieve as cost-effective a weed-control program, even with more expensive alternates, resulting in significant financial losses for farmers growing conventional soybeans, and less affordable soybeans for consumers. Given that use of RR® soybean also results in better weed control in the crops following it in the rotation, elimination of RR® soybean will lead to higher cost of weed control and more use of herbicides for all other crops following it in the rotation, with negative implications for the environment because of more applications of alternative herbicides, which will also erode profitability. Preclusion of RR® soybean legal plantings in Romania will reduce national production by up to one third which can only be compensated with imports that will likely be RR® soybean and imports will have to be purchased with scarce foreign exchange. Experience in other countries indicates that denying the legal use of RR® soybean to Romanian farmers will lead to illegal plantings of a significant magnitude with all its negative implications for all parties concerned.

As a 2007 accession country to the EU, Romania's positive experience over the last eight years with biotech soybeans has important policy implications vis-à-vis cultivation of biotech crops in all other EU accession countries like Bulgaria, and other neighboring countries in the Black Sea region. Romania's role model as a successful grower of biotech crops in Eastern Europe is clearly important, particularly since it is a 2007 accession country to the EU. Furthermore, Romania's success with biotech crops need not be limited to RR® soybean because it is also by far the largest grower of maize in Europe - 2.6 million hectares in 2005, compared with 1.6 million hectares in France, 1.2 million hectares in Hungary, 1 million hectares in Italy and 0.4 million hectares in Germany. In this context, it is noteworthy that in 2006, six EU countries, Spain, France, Portugal, the Czech Republic, Germany and Slovakia, successfully grew an increasing hectarage of Bt maize on approximately 70,000 hectares in 2006.

### *Mexico*

Mexico is the last of the six "founder biotech crop countries" having grown biotech Bt cotton in 1996, the first year of the global commercialization of biotech crops. After a large increase in 2005 to 120,000 hectares, biotech cotton hectarage in 2006 decreased to approximately 55,000 because of regulatory delays that precluded the importation of biotech cotton seed for the early plantings in Mexico. Subsequent to solving the regulatory problem, seed was imported for later plantings but as a consequence the total biotech cotton area in 2006 was reduced significantly. In 2006, biotech cotton in Mexico comprised Bt cotton (about 25,000 hectares), herbicide tolerant (HT) cotton (1,000 hectares) and the stacked traits of Bt /HT (30,000 hectares). Mexico is one of four countries to deploy the Bt /HT stacked cotton, the other countries are the US, Australia and South Africa. In 2006, the modest area of RR® soybean was only about 5,000 hectares. Biotech crops that are currently being field-tested include RR® Flex cotton, Bollgard® II /RR® Flex cotton and RR® alfalfa.

**MEXICO**



Population: 106.2 million

GDP: $768.4 billion

% employed in agriculture: 18

Agriculture as % GDP: 4%

Agricultural GDP: $30.7 billion

Arable Land (AL): 25.6 million hectares

Ratio of AL/Population*: 1.1

Major crops:

- Maize
- Wheat
- Soybeans
- Rice
- Beans
- Cotton
- Coffee
- Fruit
- Tomatoes

Commercialized Biotech Crops:

- Bt/HT/Bt-HT Cotton
- HT Soybean

Total area under biotech crops and (% increase in 2006):
0.1 Million Hectares (-56% in 2006)

Farm income gain from biotech, 1996-2005: $55 million

*Ratio: % global arable land / % global population

Mexico is estimated to have enhanced farm income from biotech crops by $55 million in the period 1996 to 2005.

Mexico has no trade constraints related to biotech crops and is a major importer of food, feed and fiber from the US. In 2005, Mexico imported US$ 9.9 billion worth of agricultural products from the US. These included 5.7 million tons of corn, 3.7 million tons of soybeans and 387,000 tons of cotton. While Mexico has no trade constraints related to biotech crops generally, it is the center of diversity for maize and the conservation of biodiversity in Mexican landraces has fuelled a long standing debate vis-à-vis the potential for gene flow from biotech maize imported from the US.

The content and detail of the debate is beyond the scope of this Brief and interested readers are directed to the voluminous literature on this subject, with the latest study contradicting earlier findings, by reporting no trace of Bt genes in Mexican maize. In 2006, application to field test biotech maize in Northern Mexico, where teosinte is not present, was submitted but as of November 2006, permission had not been granted.

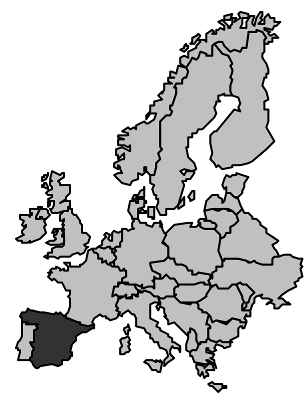
Following years of debate, the Mexican Congress Senate approved a Biosafety law on 15 February 2005 that facilitates the introduction of biotech crops despite the fear of some regarding gene flow in maize. Under the new law, authorization for the sale, planting and utilization of biotech crops and products is on a case-by-case basis, under the control of CIBIOGEM, an inter-ministerial body. Increasing trade in biotech crops made the new law necessary, and Mexican policy makers believe it is a major step forward in dealing with an issue that required urgent attention.

***Spain***

Spain is still the only country in the European Union to grow a substantial area of a biotech crop. Spain has grown Bt maize for eight years since 1998 when it planted approximately 22,000 hectares out of a national maize area of 500,000 hectares. Since 1998, the area of Bt maize has grown consistently reaching a peak of 58,000 hectares in 2004, qualifying Spain as one of the 14 biotech mega-countries globally growing 50,000 hectares or more of biotech crops. Whereas the Government has not yet published the biotech maize area for 2006 several sources estimate the Bt maize area in Spain at close to 60,000 hectares which is 16% of the total maize grain area of 370,000 hectares, compared with 12% in 2005.

The benefits to Spanish farmers from Bt maize has been reported by PG Economics and indicates that the average increase in yield was 6%, and the net impact on gross margin $112 per

**SPAIN**



Population: 44.1 million

GDP: $1,127.1 billion

% employed in agriculture: 5%

Agriculture as % GDP: 3.6

Agricultural GDP: $40.58 billion

Arable Land (AL): 14.1 million hectares

Ratio of AL/Population*: 1.3

Major crops:

- Maize
- Olives
- Sugar beets
- Vegetables
- Wine grapes
- Citrus

Commercialized Biotech Crop: Bt Maize

Total area under biotech crops and (% increase in 2006):
0.1 Million Hectares (+25% in 2006)

Increased farm income for 1998-2005: $28 million

*Ratio: % global arable land / % global population

hectare. Recent data from the IRTA public research institute in Spain indicate that for an area where the corn borer is prevalent, Bt-varieties have a yield advantage of 7.5 % with an 83% reduction in levels of fumonisins. There is potential for increasing Bt maize hectarage in Spain on up to one-third of the total maize area and the national gain is estimated at $13 to 18 million per year. The grain harvested from Bt maize in Spain is sold through the normal channels as animal feed or fed to animals on the farm.

Currently, varieties of nine seed companies, including event MON810 of biotech maize have been approved for commercial planting. Up until 2002, only the variety COMPA CB was grown with Bt-176 for insect resistance, and this variety was grown until the 2005 season. MON 810 varieties for insect resistance were approved in 2003 and now there are 46 varieties registered with MON 810. In November 2004, herbicide tolerant NK603 maize was approved for import, but the approval for planting in the European Union is still pending. When approved, biotech maize varieties with NK603 are likely to be deployed throughout Spain.

Spain is a feed stock deficit country and therefore there is incentive for Spanish farmers to increase productivity and be competitive, by employing innovative and cost effective technologies. The future growth of biotech maize in Spain will be dependent on the continued growth in area of Bt maize, the approval of NK603, and particularly a progressive and tolerant government policy especially in relation to coexistence.

### *Colombia*

Colombia introduced Bt cotton in 2002 on approximately 2,000 hectares and in the interim this has increased consistently each year in 2003, 2004 and 2005 to reach 30,000 hectares in 2006, equivalent to almost 40% of the national cotton crop of 72,000 hectares in 2006. In 2006, Colombia also grew its first crop of herbicide tolerant cotton on approximately 1,000 hectares. Colombia also has approximately 630,000 hectares of maize which could be a potential application for biotech maize.

### *France*

France resumed the planting of Bt maize in 2005 after a four-year gap having planted Bt maize in 1998 (1,500 hectares), 1999 (150 hectares) and 2000 (<100 hectares). In 2006, France planted approximately 5,000 hectares compared with only 500 to 1,000 hectares in 2005 - at least a five-fold increase from 2005. The planting of the commercial Bt maize in 2006 is fully supported by the French Maize Growers Association, with the grain from the Bt maize harvest being sold to Spain for animal feed. All of the Bt maize is thought to be MON 810. As one of the lead member states in the EU, and where opposition to biotech crops has been vigorous, the growing of even a token hectarage of Bt maize in France is an important and symbolic development. France is the major maize growing country in the EU with an area of 1.7 million hectares in 2005 and stands to gain more than any other country in the EU from biotech maize. At the Annual meeting of the French Maize Growers Association in September 2005, several hundred maize growers expressed their open support for biotechnology and called on the Minister of Agriculture to expedite the transposition of EU directive 2001/18 into French law. The underlying concern expressed by the maize growers was the fear that France was lagging behind in biotech crops when countries like China and India were embracing the technology to their advantage. France has a decree in place that prohibits the growing of biotech canola until October 2006. France rigorously implements the EU policy in terms of labeling and traceability. France does not import maize gluten feed for animal feed but does import large quantities of soybean (4.5 million tons of soybean and 470,000 tons of soybean meal in 2003/04) with Brazil having displaced the US as the major supplier. The French biotech bill is still under consideration and is very unlikely to be voted on by the National Assembly before the presidential and parliamentary elections in May 2007, as the French government considers the biotech issue too controversial to discuss at the legislative level during a political campaign. The bill includes a coexistence policy, as well as evaluation procedures for biotech crop products.

***Iran***

Iran, with a population of 70 million people, has limited land for crop production in an arid environment and this is exacerbated by limited water supplies, which is particularly important for the rice crop where productivity is constrained by abiotic stresses related to drought and salinity and biotic stresses related to insect pests. Iran grows about 630,000 hectares of rice and, along with Indonesia, Bangladesh and Brazil, is one of four large importers of rice in the world, about 1 million tons per year, or more. The Agricultural Biotechnology Research Institute (ABRI) at Karaj in Iran has developed a Bt rice, which was officially released in Iran in 2004 on 2,000 hectares, to coincide with the International Rice Year with the Prime Minister of Iran inaugurating the first harvest of the biotech rice. The Bt rice was developed in Iran in a breeding program in which rice with Bt incorporated was tested in greenhouse experiments and field trials during the period 1999 to 2004 to meet national regulations for biotech crops. The Bt rice features a synthetic *cry1Ab* gene in a local high quality aromatic rice variety "Tarom molaii" that confers resistance to stem borers, particularly the striped stem borer which is the most important economic pest on rice in Iran. In 2005, several hundred farmers, (estimated at more than 500 and less than one thousand), grew around 4,000 hectares of Bt rice on their farms in Iran at no extra cost compared with the conventional variety. Over the last year, there have been indications that the status of Bt rice in Iran is under review and there are no confirmed estimates available of the hectares planted to Bt rice in 2006. Based on experience of other countries with farmer saved seed and considering the benefits that Bt rice offers farmers, it is conservatively estimated that the planted area will be at least equivalent to the 4,000 hectares that farmers planted in 2005, and probably considerably more, with farmers having saved enough of their own seed in 2005 for their replanting needs in 2006. The Bt gene has also been backcrossed into higher yielding rice varieties that are well adapted to conditions in Iran, and some of these improved varieties should be available in the coming season for multiplication.

The biotech rice program in Iran is well advanced but is only one of several biotech crop initiatives at 23 institutes in Iran, where 141 researchers are working on several biotech crops. These include Bt cotton, herbicide tolerant canola, and virus resistant sugar beet. The Iranian national biotechnology strategy was presented at the BioAsia 2005 conference in Hyderabad, India in February 2005. Iran and China are the most advanced in the commercialization of biotech rice, which is the most important food crop in the world and the principal food of the poor and thus has enormous implications not only for biotech rice but also for poverty alleviation and for all biotech crops and their acceptance on a global basis.

### *Honduras*

Honduras introduced Bt maize in 2002 with a pre-commercial introductory area of approximately 500 hectares. In the interim, the Bt maize area has increased modestly, and in 2006 was approximately 1,000 hectares of Bt maize and for the first time, close to 1,000 hectares of herbicide tolerant maize were planted. The national maize crop of Honduras is approximately 350,000 hectares. Honduras is the first country in Central America and the Caribbean to grow a biotech crop.

### *Czech Republic (Czechia)*

The Czech Republic, more familiarly known as Czechia, approved the commercial production of a biotech crop for the first time in 2005 and grew 150 hectares of Bt maize. In 2006, Czechia grew 1,290 hectares of Bt maize - almost a 10-fold increase acknowledging the total area is small. Czechia grows almost 300,000 hectares of maize so the potential for biotech maize is significant. Coexistence rules apply with 70 meters between Bt maize and conventional maize (or alternatively 1 row of buffer replaces 2 meters of isolation) and 200 meters between Bt maize and organic maize (or alternatively 100 meters of isolation and 50 buffer rows).

### *Portugal*

Portugal resumed the planting of Bt maize in 2005 after a five-year gap having planted an introductory area of approximately 1,000 hectares in 1999 for one year. In 2006 Portugal planted 1,246 hectares of Bt maize, almost double the 2005 area of 750 hectares of the MON 810 biotech maize, resistant to European Corn Borer. As a member country of the EU, Portugal's resumption of the cultivation of Bt maize is an important development even though the national maize area is modest at 135,000 hectares.

The Government of Portugal passed a Decree, which requires a minimum distance of 200 meters between biotech and conventional maize and 300 meters between biotech maize and organic maize; buffer zones can substitute for these distances. Implementation of coexistence laws will probably result in biotech maize being grown in the central and southern regions of Portugal where the farms are bigger, and where coexistence distances can be accommodated and also where producers are more responsive to the introduction of new and more cost effective technologies. The Ministry of Agriculture also passed legislation to establish biotech free areas where all the farmers in one town, or 3,000 hectare area, can elect not to grow biotech varieties. All biotech varieties approved in the EC catalogue can be grown in Portugal.

***Germany***

Germany has officially grown a small hectarage, from 300 to 500 hectares of Bt maize commercially for the last six years, starting in 2000; Bt176 was used until 2003 when MON810 was introduced. The area of officially approved commercial Bt maize in Germany in 2006 was 950 hectares compared with 345 hectares in 2005 - almost a tripling of the modest area of Bt maize, most of which is harvested as silage. The regulation governing the planting of this token area of biotech maize is as follows. Given that Germany does not allow the sale of biotech seeds for unlimited planting, seed companies can apply for special permits annually to supply a limited amount of biotech seed. For maize, the limit is 0.1 percent of any registered variety. To preclude any liability related to the cultivation of this small area of Bt maize in Germany, the milling company Maerka Kraftfutter has voluntarily agreed to purchase, at market prices, all the maize grain from any field within 500 meters of a biotech maize field. In 2004, detailed monitoring of biotech maize fields in Germany confirmed that maize samples taken more than 20 meters from biotech maize had less than the 0.9 percent threshold for biotech content. In early 2005, Germany introduced the first elements of a Genetech law, which covers coexistence and liability; the law has been heavily criticized because it is so restrictive leaving no incentive, but significant disincentive for farmers to adopt Bt maize in Germany.

***Slovakia***

Slovakia grew its first commercial biotech crop, Bt maize in 2006. Thirty hectares of Bt maize were grown for commercial production by several farmers. As an EU member state, Slovakia can grow maize with the MON 810 event which has been approved by the EU for all of its 25 member countries. Slovakia grew approximately 240,000 hectares of maize in 2006. Slovakia becomes the 25th country in the world to grow approved biotech crops commercially. With the addition of Slovakia this brings the total number of EU countries growing biotech crops commercially to 6 which is approximately one quarter of the 25 EU member states.

## Distribution of Biotech Crops, by Crop

The distribution of the global biotech crop area for the four major crops is illustrated in Figure 5 and Table 8 for the period 1996 to 2006. It clearly shows the continuing dominance of biotech soybean occupying 57% of the global area of global biotech crops in 2006; the entire biotech soybean hectarage is herbicide tolerant RR® soybean. Biotech soybean retained its position in 2006 as the biotech crop occupying the largest area globally occupying 58.6 million hectares in 2006 growing at 8% between 2005 and 2006. Biotech maize had the second highest area at 25.2 million hectares and had the second highest year-to-year growth rate at 19% between 2005 and 2006. Biotech cotton reached 13.4 million hectares in 2006 and grew at the highest rate of 37% between 2005 and 2006 mainly due to the 2.5 million hectare increase in India in 2006 (Table 4). Canola grew at 4% between 2005 and 2006, and is the lowest area of the four biotech crops at 4.8 million hectares grown in Canada and the US. RR® alfalfa, first grown in 2006, occupied 80,000 hectares equivalent to approximately 5% of the 1.3 million hectare seeded in the US in 2006. In the absence of confirmed reports from Iran in 2006, the hectarage of biotech rice in Iran, first commercialized in 2005 on about 4,000 hectares, is conservatively reported in 2006 at the same level as 2005. Small hectarages of biotech virus-resistant squash and papaya continue to be grown in the US.

Distribution of economic benefits for the four major biotech crops for the decade1996 to 2005 were as follows: soybean $.14.4 billion, Bt cotton $ 7.5 billion, Bt maize $ 2.4 billion, herbicide tolerant cotton $ $0.9 billion, herbicide tolerant canola $ 0.9 billion, herbicide tolerant maize $0.8 billion for a total of $27 billion.

### *Biotech soybean*

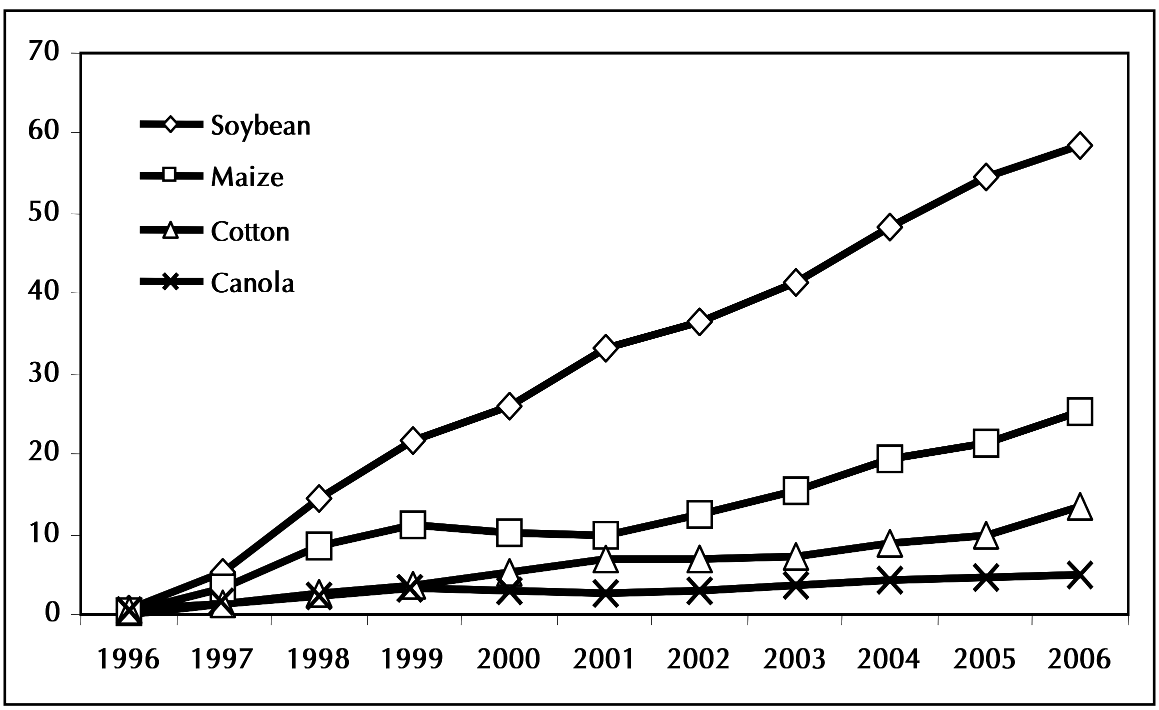
In 2006, the global hectarage of herbicide tolerant soybean is estimated to have increased by 4.2 million hectares, equivalent to an 8% increase to reach 58.6 million hectares worldwide and equivalent to 64% of the global 91 million hectares of soybean. The substantial gains in biotech soybean in 2006 were in Brazil (2 million hectares), the US (1.5 million hectares) and Argentina (0.4 million hectares). In Brazil in 2006, about 55% of the soybean crop was estimated to be RR® soybean. In the US, herbicide tolerant soybean hectarage in 2006 occupied 28.0 million hectares of the 30.3 million hectare crop. In Argentina, continued growth is projected to result in 15.8 million hectares in 2006, up from 15.4 million hectares in 2005; virtually all the Argentinean national soybean hectarage is planted with herbicide tolerant soybean. Paraguay reported 1.8 million hectares of herbicide tolerant soybean in 2005 and this area increased in 2006 to 2.0 million hectares, equivalent to 90% adoption of the 2.2 million hectare crop, up from 85% in 2005, when the national hectarage of soybean was 2 million hectares. Canada continued to plant about 60% of its national soybean hectarage with herbicide tolerant soybean in 2006. Uruguay's herbicide tolerant soybean continued to occupy 100% of the national soybean hectarage of 350,000 hectares in 2006. Romania,

**Table 8. Global Area of Biotech Crops, 2005 and 2006: by Crop (Million Hectares)**

| Crop | 2005 | % | 2006 | % | +/- | % |
|---|---|---|---|---|---|---|
| Soybean | 54.4 | 60 | 58.6 | 57 | 4.2 | +8 |
| Maize | 21.2 | 24 | 25.2 | 25 | 4.0 | +19 |
| Cotton | 9.8 | 11 | 13.4 | 13 | 3.6 | +37 |
| Canola | 4.6 | 5 | 4.8 | 5 | 0.2 | +4 |
| Alfalfa | - - | -- | <0.1 | <1 | -- | -- |
| Rice | <0.1 | <1 | <0.1 | <1 | -- | -- |
| Others | <0.1 | <1 | <0.1 | <1 | -- | -- |
| **Total** | **90.0** | **100** | **102.0** | **100** | **+12.0** | **+13** |

**Source: Clive James, 2006.**

**Figure 5. Global Area of Biotech Crops, 1996 to 2006: by Crop (Million Hectares)**




**Source: Clive James, 2006**

which has benefited from yield increases of the order of 30%, as a result of improved weed control, also increased its area of herbicide tolerant soybean marginally in 2006 to 115,000 hectares. South African and Mexican biotech soybean hectarage decreased slightly to approximately 160,000 hectares and 5,000 hectares, respectively, in 2006 in line with decreased total plantings of soybean in the two countries. The increase in income benefits for farmers growing biotech soybean during the decade 1996 to 2005 was $14.4 billion.

***Biotech maize***

In 2006, biotech maize increased by 19% to 25.2 million hectares, compared with 8% for soybean, 37% for cotton and 4% for canola (Table 8). The annual growth rate of 19% for biotech maize in 2006 compares with growth rates over the last three years of 10% in 2005, 25% in 2004, and 25% in 2003. Thus, there have been five consecutive years of consistent and significant growth with biotech maize and this is likely to continue in the near-term with maize already occupying 17% of the global maize area of 148 million hectares globally in 2006. Most of the increase in biotech maize in 2006 occurred in five countries, USA with an increase of 2.5 million hectares, South Africa 0.9 million hectares, Argentina 240,000 hectares, the Philippines 125,000 hectares and Canada 70,000 hectares. Modest increases were reported in Uruguay and Honduras and small absolute increases, but large proportional increases, in all the five EU countries that grew Bt maize in 2005, with Slovakia growing Bt maize for the first time in 2006.

Preliminary projections of yield gains from drought tolerant maize in the US, expected to be available after 2010, are 8 to 10% in the non-irrigated areas from North Dakota to Texas. By 2015, current yields of 5.5 MT in the dry regions of the US could increase to 7.5 MT per hectare.

As the economies of the more advanced developing countries in Asia and Latin America improve this will significantly increase demand for feed maize to meet higher meat consumption in diets as people become more prosperous. Coincidentally the increased usage of customized maize for ethanol production, which currently consumes 18% of maize in the US in 2006, is expected to increase to 41% by 2015. The increase in income benefits for farmers growing biotech maize during the decade 1996 to 2005 was $3.2 billion.

***Biotech cotton***

The area planted to biotech cotton globally in 2006 was up 3.6 million hectares, equivalent to a 37% growth over 2006, the highest of all biotech crops, reaching 13.4 million hectares globally and equivalent to 38% of the global area of 35 million hectares in 2006. Most (70%) of the 3.6 million hectare growth was in India (2.5 million hectares) followed distantly by the US (675,000 hectares), Argentina 285,000 hectares, and China 200,000 hectares. This significant growth overshadowed the biotech cotton decreases of 80,000 hectares in Mexico, due to seed import constraints, and 90,000 hectares in Australia, in line with substantial reductions of total plantings of cotton due to drought. Approximately 120,000 hectares of Bt cotton was grown in Brazil for the first time and this is expected to be a steep adoption curve similar to that witnessed in India and China to-date. The total plantings of biotech cotton in the USA in 2006 at 5.3 million hectares are a record high in hectarage and adoption (88%). RR® Flex cotton was introduced in the US and Australia for the first time in 2006 by Monsanto. It was marketed as a single gene and also as a stacked product with insect resistance in Bollgard II. RR Flex® herbicide tolerant cotton was launched in 2006 on over 800,000 hectares. RRFlex® cotton was planted as a single trait and as a stacked product with Bt, with the latter occupying the majority of the hectarage. The plantings were principally in the US with a smaller hectarage in Australia. The first ever biotech variety of American Pima cotton, PHY 810 R, tolerant to the herbicide RoundUp® was planted in the US in 2006. The product was introduced by Phytogen, a joint venture between Mycogen Corporation and an affiliate DowAgroSciences LLC, and J G Boswell. It is estimated that PHY 810 R occupied approximately 5% of the American Pima cotton hectarage in the US in 2006. In China, total cotton plantings were up by approximately 5% from 5.1 million hectares in 2005 to 5.3 million hectares in 2006 and this paralleled increases in Bt cotton from 3.3 million hectares in 2005 to 3.5 million hectares in 2006 with the adoption rate remaining approximately the same as 2005 at 66%. It is estimated that in 2006, 6.8 million small resource-poor farmers benefited from Bt cotton in China, farming, on average, approximately one-half of one hectare. Notably, the public sector in China has invested significantly in crop biotechnology and has developed Bt cotton varieties that share the market with varieties developed by the international private sector. The simultaneous marketing of biotech crops from the public and private sectors is unique to China at this time but is expected to also become more prevalent in India as biotech crops are developed by government supported public sector institutions. It is notable that in 2006, the biotech cotton area in India exceeded the Bt cotton in China. In 2006, biotech hybrid cotton in India, the largest cotton growing country in the world, occupied 3.8 million hectares of approved Bt cotton increasing by an impressive three-fold gain between 2005 and 2006. The advantages of Bt cotton hybrid in India are significant and a substantial increase is projected again for 2007 due to significant gains in production, economic, environmental, health and social benefits. The increase in income benefits for farmers growing biotech cotton during the decade 1996 to 2005 was $8.4 billion.

A recent paper from the World Bank (WPS3197)[15], by Kym Anderson *et al.*, concluded that unlike the situation with the Cotton Initiative in the WTO's Doha round of discussions, cotton-growing developing countries in Africa and elsewhere do not have to wait until the Doha Round is complete before benefiting from increased income from cotton. Developing countries which have elected to continue growing cotton, as opposed to Bt cotton, have the option and authority to approve and adopt Bt cotton and benefit from the significant benefits it offers, which the study claims are greater

*[15] Anderson, K., Valenzuela E., and Jackson, L.A. Recent and Prospective Adoption of Genetically Modified Cotton: A Global CGE Analysis of Economic Impacts. World Bank Policy Research Working Paper 3197. 2006*

than the potential benefits from the removal of all subsidies and tariffs that is sought under the Doha Round. Furthermore the study concludes that the gains from the Doha Round would be greater if cotton-growing developing countries adopted Bt cotton. Thus, the onus is on Governments of potentially beneficiary cotton-growing developing countries to exercise their authority and responsibility to appraise, approve and adopt Bt cotton at the earliest opportunity; fortunately this can be greatly facilitated and accelerated today by learning from the wealth of knowledge and experience of the nine countries, six of them developing, which have tested, and benefited significantly from this proven technology over the last decade. Bt cotton is no longer the "new" technology with a potential risk that it was ten years ago - now the greater risk for cotton-growing developing countries, particularly countries that are principally dependent on cotton as their major or only source of income and foreign exchange, is to consciously elect not to use the technology.

### *Biotech canola*

The global area of biotech canola in 2006 is estimated to have increased marginally by 0.2 million hectares, from 4.6 million hectares in 2005 to an estimated 4.8 million hectares in 2006 with a modest increase in Canada, offsetting a reduction in the US for a net benefit of 0.2 million hectares globally (Table 8). In Canada, the principal grower of canola, the adoption of herbicide tolerant canola developed through chemical mutagenesis has consistently decreased from 22% in 2003 to 18% in 2004 to 14% in 2005 and 11% in 2006, when only 5% of the crop was conventional. Only two countries currently grow biotech canola, Canada and the US, but the global acreage and prevalence could increase significantly in the near term in response to the likely increased use of canola for biodiesel. The increase in income benefits for farmers growing biotech canola during the decade 1996 to 2005 was $893 million.

### *Biotech rice*

Iran initiated its rice biotech activities in 2005 with several hundred farmers growing 4,000 hectares of Bt rice on their farms. During the last year, it appears that Bt rice in Iran is under review and there are no confirmed estimates available of the hectares planted to Bt rice in 2006. Based on experience of other countries with farmer saved seed and considering the benefits that Bt rice offers farmers, it is conservatively estimated that the planted area will be at least equivalent to the 4,000 hectares that farmers planted in 2005, and probably considerably more, with farmers having saved enough of their own seed in 2005 for their replanting needs in 2006. The initial plans for commercialization of Bt rice in Iran was to achieve full commercialization in 2006, when it was planned to deploy the Bt rice on 10,000 to 20,000 hectares.

Asia produces 90% of the rice in the world. Rising demand, shrinking paddy fields, (because farmers are switching to more profitable crops), and low productivity due to inclement weather and dropping water tables, are likely to cause a supply shortage and drive rice prices up in the near-term; this will be exacerbated by the US, China and Indonesia drawing heavily on world rice stocks that are already at historical lows. Current world rice stocks are 66 million MT or 10% of global production (estimated at 628 million MT in 2005), whereas traditionally stocks have been at 15 to 20% of global production. In 2006, rice prices in Asia were already 10% above 2005; Thai 5% broken rice was $310 per MT in 2006 up from $280 in 2005 and Vietnamese 10% broken rice at $270 up 10% from 2005. Thailand normally exports 7 million MT and Vietnam 5 million MT. FAO estimated rice production in Asia in 2006 at 577 million MT, 7 million MT more than in 2005. The increase in 2006, due to bigger harvests in Thailand, Philippines and Bangladesh was offset by lower production in Pakistan, Sri Lanka, South Korea and Vietnam, where production in the Mekong Delta was 1 million MT lower because infestation levels of insect pests required farmers to "skip" their third rice crop in one year. In 2006, China, the number one rice consumer in the world may well have imported more than the 514,000 MT in 2005, because production in 2006 was lower than the 180.6 million MT in 2005. However, China does have biotech rice, pending approval, which has already been tested in extensive pre-production field trials and has a potential to increase productivity by 6%, decrease insecticides application and increase farmer income nationally by $4 billion/per annum by 2010. Global demand for rice is projected to increase by 200 million tons by 2025.

### *Biotech Alfalfa*

It is notable that a new biotech crop, herbicide tolerant RR®alfalfa, was approved for commercialization in the US in 2005. The first pre-commercial plantings (20,000 hectares) were sown in the fall of 2005, followed by larger commercial plantings of 60,000 in 2006. The 60,000 hectares of RR®alfalfa represent approximately 5% of the 1.3 million hectares alfalfa seeded in 2006. RR®alfalfa enjoys the distinction of being the first ever perennial biotech crop to be approved worldwide, and herbicide tolerance is expected to be the first of several traits to be incorporated into this important forage crop. There are approximately 9 million hectares of alfalfa grown for dry hay in the US annually worth $ 7 billion. Unlike the large biotech row crops of soybean and maize, biotech alfalfa is likely to be more of a niche market.

### *Other biotech crops*

Small areas of biotech virus resistant squash and papaya (Hawaii) continued to be grown in the USA in 2006.

## Distribution of Biotech Crops, by Trait

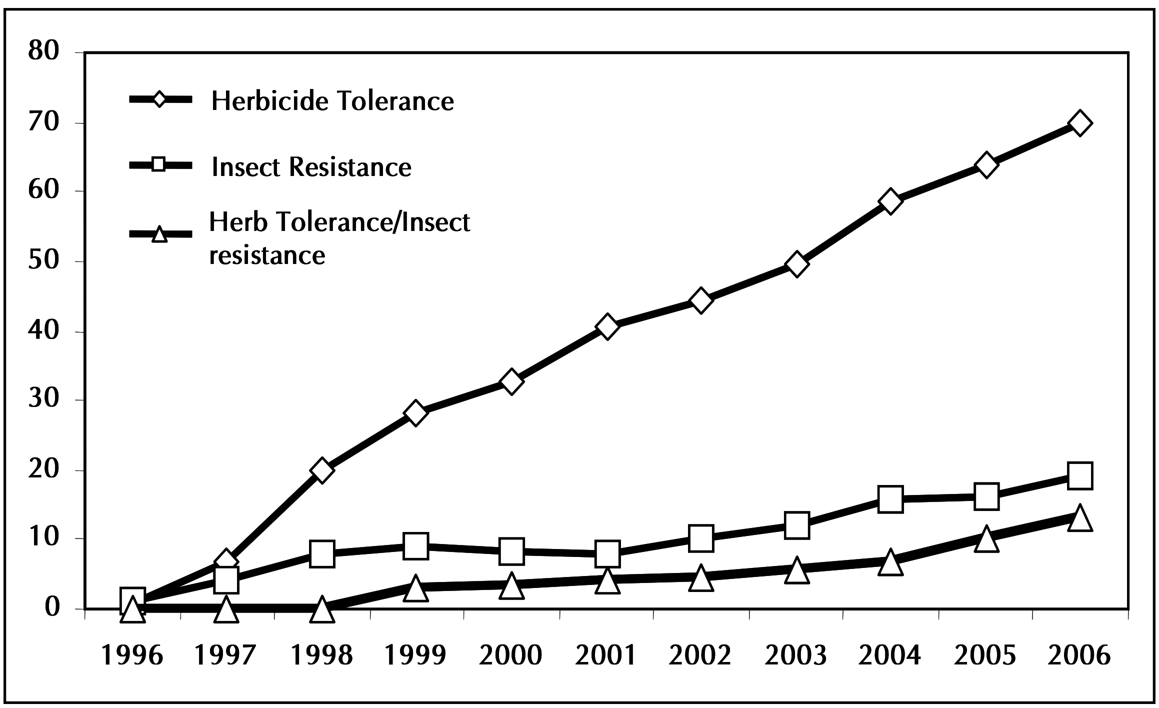
During the eleven year period 1996 to 2006, herbicide tolerance has consistently been the dominant trait with insect resistance second (Figure 6). In 2006, herbicide tolerance, deployed in soybean,

**Table 9. Global Area of Biotech Crops, 2005 and 2006: by Trait (Million Hectares)**

| Trait | 2005 | % | 2006 | % | +/- | % |
|---|---|---|---|---|---|---|
| Herbicide tolerance | 63.7 | 71 | 69.9 | 68 | +6.2 | +10 |
| Insect resistance (Bt) | 16.2 | 18 | 19.0 | 19 | +2.8 | +17 |
| Bt/Herbicide tolerance | 10.1 | 11 | 13.1 | 13 | +3.0 | +30 |
| Virus resistance/Other | <0.1 | <1 | <0.1 | <1 | <0.1 | <1 |
| **Total** | **90.0** | **100** | **102.0** | **100** | **+12.0** | **+13** |

**Source: Clive James, 2006.**

**Figure 6. Global Area of Biotech Crops, 1996 to 2006: by Trait (Million Hectares)**




Source: Clive James, 2006

maize, canola cotton, and alfalfa (for the first time) occupied 69.9 million hectares or 68% of the 102.0 million hectares (Table 9). RR® Flex cotton was introduced in a significant launch the US and Australia for the first time in 2006 on a total of over 800,000 hectares. There were 19.0 million hectares planted to Bt crops, including cotton and maize. It is noteworthy that Slovakia, an EU member country, grew Bt maize for the first time in 2006 bringing the total number of EU countries planting Bt maize to six with a collective total of 70,000 hectares in 2006. Biotech crops with Bt genes occupied 19% of the global biotech area in 2006, with stacked traits for herbicide tolerance and insect resistance deployed in both cotton and maize and occupying 13% of the global biotech area, compared with 11% in 2005 (Table 9). It is significant that the stacked traits of herbicide tolerance and insect resistance in maize and cotton increased by a substantial 30% in 2006. The increase of the stacked traits in maize, a 37% increase from 6.5 million hectares in 2005 to 9.0 million hectares in 2006 was much greater than the corresponding increase in cotton, a 14% increase from 3.6 million hectares in 2005 to 4.1 million hectares in 2006. This significant increase in stacked traits in maize and cotton reflects the needs of farmers who have to simultaneously address the multiple yield constraints associated with various biotic and abiotic stresses. This stacking trend will continue and intensify as more traits become available to farmers and is a very important feature of the technology.

The deployment of stacked traits of Bt and herbicide tolerance is becoming increasingly important and is most prevalent in the US with 69.9 million "trait hectares" in 2006, compared with only 54.6 million hectares. The other five countries deploying stacked traits are Canada (0.2 million hectares), Australia (0.1 million hectares), and Mexico, South Africa and the Philippines with less than 0.1million hectares. The stacked trait in maize, approved in the Philippines in 2005 and first deployed in 2006, was planted on 25,000 hectares in the first year of adoption in 2006. Applications for approval of stacked traits are pending for maize in several countries, including Argentina and South Africa. These countries will derive significant benefits from deploying stacked products because productivity constraints at the farmer level are related to multiple biotic stresses, and not a single biotic stress.

In the US in 2006, over a third (42%) of the biotech maize hectarage featured a double or triple construct of Bt and herbicide tolerant traits whereas over 75% of biotech cotton in the US featured the stacked traits for insect resistance and herbicide tolerance. In Canada, 13% of the biotech maize hectarage had stacked traits for insect resistance and herbicide tolerance in 2006. Similarly in Australia in 2006, 73% of the biotech cotton had stacked traits for insect resistance and herbicide tolerance. The triple gene products in biotech maize, featuring two Bt genes, (one to control the European corn borer complex and the other to control rootworm) and one herbicide trait, first commercialized in the US in 2005, continued to grow in adoption in 2006. The European corn borer and the corn rootworm can both be major economic pests that cost US farmers up to $1 billion dollars, each, per year, in losses and insecticide control costs.

New traits deployed in 2006 include RR® Flex cotton in the US and Australia, RR® Alfalfa in the US, corn rootworm as a single and stacked gene in Canada, the double gene Bollgard II in India as well as two Bt cotton hybrids with single genes.

Distribution of economic benefits at the farm level by trait, for the first decade of commercialization of biotech crops 1996 to 2005 was as follows: herbicide tolerant soybean $14.4 billion, Bt cotton $7.5 billion, insect resistant maize $2.4 billion, herbicide tolerant cotton, $927 million, herbicide tolerant canola $893 million, and herbicide tolerant maize $795 million, for a total of $27 billion. The aggregate economic benefits from herbicide tolerance across all four crops was $17.0 billion equivalent to 63% of the total of $27 billion, with the balance of $10 billion, equivalent to 37% due to insect resistance in cotton and maize.

## Dominant Biotech Crops in 2006

Herbicide tolerant soybean continued to be the dominant biotech crop grown commercially in nine countries in 2006; listed in order of hectarage, the nine countries were the USA, Argentina, Brazil, Paraguay, Canada, Uruguay, South Africa, Romania and Mexico. Globally, herbicide tolerant soybean occupied 58.6 million hectares, representing 57% of the global biotech crop area of 102 million hectares for all crops (Table 10). The second most dominant crop was Bt maize, which occupied 11.1 million hectares, equivalent to 11% of global biotech area and was planted in 13 countries - USA, Argentina, Canada, South Africa, the Philippines, Spain, Uruguay, Honduras,

**Table 10. Dominant Biotech Crops in 2006 (Million Hectares)**

| Crop | 2005 | 2006 | % Biotech in 2006 |
|---|---|---|---|
| Herbicide tolerant Soybean | 54.4 | 58.6 | 57 |
| Bt Maize | 11.3 | 11.1 | 11 |
| Bt/Herbicide tolerant Maize | 6.5 | 9.0 | 9 |
| Bt Cotton | 4.9 | 8.0 | 8 |
| Herbicide tolerant Maize | 3.4 | 5.0 | 5 |
| Herbicide tolerant Canola | 4.6 | 4.8 | 5 |
| Bt/Herbicide tolerant Cotton | 3.6 | 4.1 | 4 |
| Herbicide tolerant Cotton | 1.3 | 1.4 | 1 |
| Herbicide tolerant Alfalfa | -- | <0.1 | <1 |
| Bt Rice | <0.1 | <0.1 | <1 |
| **Total** | **90** | **102.0** | **100%** |

**Source: Clive James, 2006.**

Portugal, Germany, France, Czech Republic and Slovakia The third most dominant crop was Bt/Herbicide tolerant maize, which occupied 9.0 million hectares, and equivalent to 9% of global biotech area and planted in the US, Canada and the Philippines. It is noteworthy that Bt/Herbicide maize, occupied a total of 9.0 million hectares compared with only 6.5 million hectares in 2005, a year-to-year substantial increase of 38%. The fourth most dominant crop was Bt cotton, with 8 million hectares, a 63% growth on 2005, and planted in nine countries, listed in order of hectarage; India, China, Argentina, Brazil (first time n 2006), USA, Australia, Colombia, Mexico and South Africa. The fifth most dominant crop was herbicide tolerant maize occupying 5.0 million hectares, about 47% more area in 2006 than 2005 and planted in six countries, the US, South Africa, Canada, Argentina, the Philippines and Honduras. The sixth most dominant crop was herbicide tolerant canola occupying 4.8 million hectares, <5% more area in 2006 than 2005 and planted in Canada and the US. The four other crops listed in Table 10 occupied from 4% to <1% of global biotech crop area and include, in descending order of area: Bt/herbicide tolerant cotton (4%) grown on 4.1 million hectares in the USA, Australia, and Mexico; herbicide tolerant cotton grown in the USA, Argentina, Australia, Mexico and South Africa on 1.4 million hectares, equivalent to 1% of the global crop biotech hectarage; herbicide tolerant alfalfa grown on less than 0.1 million hectares (80,000 hectares in the US for the first time in 2006) and Bt rice grown in Iran on less than 0.1 million hectares in 2005 and on a similar hectarage in 2006.

## Global Adoption of Biotech Soybean, Maize, Cotton and Canola

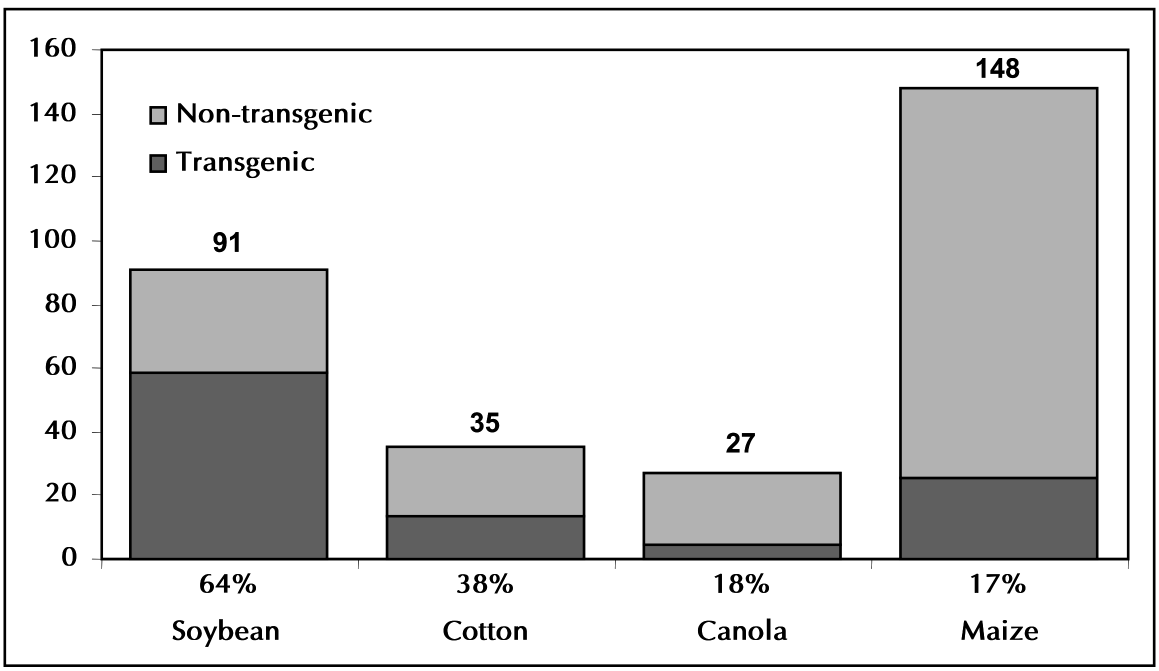
Another way to provide a global perspective of the status of biotech crops is to characterize the global adoption rates as a percentage of the respective global areas of the four principal crops - soybean, cotton, canola and maize - in which biotechnology is utilized (Table 11 and Figure 7). The data indicate that in 2006, 64% of the 91 million hectares of soybean planted globally were biotech - up from 60% in 2005. Of the 35 million hectares of global cotton, 38 % or 13.4 million hectares were biotech in 2006 compared with 28% or 9.8 million hectares planted to biotech cotton in 2005 - an impressive increase from 28% to 38% of global cotton in one year mainly due to the significant 2.3 million hectare increase in Bt cotton in India. The area planted to biotech canola in 2006, expressed on a percentage basis, was 18% or 4.8 million hectares compared with 18%, or 4.6 million hectares of the 26 million hectares of canola planted globally in 2005. Similarly, of the 147 million hectares of maize planted in 2006, 17% or 25.2 million hectares, compared with only 14% or 21.2 million hectares planted to biotech maize in 2005 - a significant 4 million hectare increase in one year on a global basis. If the global areas (conventional plus biotech) of these four crops are aggregated, the total area is 301 million hectares, of which 34%, equivalent to 102 million hectares, were biotech in 2006 - up from 30% in 2005, despite an increase in total global plantings of the four crops from 299 million hectares in 2005 to 301 million hectares in 2006.

Table 11. Biotech Crop Area as % of Global Area of Principal Crops, 2006 (Million Hectares)

| Crop | Global Area* | Biotech Crop Area | Biotech Area as % of Global Area |
|---|---|---|---|
| Soybean | 91 | 58.6 | 64 |
| Cotton | 35 | 13.4 | 38 |
| Canola | 27 | 4.8 | 18 |
| Maize | 148 | 25.2 | 17 |
| **Total** | **301** | **102** | **34** |

**Source: Clive James, 2006.** *FAO 2005 hectarage

Figure 7. Global Adoption Rates (%) for Principal Biotech Crops, 2006 (Million Hectares)




Source: Clive James, 2006

**Table 12. The Global Value of the Biotech Crop Market, 1996 to 2006**

| Year | Value (Million of $US) |
|---|---|
| 1996 | 115 |
| 1997 | 842 |
| 1998 | 1,973 |
| 1999 | 2,703 |
| 2000 | 2,734 |
| 2001 | 3,235 |
| 2002 | 3,656 |
| 2003 | 4,152 |
| 2004 | 4,663 |
| 2005 | 5,248 |
| **2006** | 6,151 |
| **Total** | **35,472** |

**Source: Cropnosis 2006 (Personal Communication)**

Whereas critics of biotech crops often contend that the current focus on biotech soybean, maize, cotton and canola reflects only the needs of large commercial farmers in the richer industrial countries, it is important to note that two-thirds of these 301 million hectares are in the developing countries, farmed mainly by millions of small, resource-poor farmers, where yields are lower, constraints are greater, and where the need for improved production of food, feed, and fiber crops is the greatest.

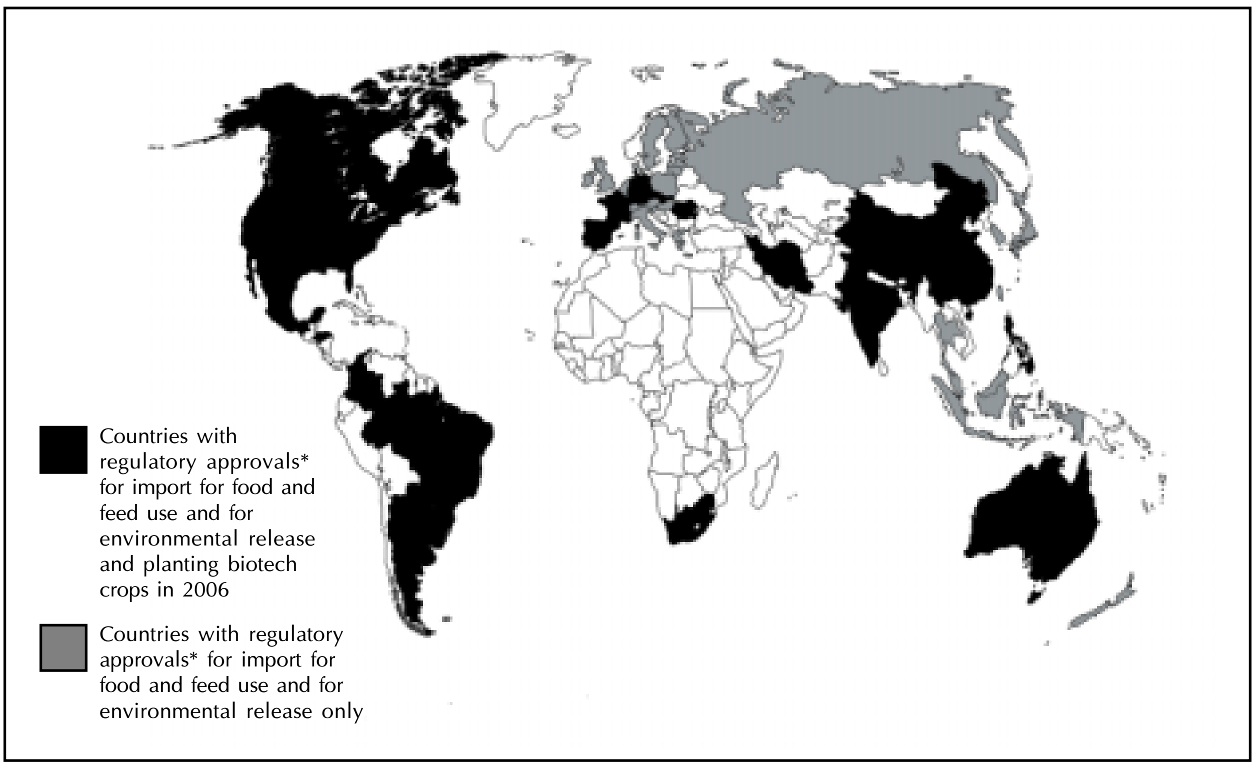
## The Global Value of the Biotech Crop Market

In 2006, the global market value of biotech crops, estimated by Cropnosis, was $6.151 billion representing 16% of the $38.5 billion global crop protection market in 2006 and 21% of the ~$30 billion 2006 global commercial seed market. The $6.15 billion biotech crop market comprised of $2.68 billion for biotech soybean (equivalent to 44% of global biotech crop market), $2.39 billion for biotech maize (39%), $0.87 billion for biotech cotton (14%), and $0.21 billion for biotech canola (3%). The market value of the global biotech crop market is based on the sale price of biotech seed plus any technology fees that apply. The value of the biotech crop market since its commercialization in 1996 is shown in Table 12. The accumulated global value for the eleven-year period, since biotech crops were first commercialized in 1996, is estimated at $35.5 billion. The global value of the biotech crop market is projected at approximately $6.8 billion for 2007.

## Global Status of Regulatory Approvals

This section provides the latest information on the status of all biotech crop products that have received regulatory approvals worldwide. The data in Appendix 1 draws on a large number of sources including government regulatory bodies, publicly available dossiers, and public and private databases available on the internet. This global overview serves to provide an up-to-date summary of all events[12] that have received regulatory approval for import for food and feed use and for release into the environment in a convenient format that allows the reader to quickly analyze the data on a per country basis. Information compiled here describes which crops, events, and traits have been approved in specific countries, who developed them and which year they were approved. The data presented in Appendix 1 is as comprehensive as documented in currently available databases from various countries.

**Figure 8. Global Status of Regulatory Approvals*, through to November 2006**




Source: Compiled by ISAAA, 2006

[12] *An event refers to a unique DNA recombination event that took place in one plant cell, which was then used to generate entire transgenic plants. Every cell that successfully incorporates the gene of interest represents a unique "event". Every plant line derived from a transgenic event is considered a biotech crop. The Event Names correspond to the identifiers commonly used by regulatory authorities and international organizations, such as the Organization for Economic Cooperation and Development (OECD).*

A regulatory approval refers to a product that has been approved for import for food and feed use and for release into the environment. However, a regulatory approval for environmental release in a country must not be interpreted as an indication that the product is being planted commercially in that country. There are many examples of products that were granted regulatory approval but were never commercialized, or if they were, have been subsequently discontinued[16]. Furthermore, in some of the countries listed where environmental, food, and feed safety approvals have been granted, further approvals are necessary to allow commercial planting.

Note that official regulatory documents refer to canola as either Argentine canola (*Brassica napus*) or Polish canola (*Brassica rapa*). The former is the more common canola which is grown commercially in 53 countries. Canola is used in this Brief to refer to both Argentine canola and Polish canola.

### *By country*

A total of 51 countries have granted regulatory approvals for various biotech crops since they were first commercialized in 1996 (Figure 8), more than double the number of countries that planted biotech crops in 2006 (22). The remaining 29 countries in the list include some of the major food importing countries like Japan, South Korea, and Taiwan, and also include New Zealand, the Russian Federation, Malaysia, Singapore, Indonesia, Switzerland, Thailand and 19 countries of the 25 EU member states.

Since 1996, a total of 539 approvals have been granted worldwide (Table 13). The top ten countries with the most approvals granted are the US (77) followed by Japan (76), Canada (57), South Korea (46), Australia (40), Philippines (36), Mexico (36), New Zealand (34), the EU-25 (27), China (25), and the remaining 17 countries with 85 regulatory approvals.

The US has granted the most regulatory approvals (77) since biotech crops were first commercialized 11 years ago. In the US, some approvals cover more than one event whereas in Japan, each event is approved individually. There were two new approvals in the US in 2006. The first was for biotech maize with increased lysine levels (event LYO38) developed for the animal feed market and the second was the more recent deregulation of biotech rice (event LLRICE601) modified for tolerance to the herbicide glufosinate. Despite only two approvals this year, the US planted 10% more biotech crops in 2006 than it did in 2005. In addition to increases in biotech soybean and cotton plantings, there was significant growth in biotech maize with stacked traits for insect resistance and herbicide tolerance. It is noteworthy that the US does not require new approvals for biotech crops with stacked traits if the individual events have been previously approved. Therefore, the data in Appendix 1 does not fully reflect the current status of stacked biotech products that have been approved for use in the US.

[16] *http://www.agbios.com*

Japan follows the US in the number of regulatory approvals granted at 76. It is important to note that this figure is inflated vis-à-vis the US because in Japan, all individual events are approved separately. Japan is one of the largest food importers in the world and relies heavily on imports of maize and soybeans, two major biotech crops produced in the U.S and it also imports canola, mainly from Canada, which is the major biotech canola producer. Due to strong anti-biotech concerns among consumers in Japan, there is currently no commercial production of biotech crops in the country even though some products have been cleared for planting. Some localities, including the Hokkaido Prefecture have additional legislation or guidelines for the planting of biotech crops to protect their local products. A uniquely colored (blue) carnation developed by modern biotechnology is commercially marketed by Suntory Co. but it is grown abroad and imported into Japan.

Like the US, the data for Canada in Appendix 1 does not fully reflect the deployment of stacked traits because Canada's system is also based on product novelty, i.e. only if the stacked traits have some new events , that are not present in the parent events is approval required. None of the existing stacked events in the marketplace have triggered a separate authorization by the Canadian Food Inspection Agency and there are no requirements for separate approvals (or even notifications) of stacked events by Health Canada.

South Korea, like Japan, imports substantial amounts of biotech crops and products that are further processed to make products such as soybean oil. To date, South Korea has approved 46 biotech events for food. However, no biotech crops have been planted as commercialized biotech crops in South Korea. So far, the process for biotech crop and food approval has only been applied to imported products. South Korea has two separate systems, one for obtaining food safety approvals and the other for Environmental Risk Assessments, (ERAs) for biotech food and crops. At present, food safety approvals for biotechnology crops are mandatory but ERAs are voluntary. To date, no ERAs for intentional environmental release (i.e., planting) have been completed. Thus, the scope of all ERAs that have been completed so far has been limited to assessing the environmental risk of unintentional release.

In Australia, of the 40 approvals granted, only three crops have been approved for commercial planting: cotton, carnations, and canola with only one of these crops, biotech cotton, grown widely commercially at this time. The commercial releases of two biotech canola varieties (InVigor® hybrid & Roundup Ready®) were approved by the Office of the Gene Technology Regulatory (OGTR) in 2003. However, commercial plantings of these varieties have been precluded due to moratoriums that have been implemented by state governments in Australia's major canola producing states. As a result of the bans, Monsanto has withdrawn their Roundup Ready® canola product from the Australian market. With respect to biotech cotton, in the interest of resistance management, Australia has completely substituted the single Bt gene product, Bollgard 1 (event MON 531) with the dual Bt gene varieties (Bollgard 2 event MON 15985).

**Table 13. Global status of GM Products that have received regulatory approvals since 1996**

| Country | No. of Approvals | Crops (No. of Approvals) | Traits |
|---|---|---|---|
| USA | 77 | Alfalfa (1), canola (10), chicory (1), cotton (12), creeping bentgrass (1), flax (1), maize (22), melon (1), papaya (1), potato (6), rice (2), soybean (6), squash (2), sugar beet (3), tobacco (1), tomato (6), wheat(1) | Herbicide tolerance, insect resistance, oil content, fertility restored, lysine content, delayed ripening, virus resistance, nicotine reduction |
| Japan | 76 | Alfalfa (3), canola (15), carnation (1), cotton (16), maize (25), potato (8), soybean (4) , sugar beet (3), tomato (1) | Herbicide tolerance, insect resistance, oil content, flower color, delayed ripening, virus resistance |
| Canada | 57 | Alfalfa (1), canola (12), cotton (8), flax (1), maize (18), papaya (1), potato (4), rice (1), soybean (3), squash (2), sugar beet (2), tomato (4) | Herbicide tolerance, insect resistance, oil content, flower color, delayed ripening, virus resistance, fertility restored, lysine content |
| Korea | 46 | Canola (6), cotton (11), maize (23), potato (4), soybean (1), sugar beet (1) | Herbicide tolerance, insect resistance, virus resistance |
| Australia | 40 | Canola (7), carnation (2), cotton (11), maize (12), potato (3), soybean (3), sugar beet (2) | Herbicide tolerance, insect resistance, oil content, flower color, delayed ripening, virus resistance, fertility restored |
| Philippines | 36 | Alfalfa (1), canola (1), cotton (7), maize (21), potato (3), soybean (1), sugar beet (2) | Herbicide tolerance, insect resistance, virus resistance, lysine content |
| Mexico | 36 | Alfalfa (1), canola (4), cotton (11), maize (11), tomato (3), potato (3), soybean (2), sugar beet (1) | Herbicide tolerance, insect resistance, oil content, virus resistance |
| New Zealand | 34 | Canola (7), cotton (7), maize (12), potato (3), soybean (2), sugar beet (2) | Herbicide tolerance, insect resistance, virus resistance, fertility restored |
| EU (=25) | 27 | Canola (6), carnation (3), chicory (1), cotton (5), maize (10), soybean (1), tobacco (1) | Herbicide tolerance, insect resistance, flower color, altered shelf life |
| China | 25 | Canola (7), cotton (4), maize (8), tomato (3), petunia (1), soybean (1), sweet pepper (1) | Herbicide tolerance, insect resistance, flower color, delayed ripening, virus resistance |
| Others | 85 | Canola (1), carnation (1), cotton (13), maize (48), potato (4), rice (2), soybean (14), sugar beet (2) | Herbicide tolerance, insect resistance, fertility restored, virus resistance |
| **51** | **539** | | |

**Source: Compiled by ISAAA, 2006.**

The Philippines continues to be the regional leader in South East Asia in biotech development with 36 events approved for import for food and feed use and for release into the environment. Four events in maize have been approved for planting since 2002: insect resistance (IR) maize (MON 810), herbicide tolerant (HT) maize (NK603), HT and IR maize (Bt 11); and HT and IR maize (MON603 x MON810).

Mexico is now the second largest US agricultural export market, surpassing Japan in 2004. In 2005, Mexico imported US $9.9 billion worth of agricultural products from the US. These included 5.7 million tons of corn, 3.7 million tons of soybeans, and 387,000 tons of cotton. Biotech-derived products such as grains, feeds, and oilseeds represent roughly half of the value of total U.S. agricultural exports to Mexico. Thirty-six biotech events have been approved for human consumption in Mexico (Appendix 1). Unlike the US, Mexico does not make a distinction between food and feed approval, but rather approves both for human consumption. Mexico commercializes biotech cotton and soybean and has approved field experiments for biotech crops in accordance with the Biosafety Law which came into force in February 2005.

Biotech crops are not commercially grown in New Zealand at present. However, 34 food products with biotech crop content are legally offered for sale and consumption, having been approved by the Food Standards New Zealand authority (see Appendix 1). To date, no application has been made for government approval for a commercial release of a biotech crop in New Zealand.

The EU has granted Food/Feed approvals for 27 biotech events, and has granted planting approvals for carnation, canola and maize. However, only biotech maize varieties derived from insect resistance MON810 maize are grown widely commercially at present. A total of 31 varieties (17 in 2004 and 14 in 2005) have been inscribed in the Common EU Catalogue of Varieties of Agricultural Plant Species. Seeds of varieties in the Common Catalogue can be marketed in the entire EU. In 2006, six countries of the EU, Spain, France, Czech Republic, Portugal, Germany, and Slovakia planted MON810 maize varieties in 2006.

China has approved commercialization of four biotech crops since 1997, including cotton (3 events), tomato (3 events), sweet pepper (1 event) and petunia (1 event), with only Bt cotton widely grown. However, China has approved more biotech products for import and processing: 7 events in canola, 1 event in cotton, 8 events in maize and 1 event in soybean (Appendix 1). China remains the largest market for US biotech crops, particularly biotech soybeans. In September 2006, it was gleaned that China's National Biosafety Committee had recommended commercialization of a locally developed biotech papaya resistant to papaya ringspot virus (PRSV).

The remaining 17 countries of the 51 have granted regulatory approvals for a total of 85 biotech events for import for food and feed use and release into the environment (see Table 13). The absence of regulatory approvals in most of Africa (Figure 8) is noteable. However, in practice, biotech products are imported by many countries.

### *By crop and trait*

A total of 21 crops have received regulatory approvals since the first crop was commercialized in 1996. The top four crops with the most approvals are maize at 210, followed by cotton 105, canola 76, and soybean with 38 approvals. Other biotech crops that have been approved include alfalfa, chicory, creeping Bentgrass, flax-linseed, melon, papaya, petunia, potato, rice, squash sugar beet, sweet pepper, tobacco, tomato, and wheat. The traits that have been introduced into these crops include herbicide tolerance, insect resistance, fertility restoration, modified lysine content, modified oil content, delayed ripening or altered shelf-life, virus resistance, modified flower color, and nicotine reduction. Herbicide tolerance and insect resistance are the two most popular traits to be approved.

### *By event*

A total of 107 events have been approved for 21 crops (Table 14). Maize has the most events approved (35) followed by cotton (18), Argentine canola (14), and soybean (7). However, the event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 21 approvals (EU=25 counted as 1 approval only), followed by insect resistant maize (MON 810) and herbicide tolerant maize (NK603) with 18 approvals, then by insect resistant cotton (MON 531/757/1076) with 16 approvals worldwide (Table 15).

## Global Overview of Biofuels

This overview of biofuels serves to introduce the subject, and is focused on the implications of the growing interest and investments in biofuels in relation to two specific topics - crop biotechnology, and the developing countries - which is entirely consistent with ISAAA's mandate of alleviating poverty and sharing knowledge on crop biotechnology applications of potential benefit to developing countries.

Several factors have contributed to the recent increase in interest and investments in biofuels. These include the recent rise of the price of oil up to US$70 barrel, growing concern about increasingly high consumption of oil and moreover that the supply of fossil fuels is finite and concentrated in geographical areas which could seriously disrupt supplies in a world of political turmoil. Between 2002 and 2004, world oil demand increased by 5.3% whereas China's consumption alone increased by 26.4%, the US by 4.9%, Canada by 10.2% and the UK by 6.3%. Increasing concerns about global warming and greenhouse gas (GHG) emissions from fossil fuels, which biofuels can help reduce, has resulted in heightened interest in biofuels. During 2005, biofuels may have entered a new golden era of "green gold" having attracted substantial long-term commitments of resources and investments worldwide from both the public and private sectors.

There are two principal biofuels currently in use, ethanol produced from sugarcane, maize and other starchy grains, and biodiesel produced principally from rapeseed/canola, soybean and palm

**Table 14. Number of events approved per crop**

| Crop | Number of Events |
|---|---|
| Maize | 35 |
| Cotton | 18 |
| Argentine Canola | 14 |
| Soybean | 7 |
| Tomato | 6 |
| Potato | 4 |
| Carnation | 3 |
| Sugar Beet | 3 |
| Polish Canola | 2 |
| Tobacco | 2 |
| Squash | 2 |
| Rice | 2 |
| Alfalfa | 1 |
| Creeping Bentgrass | 1 |
| Chicory | 1 |
| Flax-Linseed | 1 |
| Melon | 1 |
| Papaya | 1 |
| Sweet pepper | 1 |
| Petunia | 1 |
| Wheat | 1 |
| **Total** | **107** |

**Source: AgBios**

**Table 15. Most approved events - Top 8**

| Event | Trait* | No. of Approvals** |
|---|---|---|
| Soybean GTS 40-3-2 | HT | 21 |
| Maize MON810 | IR | 18 |
| Maize NK603 | HT | 18 |
| Cotton MON 531/757/1076 | IR | 16 |
| Maize Bt 11 | HT + IR | 15 |
| Maize GA21 | HT | 14 |
| Maize Bt 176 | HT + IR | 13 |
| Maize TC1507 | HT + IR | 13 |

* HT - herbicide tolerance; IR - insect resistance ** EU counted as 1 approval (=25 countries)

**Source: Compiled by ISAAA, 2006**

oil. To put biofuels into context, global biofuel production in 2004 was only 33 billion liters, equivalent to only 3% of the 1,200 billion liters of gasoline used. Brazil has been the world leader in the production and consumption of sugarcane-based ethanol for the last 25 years, followed by the US where ethanol production from maize increased rapidly from 4 billion liters in 1996 to 44 billion liters in 2005. The recent high priority accorded to biofuels by the US, which used 18% of its maize production to generate 2% of the non-diesel transport fuel in 2005 allowed the US to overtake Brazil in ethanol production in 2005 (Table 16). The US has 97 ethanol plants in production and another 33 more under construction. Other countries producing ethanol, listed in alphabetical order, include China, France, Germany, India, Russia, South Africa, Spain and Thailand. Ethanol accounts for 90% of biofuels today, and biodiesel for the balance of 10%. Ethanol is generated through fermentation of sugar and starchy grain crops and biodiesel is produced through esterification of vegetable oil from oilseed crops such as rapeseed or soybean and the addition of methanol. The global production of biodiesel was almost 4 billion liters in 2005 with Germany playing the principal role to-date, using rapeseed and sunflower seeds followed by France, US and Italy with several other countries at a lower level of production, including Czech Republic, Austria, Spain, Denmark, Poland, and the United Kingdom (Table 17).

Both ethanol and biodiesel can be blended with gasoline and petroleum-diesel respectively, and used in conventional vehicle engines or in modified engines designed for 100% biofuels or blends of high biofuel content. Feasibility studies have indicated that the US has the potential to substitute up to 37% of gasoline within 25 years and a corresponding substitution of 25% in the EU for transport fuel, which is expected to be responsible for 90% of the increase in greenhouse gas emissions by 2010. Accordingly, the EU has a policy to substitute 5.75 % of transport fuel with biofuel by 2010 and 25% by 2030. For the short term, goals for biofuel production in the next 10 to 15 years will be met with the "first generation" technologies of ethanol and biodiesel from the food crops sugarcane, maize, rapeseed and soybean and palm oil.

However, the longer term goals will need a "second generation" of technologies that will feature the production of biofuels from energy crops, rich in ligno-cellulose biomass such as the tall grasses of switch grass (*Panicum virgatum*) and *Miscanthus*, fast growing trees including willow, hybrid poplar and eucalyptus, crop waste products including straw, maize stover, bagasse, sawdust, wood thinnings and organic residues such as wood from municipal solid waste. These "second generation" technologies are required for two reasons. Firstly, to expand by a quantum amount, the volume of biomass feedstocks, and secondly to increase significantly the efficiency and cost-effectiveness of converting biomass to liquid biofuel. It is speculated that ethanol from cellulose could bring down the cost of ethanol to as low as 25 cents per liter. The green house gas (GHG) balance of biofuels will vary by source of biomass and processing but all biofuels contribute to a positive balance with the greatest benefits from cellulose biomass, and all the biofuel crops also sequester carbon in the soil during the growing cycle in the field.

**Table 16. World ethanol production by country, 2005**

| Country | Production (Million Liters) | Production (Million Gallons) |
|---|---|---|
| United States | 16,214 | 4,283 |
| Brazil | 16,067 | 4,244 |
| China | 3,800 | 1,004 |
| India | 1,700 | 449 |
| France | 910 | 240 |
| Russia | 750 | 198 |
| South Africa | 390 | 103 |
| Spain | 376 | 99 |
| Germany | 350 | 92 |
| Thailand | 300 | 79 |
| Rest of World | 4,017 | 1,063 |
| **World** | **44,875** | **11,855** |

**Source: F.O. Licht, "Ethanol: World Production, by country," table, World Ethanol and Biofuels Report, vol. 4, no. 17 (May 2006), p. 395**

**Table 17. World Biodiesel production by country, 2005**

| Country | Production (Million Liters) | Production (Million Gallons) |
|---|---|---|
| Germany | 1,921 | 507 |
| France | 557 | 147 |
| United States | 284 | 75 |
| Italy | 227 | 60 |
| Czech Republic | 136 | 36 |
| Austria | 85 | 22 |
| Spain | 84 | 22 |
| Denmark | 80 | 21 |
| Poland | 80 | 21 |
| United Kingdom | 74 | 20 |
| Rest of World | 236 | 62 |
| **World** | **3,762** | **994** |

**Source: F.O. Licht, "Ethanol: World Production, by country," table, World Ethanol and Biofuels Report, vol. 4, no. 16 (April 2006), p. 365**

Production of biofuel will be in diffusely distributed biorefineries in the rural areas that will generate biofuel as the principal product plus higher value enriched secondary products such as enriched animal feed that will create added value and hence contribute to increased efficiency and lower cost of biofuel. Unlike large centralized fossil fuel refineries, biofuel production lends itself for decentralization with large numbers of small distilleries and hence can contribute to rural development, which is an important goal for most developing countries whose populations are predominantly rural. One of the original issues with biofuels was that the energy required to produce them was more than the energy they generated i.e. a negative energy balance. Whereas this was a valid critique of early experiences with maize, the energy balance is now well over 1 as a result of higher "biofuel yield" from improved maize (which could be significantly further enhanced through biotechnology) and also in ethanol refining. Estimates of the long-term potential of biofuel depend on many factors but the more optimistic scenarios project that they could equal current oil supplies by 2050. However, over the next two decades the existing food crops of sugarcane, maize, rapeseed, soybean, and palm oil, rich in sugar, starch and oil will provide the majority of the biofuel. Based on current technology, by far the most efficient strategy is to utilize sugarcane for the production of ethanol and this presents an opportunity for some of the 100 developing countries that grow sugarcane.

A quantum increase in production of biofuel from food crops over the next 20 years presents both opportunities and challenges for crop biotechnology and for the developing countries. Increasing production of food crops for biofuel must be achieved without reneging on the pledge made by the global community to a global food, feed and fiber strategy embodied in a commitment to the developing countries to reduce poverty and hunger by 50% by 2015. Biofuel targets must not be achieved at the expense of food security. Thus, a strategy must be in place to address the issues involved in the food versus fuel debate, particularly as it relates to the developing countries where there is a food deficit that currently affects 850 million hungry and poor people in the world, 80% of whom are in the rural areas, and the majority of whom are resource-poor subsistence farmers surviving on less than one dollar a day and less than one hectare of land. Contrast this to Europe which has a set-aside policy for surplus agricultural land and is projecting that from 3% to 14% of crop land will need to be devoted to the production of food crops for biofuels, employing a sustainable land strategy that is compatible with EU policies on climate change, the environment and the broader socio economic framework. Compared with temperate regions like the EU, there is a much greater potential for producing biofuel that is competitively priced in high yielding food crops like sugarcane in developing countries, which generally have a tropical climate that is conducive for fast crop growth and where land and labor costs are significantly lower.

The new interest in biofuels has already ignited global agricultural commodity markets with futures in maize reaching 10 month highs and rapeseed reaching record highs due to prospects of more demand for both crops for biofuel. Cost and competitiveness of biofuel with gasoline and diesel will continue to be a principal challenge, and to a significant extent the price of biofuels will depend on the potential of biotechnology to contribute to increased efficiency by increasing the yield and energy content of food crops - biotechnology is judged to offer many opportunities in both the near- and long-term.

Biotech can be used to increase the "biofuel yield" of crops in several ways. For example, for a crop such as sugarcane, some traits have already been incorporated to reduce losses to biotic stresses associated with pests, weeds and diseases and to abiotic stresses due to drought and salinity. Biotech can also effect changes to optimize sugar content and quality. More advanced biotech applications can be used to increase the potential yield or ceiling of sugarcane. Some of the modifications, such as control of biotic stresses have already been commercialized in several crops including maize, soybean and cotton and therefore can be incorporated relatively fast in sugarcane which has not yet benefited from commercialized biotechnology applications but experimental work has been undertaken on the crop; resistance to the lethal virus sugarcane mosaic virus (SCMV) has been developed as well as herbicide tolerant varieties. Applications for biotech sugarcane have already been submitted for approval in Brazil. With the advent of trade liberalization in sugar, all the major producers of sugar, including sugar beet producers in the EU will have to invest more in R&D to remain competitive and biotech investments are likely to be key. Molecular marker technology for sugarcane improvement is already being extensively used in the Philippines, and Brazil has the advantage of having already sequenced the crop's genome.

Sugarcane (*Saccharum officinarum*) is a tall grass, originally from Asia, which requires a tropical or subtropical climate and a minimum of 400 mm of moisture annually. Sugarcane is a C4 crop and is one of the most efficient photosynthesizers, capable of converting up to 2% of incident solar energy into biomass, which translates to 20kg of biomass per square meter. Sugarcane is propagated from cuttings, not seed, although some types produce seeds. Up to 10 harvests can be taken from sugarcane after the first planting - the new stalks that grow after the first harvest are called ratoons. The biological characteristics of sugarcane (high level of polyploidy and vegetative propagation) have made crop improvement through conventional means both difficult and slow. Biotechnology applications can help overcome or reduce some of the constraints associated with conventional approaches. In summary, sugarcane is by far the most efficient and likely crop that developing countries could select for ethanol production and the prospects look promising for improving the biofuel yield of sugarcane with biotechnology.

### *Production of ethanol from sugarcane in developing countries*

As noted above there are several biological characteristics of sugarcane as a crop, which make it attractive as a biofuel crop for the production of ethanol in the developing countries of the world. Moreover, based on the most recent FAO 2004 data, approximately 95% of the global sugarcane crop of 19.7 million hectares is cultivated by 95 developing countries with only 800,000 hectares grown by two industrial countries, Australia (420,000 hectares) and the US (387,000 hectares). The top five countries for sugarcane, by area and production, are all developing countries. They are Brazil (5.8 million hectares and 420 million metric tons (MT), of sugarcane production), India (3.8 million hectares and 232 million MT of production), China (1.3 million hectares and 88 million MT of production), Thailand (1 million hectares and 49 million MT of production) and Pakistan (1 million hectares and 47 million MT of production).

Other characteristics of sugarcane that make it attractive as a crop are its high labor requirement with the labor representing some of the poorest labor markets in developing countries. The potential benefits of using sugarcane to produce ethanol are important in that it would provide new opportunities for creating a sustained demand for labor at higher income levels, which would contribute to the alleviation of poverty for a targeted group of agricultural laborers with one of the lowest income ratings in the developing world and where employment is also often uncertain. Most of the sugarcane is grown on large estates and Governments electing to produce ethanol from sugarcane should ensure, through legislation, that the large and poorly paid sugarcane labor force share some of the benefits through incentive orientated profit sharing schemes.

Projections suggest that world production of sugarcane, could be expanded to substitute for 10% of all gasoline worldwide. Thus, the potential benefits for developing countries, which represent the majority (95%) of the global hectarage are evident, provided there is a high priority already in place to address food security and alleviation of poverty. The advent of biofuels, particularly ethanol from sugarcane has the potential to coincidentally provide:

- new opportunities for sustained domestic economic growth and exports for developing countries;
- increased income and benefits for some of the poorest of the poor in the rural areas who work on sugar plantations and small farms in the developing countries;
- billions of fuel consumers in both industrial and developing countries with a renewable and affordable energy resource that can contribute to a safer and more sustainable environment.

Of the 47 poorest countries in the world, 38 are net importers of oil and 25 are completely dependent on imports. Most of these poor countries have a strong agricultural base and at least 30 developing countries, including 12 in Africa are exploring or expanding the use of biofuels. An attractive feature of biofuel for developing countries is that not only can biofuel production be decentralized in small distilleries in rural areas where unemployment and poverty is high, but also it is much more labor intensive than fossil fuel. In a recent study the World Bank concluded that biofuels require 100 times more labor than fossil fuel. In Brazil, biofuel is credited with providing 500,000 more jobs. It is instructive to review in more detail the experience of Brazil, a developing country, and the world leader in biofuel.

***The Brazil Experience with ethanol from sugarcane***

Following the OPEC global price hike of gasoline in the 1970s, Brazil was the first country in the world to initiate a Pro-Ethanol program and is now ahead of any other country in biofuel production and consumption. By law, all gasoline in Brazil must contain a minimum of 25% ethanol produced from sugarcane, and now the majority of the vehicles in Brazil can run on any blend of ethanol and gasoline. Thirty years after its initial investment, Brazil is self-sufficient in ethanol, and produced 14 billion liters in 2005 plus 2 billion liters for export, and is exploring further exports to the United States, China and India; it is projected that exports could increase to 10 billion liters within a few years with a new ethanol distillery being built every month. Brazil also has a biodiesel program in place and recently announced a new biodiesel called H-Bio, which is a mixture of cotton, castor beans, sunflower seeds and soybean. Unlike other biodiesel it is mixed by the distributor and not by the refinery, which is estimated to save $145 million/year. Even allowing for subsidies, the savings for Brazil from substituting ethanol for the period 1976 to 2004 were $61 billion or $121 billion if savings on servicing foreign debt for oil is included in the calculation. Brazil is hoping to emulate its success with ethanol with biodiesel, and legislation is already in place that will require 2% biodiesel in all diesel fuel by 2008 increasing to 5% by 2013. Government policy targets poor farmers in the North and North East as potential beneficiaries for sharing the benefits from biodiesel.

Brazil has the largest area of sugarcane in the world (5.8 million hectares out of a global total of 19.7 million hectares) and it currently uses half of its sugarcane crop to provide 40% of its non-diesel transport fuel. The cost of producing one liter of ethanol from sugarcane in Brazil is the most efficient worldwide at $0.19 cents, compared with $0.32 cents from maize in the US. Brazil has also invested in strategic upstream biotechnology R & D in sugarcane and completed the sequencing of sugarcane in 2003 following a coordinated effort by more than 200 scientists from 22 institutions in Brazil. This and other research investments have opened up new opportunities for enhancing significantly the "biofuel yield" of sugarcane and for optimizing the exports of biofuel to both developing and industrial countries. The comparative advantage in R &D along with the phasing out of EU subsidies for sugar processors should help Brazil gain significant advantage in the sugar and ethanol export markets.

***Biofuel status in Latin America, Asia and Africa***

Many of Brazil's neighboring countries in Latin America and the Caribbean are eager to emulate Brazil's success with ethanol. These include Colombia which has required 10% percent ethanol in all gasoline sold in cities of 500,000 people or more as of early 2006. Venezuela, which is a major producer of fossil-based fuels, will construct 15 sugarcane distilleries during the next 5 years and is promulgating legislation that will require 10% ethanol (E10). Similarly, Bolivia, which is a smaller and poorer country than Venezuela, is also constructing 15 distilleries and considering legislation for mandating a 25% ethanol mix (E25) in all gasoline sold in the country. Cuba, a large sugarcane producer, has a current capacity of approximately 100 million liters of ethanol annually with plans to increase this five-fold by 2010. There are currently 17 distilleries in Cuba and another 7 are planned. Cuba is also researching the bush *Jatropha* which is capable of producing up to 1,500 liters of biodiesel per hectare. In Central America, Costa Rica and Guatemala are at the exploratory stage for producing ethanol from sugarcane. Finally, Argentina, Jamaica, Mexico, Paraguay and Peru all have biofuel under consideration leaving very few countries on the continent that are not pursuing active programs in biofuels.

Generally in Asia the major crop that will be used for biofuel in the future is likely to be palm oil for biodiesel, but ethanol is currently being produced in many countries from maize, wheat and cassava. China, the third largest producer of ethanol in the world, has built the biggest ethanol plant in the world (100,000 ton annual output) and the Government is promulgating a law that requires an ethanol blend of 10% (E10) in all gasoline sold in 5 provinces which account for 16% of all cars nationally. China is also expanding biodiesel production. Currently, maize and wheat are being used by China for ethanol production from large stocks of these two grains that had accumulated for some time but now stocks are already running low and constraining biofuel production. In an effort to preclude rising prices of these two food/feed commodities, China is exploring imports of cassava from Thailand, and contracting with Laos to grow cassava to satisfy the growing demand for feedstocks for ethanol production. If China is obliged to depend only on maize and wheat for expanded ethanol production this could stall its ambitious biofuel program. Although China is the third largest grower of sugarcane (the ideal crop for ethanol) in the world after Brazil and India, sugarcane is only grown in 3 provinces, with no room for expansion and the price of sugar is already high, due to a very fast-growing food industry. India has already legislated for E5 blends in most of the country and plans to upscale this to E10 and E20, subject to an adequate supply of ethanol, and is also expanding production of biodiesel. In South East Asia the four countries of Thailand, Philippines, Indonesia and Malaysia are investing in biofuels. Thailand is scheduled to have 13 ethanol plants operational by the end of 2007 compared with two at present and cassava demand for ethanol could increase from the current 1 million tons to 3 million tons per annum. Thailand is producing ethanol from sugarcane and cassava grown by small resource-poor farmers and has legislated a 10% blend of ethanol starting in 2007. Similarly the Philippines plans to promulgate a law requiring 2% biodiesel and 5% ethanol in support of their large number of coconut growers - the legislation is planned for 2007. Finally, Malaysia and Indonesia, both with large palm oil plantations are planning to expand the production of biodiesel.

In Africa, many countries in all regions are exploring the production of biofuels or expanding its current use. The countries range from large countries such as Nigeria, which is a large producer of fossil fuels, and South Africa, to countries such as Zimbabwe, which is entirely dependent on imports for fuel. The African countries exploring the production or increased use of biofuels, listed in alphabetical order, are Benin, Ethiopia, Ghana, Guinea Bissau, Kenya, Malawi, Mozambique, Nigeria, Senegal, South Africa, Zambia, and Zimbabwe.

***Summary***

It is evident that biofuels offer potentially significant advantages to developing countries, which need to be carefully explored on a country-by-country basis.

- First and foremost any investment in food crops for biofuels, must not undermine or compete, but complement the programs in place aimed at food, feed and fiber security and alleviation of poverty in food insecure countries.

- Secondly, any program developed in biofuels must be sustainable in terms of agricultural practice and forest management, the environment, the ecosystem, particularly the responsible and efficient management of water, which is the major constraint to increased productivity, particularly on rainfed and marginal lands.

- Thirdly, most developing countries, with the exception of Brazil, would benefit significantly from forging strategic partnerships with public and private sector organizations from both industrial countries and the advanced developing countries led by Brazil, which are knowledgeable and experienced in the production, distribution and consumption of biofuels and also have the biotechnology capability to ensure that they remain competitive in biofuel production.

- Fourthly, biofuels should not only benefit the national economy of the country but benefit the poorest people in the country, who are mainly in the rural areas, most of whom are small resource-poor subsistence farmers and the landless labor who are entirely dependent on agriculture and forestry for their livelihoods.

## Concluding Comments

In 2006, the first year of the second decade of commercialization of biotech crops, 2006-2015, the global area of biotech crops continued to climb at double-digit rates to 102 million hectares (equivalent to 117.7 million "trait hectares"), with a 13% gain, equivalent to 12 million hectares, the second highest increase in the last five years. In 2006, the following global milestones were achieved for biotech crops for the first time:

- Exceeded 100 million hectares of biotech crops planted in one year;
- More than 10 million farmers grew biotech crops in 22 countries;
- Bt cotton hectarage in India at 3.8 million hectares exceeded Bt cotton hectarage in China at 3.5 million hectares placing India at number 5 in the world biotech crop rankings in 2006 compared with number 7 in 2005;
- An accumulated biotech crop hectarage, for the period 1996 to 2006, exceeding 500 million hectares, resulting from an unprecedented 60-fold increase in adoption since 1996, the first year of commercialization of biotech crops.

It is noteworthy that more than half (55% or 3.6 billion people) of the global population of 6.5 billion live in the 22 countries where biotech crops were grown in 2006 and generated significant and multiple benefits. Also notable is that more than half (52% or 776 million hectares of the 1.5 billion hectares of arable land) of the cropland in the world are in the 22 countries where approved biotech crops were grown in 2006.

The positive experience of the first 11 years of commercialization of biotech crops, 1996 to 2006, has been consistent and compelling, and has met the expectations of millions of large and small farmers in both industrial and developing countries. A cumulative total of over 577 million hectares (1.4 billion acres), equivalent to almost half of the total land area of the USA or China, were planted globally in 25 countries in the 11-year period 1996 to 2006. The 60-fold increase in global commercialized biotech crops in the same 11-year period represents the highest adoption rate for any crop technology in recent times. This very high adoption rate by farmers reflects the fact that biotech crops have consistently performed well and delivered significant economic, environmental, health and social benefits to both small and large farmers in developing and industrial countries. Thus, this is a strong vote of confidence resulting from approximately 45 million individual decisions by farmers in 25 countries over an 11-year period to plant biotech crops, year after year, after gaining first-hand insight and experience with biotech crops on their own or neighbor's fields. The number of farmers benefiting from biotech crops continued to grow in 2006 to reach 10.3 million, up from 8.5 million in 2005. Notably, 90%, equivalent to 9.3 million (compared with 7.7 million in 2005) benefiting from biotech crops were small resource-poor farmers mostly planting Bt cotton, whose increased incomes have contributed to the alleviation of their poverty. The 9.3 million small farmers included: 6.8 million resource-poor farmers in all the cotton growing provinces of China; 2.3 million, and rapidly growing, small farmers in India; 100,000 thousand small farmers growing Bt maize in the Philippines and several thousand in South Africa, including women cotton farmers in the Makhathini Flats in KwaZulu Natal province; with the balance in the other seven developing countries where biotech crops were planted in 2006.

Ford Runge and Barry Ryan of the University of Minnesota estimated that the global value of total crop production from biotech crops in 2003/04 was $44 billion[17], and by extrapolation the value will probably have reached $50 to $55 billion in 2006.

Biotech crops are also delivering benefits that are less evident to consumers and society at large, through more affordable food, feed and fiber that require less pesticides and hence a more sustainable agriculture. In developing countries, biotech crops have also delivered invaluable humanitarian social benefits to poor subsistence farmers and the rural landless dependent on agriculture for their livelihood, in terms of a contribution to the alleviation of poverty, hunger and malnutrition.

[17] *Runge and Ryan. 2004. The Global Diffusion of Plant Biotechnology: International Adoption and Research in 2004. University of Minnesota.*

The most recent survey of the global impact of biotech crops for the first decade of commercialization of biotech crops, 1996 to 2005, by Graham Brookes and Peter Barfoot, PG Economics, estimates that the global net economic benefits to crop biotech farmers in 2005 was $5.6 billion, and $27 billion for the accumulated benefits during the decade 1996 to 2005; these estimates include the benefits associated with the double cropping of biotech soybean in Argentina. The accumulative reduction in pesticides for the decade 1996 to 2005 was estimated by Brookes & Barfoot at 224,300 MT of active ingredient, which is equivalent to a 15% reduction in the associated environmental impact of pesticide use on these crops, as measured by the Environmental Impact Quotient (EIQ) - a composite measure based on the various factors contributing to the net environmental impact of an individual active ingredient. In addition to the direct savings from insect resistant and herbicide tolerant traits associated with yield improvements, reduced pesticides, fuel and labor, there were also indirect benefits associated with herbicide tolerance related to an increased usage of no/low till systems and lower fuel consumption. These benefits (direct and indirect) have contributed to a permanent reduction in carbon dioxide emissions and resulted in higher carbon sequestration in soil, estimated to have produced carbon dioxide savings of approximately 9 billion kg in 2005 alone.

Biotech crops can potentially contribute to reduction of greenhouse gases and climate change in three principal ways. First, permanent savings in carbon dioxide emissions through reduced use of fossil-based fuels, associated with fewer insecticide and herbicide sprays; in 2005 this was an estimated saving of 962 million kg of carbon dioxide ($CO_2$), equivalent to reducing the number of cars on the roads by 0.43 million. Secondly, conservation tillage (need for less or no ploughing with herbicide tolerant biotech crops) for biotech food, feed and fiber crops, led to an additional soil carbon sequestration equivalent in 2005 to 8,053 million kg of $CO_2$, or removing 3.6 million cars off the road. Thus, in 2005 the combined permanent and additional savings through sequestration was equivalent to a saving of 9,000 million kg of $CO_2$ or removing 4 million cars from the road. Thirdly, in the future cultivation of a significant additional area of biotech-based energy crops to produce ethanol and biodiesel will on the one-hand substitute for fossil fuels and on the other will recycle and sequester carbon. Recent research indicates that biofuels could result in net savings of 65% in energy resource depletion[18]. Given that energy crops will likely occupy a significant additional crop hectarage in the future the contribution of biotech-based energy crops to climate change could be significant[19].

The six principal countries that have gained $0.5 billion or more from biotech crops, during the decade 1996 to 2005 are, in descending order of magnitude, the US ($12.9 billion), Argentina

*[18] The United Kingdom Parliament, Report No 27/1, 2006. Energy and Greenhouse Gas Benefits of Liquid Biofuel Technology Options.*

*[19] Stern Review on the Economics of Climate Change, UK 2006 (www.sternreview.org.uk).*

($5.4), China ($5.2 billion), Brazil ($1.4 billion), Canada ($1.0 billion), India ($0.5 billion) and others ($0.6 billion) for a total of $27 billion. Distribution of economic benefits amongst the four major biotech crops for the decade 1996 to 2005 was as follows: soybean $14.4 billion, cotton $8.5 billion, maize $3.2 billion, and canola $0.9 billion for a total of $27 billion. Distribution of economic benefits at the farm level by trait, for the decade 1996 to 2005 is as follows: herbicide tolerant soybean $14.4 billion, Bt cotton $7.5 billion, insect resistant maize $2.4 billion, herbicide tolerant cotton $927 million, herbicide tolerant canola $893 million, and herbicide tolerant maize $795 million, for a total of approximately $27 billion. The aggregate economic benefits from herbicide tolerance across all four crops was $17 billion equivalent to 63% of the total of $27 billion, with the balance of $10 billion, equivalent to 37% due to insect resistance in cotton and maize.

The most recent report from the National Center for Food and Agricultural Policy (NCFAP) in the US estimated that the net economic benefits to producers from biotech crops in the USA in 2005 was $2.0 billion. Jikun Huang, from the Chinese Academy of Sciences, has projected potential gains for China of $5 billion in 2010, $1 billion from Bt cotton and $4 billion from Bt rice, expected to be approved in the near-term. A global study by the Australian Bureau of Agricultural and Resource Economics (ABARE) on biotech grains, oil seeds, fruit and vegetables, has projected a global potential gain of $210 billion by 2015; the projection is based on full adoption with 10% productivity gains in high and middle income countries, and 20% in low income countries.

### *The Future*

Based on the unprecedented adoption and substantial impact of biotech crops in the first 11 years of commercialization, 1996-2006, it is projected that the strong growth will continue in the second decade of commercialization 2006-2015; some of the principal trends and developments are highlighted in the closing 10 paragraphs below:

- Continuing strong growth in established and mature industrial country markets such as US and Canada, increasingly manifested through stacking of traits expressed as 'trait hectares' rather than adopted 'hectares' which are already close to saturation in soybean and cotton in the US. An expanded range of crops will become available featuring more agronomic traits, particularly the all important drought trait, and for the first time an increasing range of quality traits ranging from improved and healthier oils to more nutritious products, and other non-conventional products such as vaccines and specialized products. After a decade of consumer attitudinal research in the US, now a nation of 300 million people, a November 2006 International Food Information Council (IFIC) study[20] confirmed that although 59% of

[20] *International Food Information Council. 2006. Food Biotechnology: A Study of U.S. Consumer Attitudinal Trends, 2006 Report.*

Americans avoid some type of food, none avoid biotech foods. When asked explicitly about biotech foods, only 2% noted concerns. Knowledge and awareness about benefits of biotech foods is a key factor in increasing consumers likelihood to buy biotech foods, with 77% more likely to buy biotech-based products with high omega-3 fatty acid content, 75% for insect protection/insecticide reduction and 75% for reduced saturated fat content. An overwhelming majority of consumers (82%) stated that there was no information that they would like to see added to food labels. Only one percent named biotechnology as information they would like to see added. Thus, overall, a majority of Americans are confident in the safety of the US food supply and express little to no concern about food and agricultural biotechnology.

- Whereas the first decade, 1996-2005, was the decade of the Americas, (where 94% of global biotech crops were planted in 2005) the second decade, 2006-2015, will likely feature strong growth in the key developing countries of Asia led by China, India and countries like Pakistan, Vietnam and the tiger economies of SEAsia where the Philippines has led with biotech maize and is assigning high priority to biotech rice, including Vitamin A rice expected to be available by 2010.

- What China is to Asia, Brazil is to Latin America. Brazil, which is already commercializing biotech soybean and cotton has enormous potential to grow to be the lead country in Latin America. Brazil has the largest hectarage of the biofuel/ethanol producing sugarcane in the world and which they have already sequenced, the second largest area of soybean after the US, the third largest area of maize, the sixth largest of cotton, and the tenth largest area of rice, all of which, with exception of sugarcane, are already commercialized as biotech crops, and thus relatively facile to introduce. In addition, Brazil has a strong public sector program in biotech crops and up to 100 million hectares of new crop land with an adequate supply of water, the most important constraint to increased productivity. Biotech crops are already grown in the majority of countries in Latin America, and countries like Chile (which already grows a significant hectarage of biotech crops for seed) are likely to adopt before 2015.

- In Africa, the number of countries adopting biotech crops are expected to increase modestly. Egypt in North Africa is likely to introduce biotech cotton and maize. In West Africa, third year field trials in Bt cotton in Burkina Faso confirm significant benefits already enjoyed by nine other countries around the world growing Bt cotton. Adoption of Bt cotton in Burkina Faso would have significant collateral impact in other cotton growing countries in West Africa such as Mali, Benin, Nigeria, Chad, Cote d'Ivoire, Cameroon and Togo which collectively grow approximately 2.5 million hectares of cotton. In East Africa, Kenya is already testing Bt cotton with encouraging results and has collaborative international programs to develop Bt maize.

- Within the European Union, six countries, equivalent to almost one quarter of the 25 EU member states, successfully grew Bt maize in 2006 and the farmers who benefited from the experience are seeking more access to biotech crops without which they know they are disadvantaged and non-competitive. Spain continued to be the lead country in Europe planting 60,000 hectares in 2006. Importantly the collective Bt maize hectarage in the other five countries increased over 5-fold from approximately 1,500 hectares in 2005 to approximately 8,500 hectares, albeit on small hectarages, and growth in these five countries is expected to continue in 2007; this reflects farmer satisfaction with Bt maize in almost one quarter of the countries of the EU. Cultivation of Bt maize in EU countries is possible because the EU Commission has approved 31 maize varieties derived from MON810 maize (17 in 2004 and 14 in 2005). The area of Bt maize in these countries is likely to increase in 2007 and beyond and also to include EU accession states like Romania and Bulgaria who already have a positive experience with other biotech crops and are likely to adopt Bt maize (MON810) already approved in the EU for production in all 25 countries. Russia is likely to release Bt potatoes in the near-term, a very effective technology in the potato crop that is important in both eastern and western Europe. These trends for increased adoption of biotech crops at different levels, first within the EU 25, secondly from accession countries, third from large trading countries like Russia and fourthly at the international level from an increased number of countries in all continents, will likely prove to be a growing global trend that the EU cannot ignore, in a world that is becoming increasingly interdependent and where globalization is exerting increased pressure to conform, as it does for countries within the EU itself.

- While 22 countries planted biotech crops in 2006, there are an additional 29 countries, totaling 51, that have granted regulatory approvals for biotech crops for import for food and feed use and for release into the environment. A total of 539 approvals has been granted for 107 biotech events for 21 crops worldwide since biotech crops were first commercialized in 1996. Thus, biotech crops have already been approved and accepted by many countries not only for commercial planting but also for import for food and feed use. This trend is likely to grow in the coming years as more countries adopt and implement more progressive biotech policies and open up their markets to biotech products.

- Use of biotechnology to increase the efficiency of biofuel production in both first and second generation biofuel crops will be a major new development. In the coming decade when food/feed crops will be the principal crops for production of biofuel, biotechnology will become important for increasing "biofuel yields" from sugarcane, maize, grains and cassava for ethanol, and biodiesel from soybean, canola and palm oil. For the longer term, the use of biotechnology will be equally important in research programs to increase the efficiency of biofuel production from cellulose in specifically modified energy crops such as switchgrass and hybrid poplar trees. One of the challenges, particularly for resource-poor developing countries, is how to optimize the use of limited biotechnology resources to meet the competing needs of food and fuel and ensure that food security is not sacrificed for biofuel. Collaboration will be the key for developing countries to create the critical mass that they require to meet both needs coincidentally, in carefully balanced programs that fully benefit from the comparative advantages of the collaborating parties.

- By far, the biggest challenge for crop biotechnology in the next decade will be to contribute to the Millennium Development Goal of reducing poverty and hunger by 50% by 2015. The global number and proportion of small farmers from developing countries growing biotech crops are expected to increase dramatically from the 9.3 million in 2006 as biotech cotton will be adopted in Africa in the staple crop of maize, followed in the near term by rice adopted by millions of small farmers, particularly in Asia, to meet increasing food/feed requirements and the demand for more meat in the diets of more affluent populations. There are more than 200 million maize farmers in the world, a large proportion of whom are small resource-poor farmers and to-date only approximately 17% of the global maize area has been planted with biotech varieties leaving a substantial potential for deployment in the remaining nine years of the second decade of commercialization 2006-2015. Similarly, there are 150 million hectares of rice in the world, farmed by more than one quarter of a billion farmers, most of whom are small resource-poor farmers who stand to gain significantly from the adoption of biotech rice. Potential benefits for biotech rice in China alone have been estimated at $4 billion/annum in 2010. This benefit applies only to Bt rice whereas there are many other traits under development including drought and salinity tolerance and the more nutritious Golden™ Rice with higher levels of Vitamin A, expected to be available by 2010. There are more than a hundred million rice farmers in China alone and a substantial number in India. A similar trend to the adoption described for biotech crops in developing countries could also benefit the less affluent and more agriculturally based countries of Eastern Europe which have recently joined the EU, and those expected to join in 2007 and beyond, such as Romania, and Bulgaria which already know from first-hand experience the value of biotech crops.

- Taking all these global developments in both industrial and developing countries into account, the outlook for the next decade of commercialization, 2006 to 2015, points to continued growth in the global hectarage of biotech crops, up to 200 million hectares, with at least 20 million farmers growing biotech crops in up to 40 countries, or more by 2015. Given that there are at least 250 million rice farmers, globally, of which a substantial proportion are small resource-poor farmers, the widespread adoption of biotech rice by small farmers (principally in Asia, but also in Africa and Latin America) by the end of the next decade in 2015, under an optimistic scenario, there could be up to 80 million biotech rice farmers (adoption by one-third of 250 million rice farmers) rather than the conservative estimate of 20 million projected above. The adoption of biotech rice could make a substantial contribution to the alleviation of poverty and hunger, given that rice is the most important food crop in the world and more importantly it is the principal food crop of the world's poor, a substantial proportion of whom are small resource-poor farmers. Whereas it is evident that technology alone does not represent a solution to the very complex challenge of poverty alleviation - it requires a multiple thrust strategy including improved policies and distribution systems and other elements, - technology will be an essential element of any successful strategy and biotech rice should be a top priority if we as a global community aim to keep our pledge of reducing poverty and hunger by 50% by 2015 - the same year that marks the end of the second decade of commercialization of biotech crops 2006-2015.

- The history of the past is the best guide for the future, and hence sharing the growing body of knowledge and experience in biotech crops that has been accumulated in the last 11 years 1996-2006, is an important goal. Thus, the collective and varied experience of the 11 developing and the 11 industrial countries that grew biotech crops in 2006 is an important experience to capture and use to guide effective and responsible future deployment of biotech crops on a significant proportion of the world's 1.5 billion hectares of arable land. Prudent management and vigilance of the technology will continue to be paramount, and become even more important as developing countries embark on the introduction of biotech crops such as maize and rice that will occupy large hectarages. Adherence to good farming practices with biotech crops is critical, including the prudent rotation of crops and the deployment and effective management of diverse genes that confer resistance to pests, pathogens and herbicides. Responsible stewardship allowed the first decade of biotech crops to be ushered in without any of the dire outcomes predicted by the opponents of the technology. Their use has already contributed to the alleviation of poverty for over 9 million small resource-poor farmers; these represent some of the poorest people in the world's 1.3 billion poor people, 1 billion of whom are children, who are destined to continue to suffer in an unjust society unless global society makes good on its promise to reduce poverty by 50% by 2015. Deploying biotech crops is one of many thrusts in a global strategy to fight poverty and hunger that must include improved food distribution and access to water that should not be denied to poor subsistence farmers. Continued responsible stewardship in the coming decade must be practiced by the countries of the South, which are likely to be the major deployers of biotech crops in the second decade of commercialization, 2006-2015. Based on the evidence and experience of the first 11 years of commercialization, 1996 to 2006, there is little doubt that in the next decade, 2006 to 2015, biotech crops have the potential to contribute substantially to the alleviation of poverty for millions of small resource-poor farmers and the rural landless who are completely dependent on agriculture. Biotech crops can also contribute significantly to the plight of the growing urban poor by providing more affordable and nutritious food for the increasing number of poverty stricken people who strive to survive in the burgeoning mega-cities of the developing countries where the majority of the world's poor of 2050 will have to survive.

## ACKNOWLEDGMENTS

The provision of data on global adoption of commercialized biotech crops by a legion of colleagues, too numerous to name, from the public and private sectors in industrial and developing countries is much appreciated. Without their collaboration, this publication would not be possible. A very special thanks to my wife Glenys James who, as always, gave of her time freely to ISAAA, and diligently persevered to input the entire manuscript, and gave me encouragement and support. It is a pleasure to thank Dr. Randy Hautea, Global Coordinator and Director of the ISAAA SEAsiaCenter and his staff, for always providing excellent and expeditious services for formatting and proofreading the manuscript. Particular thanks to Margarita Escaler for coordinating and verifying the entire document and compiling Appendix 1 and to Bhagirath Choudhary for also providing input. Thanks also to Marichel Navarro, Clement Dionglay, Claudia Canales, Von Mark Cruz, Fely Almasan and Teresita Victoria for overseeing and expediting the preparation of the manuscript for publication including formatting all the text, tables and figures. Whereas the assistance of everyone is acknowledged and greatly appreciated, the author takes full responsibility for the views expressed in this publication and for any errors of omission or misinterpretation.

# Appendix
# Global Status of Regulatory Approvals*

* This is an overview of the global status of regulatory approvals for import for food and feed use and for release into the environment through to November 2006. Regulatory approval processes for biotech products vary from country to country and therefore, countries should be consulted for specific details.

## Appendix 1. Global Status of Regulatory Approvals
Compiled by M. Escaler, ISAAA 2006

### ARGENTINA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | *Gossypium hirsutum L.* | HT | MON1445 | Monsanto Company | 1999 | ✓ | 2001 | | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531 | Monsanto Company | 1998 | ✓ | 1998 | | |
| Maize | *Zea mays L.* | HT | T14,T25 | Bayer CropScience | 1998 | ✓ | 1998 | | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | 1998 | ✓ | 2005 | | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2004 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | 1996 | ✓ | 1998 | | |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 2001 | ✓ | 2001 | | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 1998 | ✓ | 1998 | | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (Dow AgroSciences); Pioneer (Dupont) | 2005 | ✓ | 2005 | | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 1996 | ✓ | 1996 | | |

### AUSTRALIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine Canola | *Brassica napus* | HT | HCN92 | Bayer CropScience | 2003 | ✓ | | 2002 | |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | 2003 | ✓ | 2002 | | |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | 2003 | ✓ | | 2000 | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF1→PGS1 | Bayer CropScience | 2003 | ✓ | 2002 | | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF2→PGS2 | Bayer CropScience | 2003 | ✓ | 2002 | | |
| Argentine Canola | *Brassica napus* | HT +F | MS8xRF3 | Bayer CropScience | 2003 | ✓ | 2002 | | |
| Argentine Canola | *Brassica napus* | HT | OXY 235 | Bayer CropScience | | | | 2002 | |
| Carnation | *Dianthus caryophyllus* | DR | 66 | Florigene Pty Ltd. | 1995 | ✓ | | | |
| Carnation | *Dianthus caryophyllus* | FC | 4, 11, 15, 16 | Florigene Pty Ltd. | 1995 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | IR | COT102 | Syngenta Seeds | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON-ØØ531-6 x MON-Ø1445-2 | Monsanto Company | 2003 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | IR | DAS-21Ø23-5 x DAS-24236-5 | Dow AgroSciences LLC | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445 | Monsanto Company | 2000 | ✓ | | 2000 | |
| Cotton | *Gossypium hirsutum L.* | IR | MON15985 | Monsanto Company | 2002 | ✓ | | 2002 | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531 | Monsanto Company | 1996 | ✓ | | 1996 | 1996 |
| Cotton | *Gossypium hirsutum L.* | HT | BXN | Calgene Inc. | | | 2002 | | |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | 2006 | ✓ | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON88913/15985 | Monsanto Company | 2006 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON15985/1445 | Monsanto Company | 2006 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | HT | LLCotton25 | Bayer CropScience | | | | 2006 | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (Dow AgroSciences); Pioneer (Dupont) | | | | 2003 | |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | | | 2002 | | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | | 2000 | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | | 2002 | |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | | | 2001 | | |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | | | 2001 | | |
| Maize | *Zea mays L.* | HT + IR | DBT418 | Dekalb Genetics Corporation | | | | 2002 | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | | 2000 | |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2003 | |
| Maize | *Zea mays L.* | HT + IR | DAS-59122-7 | Dow AgroSciences LLC/Pioneer | | | | 2005 | |
| Maize | *Zea mays L.* | HT + IR | MON88017 | Monsanto Company | | | | 2006 | |
| Maize | *Zea mays L.* | IR | MIR604 | Syngenta Seeds | | | | 2006 | |

**LEGEND**

| | |
|---|---|
| HT | Herbicide Tolerance |
| IR | Insect Resistance |
| VR | Virus Resistance |
| FC | Modified flower color |
| DR | Delayed ripening/altered shelf life |
| Oil Content | Modified oil content |
| Lys | Enhanced Lysine content |
| NIC | Nicotine reduction |
| F | Fertility restored |
| * | Has been approved for planting/cultivation but not necessarily in commercial production at present |

Sources:
http://www.agbios.com
http://ec.europa.eu/food/dyna/gm_register/index_en.cfm
http://www.fas.usda.gov/itp/biotech/countries.html
http://www2.oecd.org/biotech/frameset.asp
http://www.ogtr.gov.au
http://www.aphis.usda.gov
http://www.hc-sc.gc.ca
http://www.inspection.gc.ca
http://www.mhlw.go.jp/english/topics/food/pdf/sec01-2.pdf
http://www.bch.biodic.go.jp
http://www.gmo-compass.org
http://www.bpi.da.gov.ph
http://bch.biodiv.org

## AUSTRALIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Potato | *Solanum tuberosum L.* | IR | ATBT04-6, ATBT04-27, ATBT04-30, ATBT04-31, ATBT04-36, SPBT02-5, SPBT02-7 | Monsanto Company | | | 2001 | | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT15-101, SEMT15-02, SEMT15-15 | Monsanto Company | | | 2001 | | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-129, RBMT21-350, RBMT22-082 | Monsanto Company | | | 2001 | | |
| Soybean | *Glycine max L.* | HT | A2704-12, A2704-21, A5547-35 | Aventis Crop Science | | | | 2004 | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 2000 | |
| Soybean | *Glycine max L.* | Oil content | G94-1, G94-19, G168 | DuPont Canada Agricultural Products | | | | 2000 | |
| Sugar Beet | *Beta vulgaris* | HT | GTSB77 | Novartis Seeds; Monsanto Company | | | 2002 | | |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | | | | 2005 | |

## BRAZIL

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | *Gossypium hirsutum* L. | IR | MON531/757/1076 | Monsanto Company | 2005 | ✓ | | 2005 | 2005 |
| Soybean | *Glycine max* L. | HT | GTS 40-3-2 | Monsanto Company | 1998 | ✓ | | 1998 | 1998 |
| Maize | *Zea mays* L. | HT + IR | Cry1Ac/Cri1AB, Cry9c, mEPSPS, PAT, BAR | AVIPE | | | | | 2005 |

## CANADA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Alfalfa | *Medicago sativa* | HT | J101, J163 | Monsanto Company and Forage Genetics International | 2005 | | | 2005 | 2005 |
| Argentine Canola | *Brassica napus* | HT | HCN10 | Aventis Crop Science | 1995 | ✓ | | 1995 | 1995 |
| Argentine Canola | *Brassica napus* | HT | HCN92 | Bayer CropScience | 1995 | ✓ | | 1995 | 1995 |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | 1996 | ✓ | | 1997 | 1995 |
| Argentine Canola | *Brassica napus* | HT | GT200 | Monsanto Company | 1996 | | | 1997 | |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | 1995 | ✓ | | 1994 | 1995 |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF1→PGS1 | Aventis Crop Science | 1995 | ✓ | | 1995 | 1995 |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF2→PGS2 | Aventis Crop Science | 1995 | ✓ | | 1995 | 1995 |
| Argentine Canola | *Brassica napus* | HT +F | MS8xRF3 | Bayer CropScience | 1996 | ✓ | | 1997 | 1996 |
| Argentine Canola | *Brassica napus* | Oil content | 23-18-17,23-198 | Calgene Inc. | 1996 | ✓ | | 1996 | 1996 |
| Argentine Canola | *Brassica napus* | HT | OXY 235 | Aventis Crop Science | 1997 | ✓ | | 1997 | 1997 |
| Cotton | *Gossypium hirsutum L.* | IR | 281-24-236 | Dow AgroSciences LLC | | | | 2005 | 2005 |
| Cotton | *Gossypium hirsutum L.* | IR | 3006-210-23 | Dow AgroSciences LLC | | | | 2005 | 2005 |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | | | | 1996 | 1996 |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | | | | 2003 | 2003 |
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 | Monsanto Company | | | | 1996 | 1996 |
| Cotton | *Gossypium hirsutum L.* | HT | LLCotton 25 | Bayer CropScience | | | | 2004 | 2004 |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | | | | 2005 | 2005 |
| Cotton | *Gossypium hirsutum L.* | HT | BXN | Calgene Inc. | | | | 1996 | 1996 |
| Flax, Linseed | *Linum usitatissimum L.* | HT | FP967 | Univ of Saskatchewan | 1996 | ✓ | | 1998 | 1996 |
| Maize | *Zea mays L.* | IR + HT | MON802 | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | IR + HT | MON809 | Pioneer Hi-Bred International Inc. | 1996 | ✓ | | 1996 | 1996 |
| Maize | *Zea mays L.* | HT | B16 (DLL25) | Dekalb Genetics Corporation | 1996 | ✓ | | 1996 | 1996 |
| Maize | *Zea mays L.* | HT | T14,T25 | Bayer CropScience | 1996 | ✓ | | 1997 | 1996 |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | 1998 | ✓ | | 1999 | 1998 |
| Maize | *Zea mays L.* | HT | MON832 | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2001 | ✓ | | 2001 | 2001 |
| Maize | *Zea mays L.* | HT + F | MS3 | Bayer CropScience | 1996 | ✓ | | 1997 | 1998 |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | 1996 | ✓ | | 1995 | 1996 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 1996 | ✓ | | 1996 | 1996 |
| Maize | *Zea mays L.* | HT + IR | DBT418 | Dekalb Genetics Corporation | 1997 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | 2002 | ✓ | | 2002 | 2002 |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | 2003 | ✓ | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | MON88017 | Monsanto Company | 2006 | ✓ | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | DAS-59122-7 | Dow AgroSciences LLC/Pioneer | 2005 | ✓ | | 2005 | 2005 |
| Maize | *Zea mays L.* | LYS | LY038 | Monsanto Company | 2006 | ✓ | | 2006 | 2006 |
| Maize | *Zea mays L.* | IR | DAS-06275-8 | Dow AgroSciences LLC | 2006 | ✓ | | 2006 | 2006 |
| Papaya | *Carica papaya* | VR | 55-1/63-1 | Cornell University | | | | 2003 | |

## CANADA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Polish canola | *Brassica rapa* | HT | HCR-1 | Bayer CropScience | 1998 | ✓ | | | 1998 |
| Polish canola | *Brassica rapa* | HT | ZSR500/502 | Monsanto Company | 1997 | ✓ | | | 1997 |
| Potato | *Solanum tuberosum L.* | IR | ATBT04-6, ATBT04-27, ATBT04-30, ATBT04-31, | Monsanto Company | 1997 | ✓ | | 1996 | 1997 |
| | | | ATBT04-36, SPBT02-5, SPBT02-7 | Monsanto Company | 1995 | ✓ | | 1995 | 1995 |
| Potato | *Solanum tuberosum L.* | IR | BT6, BT10, BT12, BT16, BT17, BT18, BT23 | | | | | | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT15-101, SEMT15-02, SEMT15-15 | Monsanto Company | 1999 | ✓ | | 1999 | 1999 |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-129, RBMT21-350, RBMT22-082 | Monsanto Company | 1999 | ✓ | | 1999 | 1999 |
| Rice | *Oryza sativa* | HT | LLRICE06, LLRICE62 | Aventis Crop Science | | | | 2006 | 2006 |
| Soybean | *Glycine max L.* | HT | ACS-GMØØ5-3 (A2704-12, A2704-21, A5547-35) | Aventis Crop Science | 1999 | | | 2000 | 2000 |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 1995 | ✓ | | 1996 | 1995 |
| Soybean | *Glycine max L.* | Oil content | G94-1, G94-19, G168 | DuPont Canada Agricultural Products | 2000 | | | 2000 | 2000 |
| Squash | *Cucurbita pepo* | VR | ZW20 | Seminis Vegetable Seeds (Upjohn/Asgrow) | | | | 1998 | |
| Squash | *Cucurbita pepo* | VR | CZW-3 | Asgrow (USA); Seminis Vegetable Inc. (Canada) | | | | 1998 | |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | | | | 2005 | |
| Sugar Beet | *Beta vulgaris* | HT | T120-7 | Bayer CropScience | 2001 | ✓ | | 2000 | 2001 |
| Tomato | *Lycopersicon esculentum* | DR | 1345-4 | DNA Plant Technology Corporation | | | | 1995 | |
| Tomato | *Lycopersicon esculentum* | DR | B, Da, F | Zeneca Seeds | | | | 1996 | |
| Tomato | *Lycopersicon esculentum* | DR | FLAVR SAVR | Calgene Inc. | | | | 1995 | |
| Tomato | *Lycopersicon esculentum* | IR | 5345 | Monsanto Company | | | | 2000 | |

## CHINA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine Canola | *Brassica napus* | HT | GT73, RT73 | Monsanto Company | | | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | Topas 19/2 (HCN92) | Bayer Crop Science | | | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | MS1, RF1?PGS1 | Bayer Crop Science | | | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | MS1, RF2?PGS2 | Bayer Crop Science | | | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | MS8xRF3 | Bayer CropScience | | | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | OXY 235 | Bayer Crop Science | | | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | | | 2004 | | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 (33B) | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |
| Cotton | *Gossypium hirsutum L.* | IR | Fusion Cry1ab/Cry1Ac (GK12) | Chinese Academy of Agricultural Sciences | 1997 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | IR | CpTi/Bt (SGK321) | Chinese Academy of Agricultural Sciences | 1999 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | | | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | | | 2004 | | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | 2004 | | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | | | 2004 | | |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | 2004 | | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | 2005 | | |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | | | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | | | 2004 | | |
| Tomato | *Lycopersicon esculentum* | DR | D2 x A53 (Huafan No. 1) | Huazhong Agricultural University | 1997 | ✓ | | 1997 | |
| Tomato | *Lycopersicon esculentum* | DR | Da Dong No.9 | Institute of Microbiology, CAS | 2000 | ✓ | | 2000 | |
| Tomato | *Lycopersicon esculentum* | VR | PK-TM8805R | Beijing University | 1998 | ✓ | | 1998 | |
| Petunia | *Petunia* | FC | CHS gene | Beijing University | 1997 | ✓ | | | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | 2004 | | |
| Sweet pepper | *Capsicum annuum* | VR | PK-SP01 | Beijing University | 1998 | ✓ | | 1998 | |

## COLOMBIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Carnation | *Dianthus caryophyllus* | FC | | Florigene Pty Ltd. | 2000 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | IR | MON 531 | Monsanto Company | 2003 | ✓ | 2003 | 2003 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON 1445 | Monsanto Company | 2004 | ✓ | 2003 | 2004 | |
| Maize | *Zea mays L.* | IR | MON 810 | Monsanto Company | 2002 | | 2003 | | |
| Maize | *Zea mays L.* | HT | NK 603 | Monsanto Company | | | 2004 | | |

## EUROPEAN UNION (25)

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine canola | *Brassica napus* | HT | TOPAS 19/2 (HCN 92) | AgrEvo | | | | 1997 | 1998 |
| Argentine canola | *Brassica napus* | HT | MS1/RF2 | Plant Genetic Systems | 1997 | ✓ | | 1997 | 1997 |
| Argentine canola | *Brassica napus* | HT | MS1/RF1 | Plant Genetic Systems | 1996 | ✓ | | 1997 | 1996 |
| Argentine canola | *Brassica napus* | HT | GT73 | Monsanto | | | | 1997 | 1996 |
| Argentine canola | *Brassica napus* | HT | T45 | Bayer Crop Science | | | | 1998 | 1998 |
| Argentine canola | *Brassica napus* | HT | MS8/RF3 | Plant Genetic Systems | | | | 1999 | 2000 |
| Carnation | *Dianthus caryophyllus* | DR | 66 | Florigene Pty Ltd. | 1998 | ✓ | | | |
| Carnation | *Dianthus caryophyllus* | FC | 4, 11, 15, 16 | Florigene Pty Ltd. | 1997 | ✓ | | | |
| Carnation | *Dianthus caryophyllus* | FC | 959A, 988A, 1226A, 1351A, 1363A, 1400A | Florigene Pty Ltd. | 1998 | ✓ | | | |
| Chicory | *Chichorium intybus* | HT + F | RM3-3, RM3-4, RM3-6 | Bejo Zaden BV | 1996 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | HT | 1445 | Monsanto | | | | 2002 | 1997 |
| Cotton | *Gossypium hirsutum L.* | IR | 531 | Monsanto | | | | 2002 | 1996 |
| Cotton | *Gossypium hirsutum L.* | IR + HT | 531 x 1445 | Monsanto | | | | 2005 | 2005 |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | | | | 2005 | 2005 |
| Cotton | *Gossypium hirsutum L.* | IR + HT | 15985 x 1445 | Monsanto | | | | 2005 | 2005 |
| Maize | *Zea mays L.* | IR + HT | Bt 176 | Syngenta Seeds | 1997 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto | 2004 | ✓ | | 1998 | 1998 |
| Maize | *Zea mays L.* | HT | T25 | AgrEvo | 1998 | ✓ | | 1998 | 1998 |
| Maize | *Zea mays L.* | IR + HT | Bt11 | Novartis | | | | 1998 | 1998 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto | | | | 2004 | 2004 |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2006 | 2005 |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | DAS1507 (TC 1507) | Pioneer Hi-Bred International Inc. | | | | 2006 | 2005 |
| Maize | *Zea mays L.* | HT + IR | NK603 X MON810 | Monsanto Company | | | | 2005 | 2005 |
| Maize | *Zea mays L.* | HT + IR | GA21 x MON810 | Monsanto Company | | | | 2005 | 2005 |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 1996 | 1996 |
| Tobacco | *Nicotiana tabacum L.* | HT | C/F/93/08-02 | Societe National d'Exploitation des Tabacs et Allumettes | 1994 | | | | |

## HONDURAS

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | IR | MON810 | Monsanto | 2002 | ✓ | | 2002 | 2002 |

## INDIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | *Gossypium hirsutum L.* | IR | MON531 | Mahyco/Monsanto Company | 2002 | ✓ | | 2002 | 2002 |
| Cotton | *Gossypium hirsutum L.* | IR | MON 15985 | Mahyco/Monsanto Company | 2006 | ✓ | | 2006 | 2006 |
| Cotton | *Gossypium hirsutum L.* | IR | GFM | Nath Seeds | 2006 | ✓ | | 2006 | 2006 |
| Cotton | *Gossypium hirsutum L.* | IR | Event-1 | JK Agrigenetics | 2006 | ✓ | | 2006 | 2006 |

## INDONESIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 | Monsanto Company | 2001 | ✓ | | | |

## IRAN

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Rice | *Oryza sativa* | IR | Tarom molaii + *cry1ab* | Agricultural Biotech Research Institute | 2005 | ✓ | | 2005 | 2005 |

## JAPAN

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Alfalfa | *Medicago sativa* | HT | J101 | Monsanto Company | 2006 | ✓ | | 2005 | 2006 |
| Alfalfa | *Medicago sativa* | HT | J101 X J163 | Monsanto Company | 2006 | ✓ | | 2005 | 2006 |
| Alfalfa | *Medicago sativa* | HT | J163 | Monsanto Company | 2006 | ✓ | | 2005 | 2006 |
| Argentine Canola | *Brassica napus* | HT | HCN10 | Bayer CropScience | 1997 | | | 1997 | 1998 |
| Argentine Canola | *Brassica napus* | HT | HCN92 | Bayer CropScience | 1996 | | | 1996 | 1996 |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | 1997 | | | 1997 | 1997 |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | 1996 | ✓ | | 1996 | 1996 |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF1→PGS1 | Bayer CropScience | 1996 | | | 1996 | 1996 |

## JAPAN

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF2→PGS2 | Bayer CropScience | 1997 | | | 1997 | 1997 |
| Argentine Canola | *Brassica napus* | HT +F | MS8 | Bayer CropScience | 1998 | ✓ | | 1997 | 1998 |
| Argentine Canola | *Brassica napus* | HT +F | RF3 | Bayer CropScience | 1998 | ✓ | | 1997 | 1998 |
| Argentine Canola | *Brassica napus* | HT +F | MS8xRF3 | Bayer CropScience | 1998 | ✓ | | 1997 | 1998 |
| Argentine Canola | *Brassica napus* | HT + F | PHY35 | Bayer CropScience | 1997 | | | 2001 | 1998 |
| Argentine Canola | *Brassica napus* | HT + F | PHY14 | Bayer CropScience | 1997 | | | 2001 | 1998 |
| Argentine Canola | *Brassica napus* | HT + F | PHY23 | Bayer CropScience | 1997 | | | 2001 | 1999 |
| Argentine Canola | *Brassica napus* | HT | GT200/RT200 | Monsanto Company | 2006 | ✓ | | 2001 | 2001 |
| Argentine Canola | *Brassica napus* | HT + F | PHY-36 | Bayer CropScience | 1997 | | | 1997 | 1997 |
| Argentine Canola | *Brassica napus* | HT | OXY 235 | Bayer CropScience | 1998 | | | 1999 | 1999 |
| Carnation | *Dianthus caryophyllus L.* | FC | 123.2.38, 123.2.2, 11363, 123.8.8 | Florigene Pty Ltd. | 2004 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | IR | DAS-21Ø23-5 x DAS-24236-5 | Dow AgroSciences LLC | | | 2005 | | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON-15985-7 x MON-Ø1445-2 | Monsanto Company | | | 2005 | 2003 | 2003 |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | 1997 | | | 1997 | 1998 |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | | | | 2002 | 2003 |
| Cotton | *Gossypium hirsutum L.* | HT | LLCotton 25 | Bayer CropScience | | | | 2004 | 2006 |
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 | Monsanto Company | 1997 | | | 1997 | 1997 |
| Cotton | *Gossypium hirsutum L.* | IR + HT | 1445 X 531 | Monsanto Company | | | 2004 | 2003 | 2003 |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 31807/31808 | Calgene Inc. | 1998 | | | 1999 | 1999 |
| Cotton | *Gossypium hirsutum L.* | HT | BXN | Calgene Inc. | 1997 | | | 1997 | 1998 |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | | | | 2005 | 2006 |
| Cotton | *Gossypium hirsutum L.* | IR | 281 (DAS 24236-5) | Dow AgroSciences LLC | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | IR | DAS-21Ø23-5 (3006-210-23) | Dow AgroSciences LLC | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 281 X 3006 x 1445 | Dow AgroSciences LLC | | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 281 X 3006 X MON88913 | Dow AgroSciences LLC | | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON88913 X 15985 | Monsanto Company | | | | 2005 | 2006 |
| Cotton | *Gossypium hirsutum L.* | | LLCotton25 x 15985 | Bayer CropScience | | | | 2006 | |
| Maize | *Zea mays L.* | HT + IR | ACS-ZMØØ3-2 (T25) x MON-ØØ81Ø-6 | Bayer CropScience | 2005 | ✓ | 2003 | | |
| Maize | *Zea mays L.* | HT + IR | MON-ØØ6Ø3-6 x MON-ØØ81Ø-6 | Monsanto Company | 2004 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | MON-ØØ863-5 x MON-ØØ6Ø3-6 | Monsanto Company | 2004 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | IR | MON-ØØ863-5 x MON-ØØ81Ø-6 | Monsanto Company | 2004 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | MON-ØØØ21-9 x MON-ØØ81Ø-6 | Monsanto Company | 2005 | ✓ | 2003 | | |
| Maize | *Zea mays L.* | IR + HT | MON802 | Monsanto Company | 1997 | | | | |
| Maize | *Zea mays L.* | IR + HT | MON809 | Pioneer Hi-Bred International Inc. | 1997 | | | | 1998 |
| Maize | *Zea mays L.* | HT | B16 (DLL25) | Dekalb Genetics Corporation | 1999 | ✓ | | 1999 | 2000 |
| Maize | *Zea mays L.* | HT | T14 | Bayer CropScience | 2006 | | | 1997 | 2001 |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | 2004 | ✓ | | 2001 | 2003 |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | 1998 | ✓ | | 1999 | 1999 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2001 | ✓ | | 2001 | 2001 |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | 1996 | | | 2001 | 1996 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 1996 | | | 2001 | 1996 |
| Maize | *Zea mays L.* | HT + IR | DBT418 | Dekalb Genetics Corporation | 1999 | | | 1999 | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | 2002 | ✓ | | 2002 | 2002 |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 1996 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | HT + IR | DAS-59122-7 | Dow AgroSciences LLC/Pioneer | 2006 | ✓ | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | MON88017 | Monsanto Company | 2006 | ✓ | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | MON863 x MON810 x NK603 | Monsanto Company | 2004 | ✓ | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | 1507 X NK603 | Monsanto Company | 2005 | ✓ | | 2004 | |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | 2004 | ✓ | | 2002 | 2003 |
| Maize | *Zea mays L.* | HT + IR | TC1507 x DAS59122-7 | Dow AgroSciences LLC | 2006 | ✓ | | 2005 | 2006 |
| Maize | *Zea mays L.* | HT + IR | MON810 x MON88017 | Monsanto Company | 2006 | ✓ | | 2005 | |
| Maize | *Zea mays L.* | HT + IR | TC1507 x DAS59122-7 x NK603 | Dow AgroSciences LLC | 2006 | ✓ | | 2005 | 2006 |
| Potato | *Solanum tuberosum L.* | IR | ATBT04-6, ATBT04-27, ATBT04-30, ATBT04-31, ATBT04-36, SPBT02-5, SPBT02-7 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR | BT6, BT10, BT12, BT16, BT17, BT18, BT23 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-129 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | New Leaf Y SEMT15-02 | Monsanto Company | | | | 2003 | |

## JAPAN

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-350 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT22-082 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | New Leaf Y RBMT15-101 | Monsanto Company | | | | 2003 | |
| Potato | *Solanum tuberosum L.* | IR + VR | New Leaf Y SEMT15-15 | Monsanto Company | | | | 2003 | 2003 |
| Soybean | *Glycine max L.* | HT | A5547-127 | Aventis Crop Science | 1999 | | | 2002 | 2003 |
| Soybean | *Glycine max L.* | HT | A2704-12 | Aventis Crop Science | 1999 | ✓ | | 2002 | 2003 |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 1996 | | | 1996 | 1996 |
| Soybean | *Glycine max L.* | Oil content | G94-1, G94-19, G168 | DuPont Canada Agricultural Products | 1999 | | | 2001 | 2000 |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | | | | 2003 | |
| Sugar Beet | *Beta vulgaris* | HT | GTSB77 | Monsanto Company | | | | 2003 | 2003 |
| Sugar Beet | *Beta vulgaris* | HT | T120-7 | Bayer CropScience | | | | 2001 | 1999 |
| Tomato | *Lycopersicon esculentum* | DR | FLAVR SAVR | Calgene Inc. | 1996 | | | 1997 | |

## MALAYSIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | 1997 | | |

## MEXICO

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Alfafa | *Medicago sativa* | HT | MON-ØØ1Ø1-8, MON-ØØ163-7 , o J101, J163 | Monsanto Company | | | | 2005 | |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | | | | 2001 | |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | | | 1996 | | |
| Argentine Canola | *Brassica napus* | HT | HCN92 (TOPAS 19/2) | Bayer CropScience | | | | 1999 | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF1?PGS1 | Aventis Crop Science | | | | 1999 | |
| Cotton | *Gossypium hirsutum L.* | IR | 281-24-236 | Dow AgroSciences LLC | | | | 2004 | |
| Cotton | *Gossypium hirsutum L.* | IR | 3006-210-23 | Dow AgroSciences LLC | | | 2004 | | |
| Cotton | *Gossypium hirsutum L.* | IR | DAS-21Ø23-5 x DAS-24236-5 | Dow AgroSciences LLC | | | | 2004 | |
| Cotton | *Gossypium hirsutum L.* | HT | BXN | Calgene Inc. | | | | 1996 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | DAS-21Ø23-5 x DAS-24236-5 x MON-Ø1445-2 | Dow AgroSciences LLC | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 | Monsanto Company | 1996 | ✓ | | 1996 | |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | | | | 2003 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | 2000 | ✓ | | 2000 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON88913/ 15985 | Monsanto Company | | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 1445 x 531 | Monsanto Company | 2000 | ✓ | | 2002 | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | | 2002 | |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2003 | |
| Maize | *Zea mays L.* | IR | MON88017 | Monsanto Company | | | | 2006 | |
| Maize | *Zea mays L.* | IR+ HT | MON88017/MON810 | Monsanto Company | | | | 2006 | |
| Maize | *Zea mays L.* | IR + HT | MON810/NK603 | Monsanto Company | | | | 2004 | |
| Maize | *Zea mays L.* | IR+ HT | MON863/NK603 | Monsanto Company | | | | 2004 | |
| Maize | *Zea mays L.* | IR+ HT | MON863/MON810 | Monsanto Company | | | | 2004 | |
| Maize | *Zea mays L.* | IR-HT | MON863/MON810/NK603 | Monsanto Company | | | | 2004 | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | | 2002 | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | | 2002 | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | | | | 2003 | |
| Tomato | *Lycopersicon esculentum* | DR | 1345-4 | DNA Plant Technology Corporation | | | | 1998 | |
| Tomato | *Lycopersicon esculentum* | DR | FLAVR SAVR | Calgene Inc. | | | | 1996 | |
| Tomato | *Lycopersicon esculentum* | DR | B,Da, F | Zeneca + Petoseed | | | | 1996 | |
| Potato | *Solanum tuberosum L.* | IR | ATBT,SPBT,BT | Monsanto Company | | | | 1996 | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBmT,SEMT | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBmT | Monsanto Company | | | | 2001 | |
| Soybean | *Glycine max L.* | HT | A2704-12 X A5547 | Bayer CropScience | | | | 2003 | |
| Soybean | *Glycine max L.* | HT | MON-Ø4Ø32-6 (GTS 40-3-2) | Monsanto Company | 1997 | ✓ | | 1996 | |
| Sugar Beet | *Beta vulgaris* | HT | KM-ØØØ71-4 (H7-1) | Monsanto Company | | | | 2006 | |

** After Biosafety Law was in place (2005) Food Safety Clearances cover Feed use for GM crops.*

## NEW ZEALAND

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine Canola | *BBrassica napus* | HT | OXY 235 | Bayer CropScience | | | | 2002 | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF1→PGS1 | Bayer CropScience | | | | 2002 | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF2→PGS2 | Bayer CropScience | | | | 2002 | |
| Argentine Canola | *Brassica napus* | HT +F | MS8xRF3 | Bayer CropScience | | | | 2002 | |
| Argentine Canola | *Brassica napus* | HT | HCN92 | Bayer CropScience | | | | 2002 | |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | | | | 2002 | |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | | | | 2000 | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 | Monsanto Company | | | | 2000 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | | | | 2000 | |
| Cotton | *Gossypium hirsutum L.* | IR | MON15985 | Monsanto Company | | | | 2002 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT | BXN | Calgene Inc. | | | | 2002 | |
| Cotton | *Gossypium hirsutum L.* | IR | COT102 | Syngenta Seeds | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | HT | LLCotton25 | Bayer CropScience | | | | 2006 | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | | | | 2003 | |
| Maize | *Zea mays l.* | HT + IR | DBT418 | Monsanto Company | | | | 2002 | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | | 2002 | |
| Maize | *Zea mays l.* | HT | T25 | Bayer CropScience | | | | 2002 | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | | 2000 | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | | 2000 | |
| Maize | *Zea mays L.* | HT + IR | Bt 11 | Syngenta Seeds | | | | 2001 | |
| Maize | *Zea mays l.* | IR | Bt176 | Syngenta Seeds | | | | 2001 | |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2003 | |
| Maize | *Zea mays L.* | HT + IR | DAS59122-7 | Pioneer Company | | | | 2005 | |
| Maize | *Zea mays L.* | HT + IR | MON88017 | Monsanto Company | | | | 2006 | |
| Maize | *Zea mays L.* | IR | MIR604 | Syngenta Seeds | | | | 2006 | |
| Potato | *Solanum tuberosum L.* | IR | ATBT04-6, ATBT04-27, ATBT04-30, ATBT04-31, ATBT04-36, SPBT02-5, SPBT02-7 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT15-101, SEMT15-02, SEMT15-15 | Monsanto Company | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-129, RBMT21-350, RBMT22-082 | Monsanto Company | | | | 2001 | |
| Soybean | *Glycine max L.* | HT | A2704-12, A2704-21, A5547-35 | Bayer CropScience | | | | 2004 | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 2000 | |
| Soybean | *Glycine max L.* | Oil content | G94-1, G94-19, G168 | DuPont Canada Agricultural Products | | | | 2000 | |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | | | | 2005 | |
| Sugar Beet | *Beta vulgaris* | HT | GTS B77 | Monsanto Company | | | | 2002 | |

## PARAGUAY

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 2004 | ✓ | 2004 | | |

## PHILIPPINES

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Alfalfa | *Medicago sativa* | HT | J101, J163 | Monsanto Company and Forage Genetics International | | | | 2006 | 2006 |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | | | | 2003 | 2003 |
| Cotton | *Gossypium hirsutum L.* | IR | MON531 | Monsanto Company | | | | 2004 | 2004 |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | | | | 2005 | 2005 |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON-15985-7 x MON-Ø1445-2 | Monsanto Company | | | | 2004 | 2004 |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON-ØØ531-6 x MON-Ø1445-2 | Monsanto Company | | | | 2004 | 2004 |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | | | | 2003 | 2003 |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | | | | 2003 | 2003 |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON 15985 x MON 88913 | Monsanto Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | MON-ØØ6Ø3-6 x MON-ØØ81Ø-6 | Monsanto Company | 2005 | ✓ | | 2004 | 2004 |
| Maize | *Zea mays L.* | HT + IR | MON-ØØ863-5 x MON-ØØ6Ø3-6 | Monsanto Company | | | | 2004 | |
| Maize | *Zea mays L.* | IR | MON-ØØ863-5 x MON-ØØ81Ø-6 | Monsanto Company | | | | 2004 | 2004 |
| Maize | *Zea mays L.* | HT + IR | MON-ØØ863-5 x MON-ØØ81Ø-6 x MON-ØØ6Ø3-6 | Monsanto Company | | | | 2005 | 2004 |

## PHILIPPINES

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | HT + IR | MON-ØØØ21-9 x MON-ØØ81Ø-6 | Monsanto Company | | | | 2004 | 2004 |
| Maize | *Zea mays L.* | HT | B16 (DLL25) | Dekalb Genetics Corporation | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2005 | ✓ | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 2005 | ✓ | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | DBT418 | Dekalb Genetics Corporation | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 2002 | ✓ | | 2002 | 2002 |
| Maize | *Zea mays L.* | HT + IR | MON88017 | Monsanto Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | DAS59122-7 | Pioneer Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | Lys | LY038 | Monsanto Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | TC1507 x NK603 | Pioneer Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | HT + IR | MON88017 x MON810 | Monsanto Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | Lys + IR | LY038 + MON810 | Monsanto Company | | | | 2006 | 2006 |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-129, RBMT21-350, RBMT22-082 | Monsanto Company | | | | 2004 | 2004 |
| Potato | *Solanum tuberosum L.* | IR | SPBT02-5 | Monsanto Company | | | | 2003 | 2003 |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT15-101, SEMT15-02, SEMT15-15 | Monsanto Company | | | | 2003 | 2003 |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 2003 | 2003 |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | | | | 2005 | 2005 |
| Sugar Beet | *Beta vulgaris* | HT | GTS B77 | Novartis Seeds; Monsanto Company | | | | 2004 | 2004 |

## ROMANIA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 2004 | ✓ | | 2004 | 2004 |

## RUSSIAN FEDERATION

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | | | | 2003 | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | | 2000 | 2003 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | | 2002 | 2003 |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | | 2000 | 2003 |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | | | | 2001 | |
| Potato | *Solanum tuberosum L.* | IR | SPBT02-05 | Monsanto Company | 2002 | | | 2000 | |
| Potato | *Solanum tuberosum L.* | IR | RBBT02-06 | Monsanto Company | 2002 | | | 2000 | |
| Potato | *Solanum tuberosum L.* | IR | 2904/1kgs | Centre Bioengineering RAS, Russia | | | | 2005 | |
| Potato | *Solanum tuberosum L.* | IR | 1210 amk | Centre Bioengineering RAS, Russia | | | | 2006 | |
| Rice | *Oryza sativa* | HT | LLRICE62 | Aventis Crop Science | | | | 2003 | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 1999/2002 | 2003 |
| Soybean | *Glycine max L.* | HT | A2704-12 | Aventis CropScience | | | | 2002 | |
| Soybean | *Glycine max L.* | HT | A5547-127 | Aventis CropScience | | | | 2002 | |
| Sugar Beet | *Beta vulgaris* | HT | GTSB77 | Novartis Seeds; Monsanto Company | | | | 2001 | |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | | | | 2006 | |

## SINGAPORE

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | | 2006 | 2006 |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2006 | 2006 |

## SOUTH AFRICA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine Canola | *Brassica napus* | HT +F | Topas 19/2, Ms1Rf1, Ms1 RF2, Ms8RF3 | Aventis Crop Science | | | approved | | |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | 2000 | ✓ | | | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531 | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |

## SOUTH AFRICA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | *Gossypium hirsutum L.* | IR | MON15985 | Monsanto Company | 2005 | ✓ | | 2005 | 2005 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 2003 | ✓ | 2003 | | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2002 | ✓ | 2002 | | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | | | 2002 | | |
| Maize | *Zea mays L.* | HT + IR | MON81 0 X NK603 | Monsanto Company | 2006 | ✓ | approved | | |
| Maize | *Zea mays L.* | HT + IR | MON810 X GA21 | Monsanto Company | | | approved | | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | | | approved | | |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | | | approved | | |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | | | approved | | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 2001 | ✓ | | 2001 | 2001 |
| Soybean | *Glycine max L.* | HT | A2704-12 | Bayer CropScience | | | approved | | |

## SOUTH KOREA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Argentine Canola | *Brassica napus* | HT | GT73 | Monsanto Company | 2005 | | | 2003 | |
| Argentine Canola | *Brassica napus* | HT | MS8/RF3 | Bayer CropScience | 2005 | | | 2005 | |
| Argentine Canola | *Brassica napus* | HT | T45 | Bayer CropScience | 2005 | | | 2005 | |
| Argentine Canola | *Brassica napus* | HT | MS1/RF1 | Bayer CropScience | | | | 2005 | |
| Argentine Canola | *Brassica napus* | HT | MS1/RF2 | Bayer CropScience | | | | 2005 | |
| Argentine Canola | *Brassica napus* | HT | Topas1912 | Bayer CropScience | | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | IR | 531 | Monsanto Company | 2004 | | | 2003 | |
| Cotton | *Gossypium hirsutum L.* | IR | 757 | Monsanto Company | 2004 | | | 2003 | |
| Cotton | *Gossypium hirsutum L.* | HT | 1445 | Monsanto Company | 2004 | | | 2003 | |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | 2004 | | | 2003 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | MON15985 X 1445 | Monsanto Company | -- | | | 2004 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 531 X 1445 | Monsanto Company | -- | | | 2004 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 281/3006 | Dow Agro | | | | approved | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 15985 X MON88913 | Monsanto Company | -- | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | | | | 2006 | |
| Cotton | *Gossypium hirsutum L.* | HT | LLCotton25 | Bayer CropScience | 2005 | | | 2005 | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 15985 X LL0-Cotton25 | Bayer CropScience | | | | 2006 | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | 2005 | | | 2002 | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 2004 | | | 2002 | |
| Maize | *Zea mays L.* | HT + IR | Bt 11 | Syngenta Seeds | | | | 2003 | |
| Maize | *Zea mays L.* | HT + IR | MON810 x NK603 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | 1507 X NK603 | Dupont Company | | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | TC1507 | Dupont Company | | | | approved | |
| Maize | *Zea mays l.* | HT | NK603 | Monsanto Company | 2004 | | | 2002 | |
| Maize | *Zea mays l.* | HT | T25 | Bayer CropScience | 2004 | | | 2003 | |
| Maize | *Zea mays l.* | IR | MON863 | Monsanto Company | 2004 | | | 2003 | |
| Maize | *Zea mays l.* | IR | Bt176 | Syngenta Seeds | | | | approved | |
| Maize | *Zea mays l.* | HT | DLL25 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | DBT418 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | MON863 X NK603 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | IR | MON863 X MON810 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | MON810 x GA21 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | MON810 X MON863 X NK603 | Monsanto Company | -- | | | 2004 | |
| Maize | *Zea mays l.* | HT + IR | Das-59122-7 | Dupont Company | | | | approved | |
| Maize | *Zea mays l.* | HT + IR | Mon88017 | Monsanto Company | | | | 2006 | |
| Maize | *Zea mays l.* | HT + IR | Das-59122-7 X 1507 X NK603 | Dupont Company | | | | approved | |
| Maize | *Zea mays l.* | HT + IR | 1507 X Das-59122-7 | Dupont Company | | | | approved | |
| Maize | *Zea mays l.* | HT + IR | Das-59122-7 X NK603 | Dupont Company | | | | approved | |
| Maize | *Zea mays l.* | HT + IR | Bt11 X GA21 | Syngenta Seeds | | | | approved | |
| Maize | *Zea mays l.* | HT + IR | MON88017 X MON810 | Monsanto Company | -- | | | 2006 | |
| Potato | *Solanum tuberosum L.* | IR | SPBT02-05 | Monsanto Company | -- | | | 2004 | |
| Potato | *Solanum tuberosum L.* | IR | RBBT06 | Monsanto Company | -- | | | 2004 | |

## SOUTH KOREA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Potato | *Solanum tuberosum L.* | IR + VR | New Leaf Y | Monsanto Company | -- | | | 2004 | |
| Potato | *Solanum tuberosum L.* | IR + VR | New Leaf Plus | Monsanto Company | -- | | | 2004 | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 2004 | | | 2000 | |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | -- | | | 2006 | |

## SWITZERLAND

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | | | | 1997 | 1997 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | | | | 1998 | 1998 |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | | 2000 | 2000 |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 1996 | 1996 |

## TAIWAN

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | B16 (DLL25)) | Dekalb Genetics Corporation | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | | | | 2004 | 2004 |
| Maize | *Zea mays L.* | HT + IR | DBT418 | Dekalb Genetics Corporation | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | GA21 | Monsanto Company | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | | | | 2002 | 2002 |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | | | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT | T25 | Bayer CropScience | | | | 2002 | 2002 |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (Dow AgroSciences); Pioneer (Dupont) | | | | 2003 | 2003 |
| Maize | *Zea mays l.* | HT + IR | Das-59122-7 | Dupont Company | | | | approved | approved |
| Maize | *Zea mays l.* | HT + IR | MON88017 | Monsanto Company | | | | approved | approved |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 2002 | 2002 |

## THAILAND

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays l.* | HT | NK603 | Monsanto Company | | | | 2000 | 2000 |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | | | | 2000 | 2000 |

## URUGUAY

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 2003 | ✓ | | 2003 | 2003 |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 2004 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (Dow AgroSciences); Pioneer (Dupont) | 2006 | ✓ | | | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2006 | ✓ | | | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 1997 | ✓ | | 1997 | 1997 |

## USA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Alfalfa | *Medicago sativa* | HT | J101, J163 | Monsanto Company and Forage Genetics International | 2005 | ✓ | 2004 | | |
| Argentine Canola | *Brassica napus* | HT | HCN10 | Aventis Crop Science | 1995 | ✓ | 1995 | | |
| Argentine Canola | *Brassica napus* | HT | HCN92 | Bayer CropScience | 2002 | ✓ | | 1995 | |
| Argentine Canola | *Brassica napus* | HT | T45 (HCN28) | Bayer CropScience | 1998 | ✓ | 1998 | | |
| Argentine Canola | *Brassica napus* | HT | GT200 | Monsanto Company | 2003 | ✓ | 2002 | | |
| Argentine Canola | *Brassica napus* | HT | GT73,RT73 | Monsanto Company | 1999 | ✓ | 1995 | | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF1→PGS1 | Aventis Crop Science | 2002 | ✓ | 1996 | | |
| Argentine Canola | *Brassica napus* | HT +F | MS1, RF2→PGS2 | Aventis Crop Science | 2002 | ✓ | 1996 | | |
| Argentine Canola | *Brassica napus* | HT +F | MS8xRF3 | Bayer CropScience | 1994 | ✓ | 1994 | | |
| Argentine Canola | *Brassica napus* | Oil content | 23-18-17,23-198 | Calgene Inc. | 1994 | ✓ | 1994 | | |
| Argentine Canola | *Brassica napus* | HT | OXY 235 | Aventis Crop Science | | | | 1999 | |
| Chicory | *Chichorium intybus* | HT + F | RM3-3,RM3-4, RM3-6 | Bejo Zaden BV | 1997 | ✓ | 1997 | | |
| Cotton | *Gossypium hirsutum L.* | IR | 281-24-236 | Dow AgroSciences LLC | 2004 | ✓ | 2004 | | |
| Cotton | *Gossypium hirsutum L.* | IR | 3006-210-23 | Dow AgroSciences LLC | 2004 | ✓ | 2004 | | |

## USA

| Crop | Latin Name | Trait | Event | Developer | Environment | * Planting | Food/Feed | Food | Feed |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | *Gossypium hirsutum L.* | IR | COT102 | Syngenta Seeds | | | 2005 | | |
| Cotton | *Gossypium hirsutum L.* | IR | DAS-21Ø23-5 x DAS-24236-5 | Dow AgroSciences LLC | 2004 | ✓ | 2004 | | |
| Cotton | *Gossypium hirsutum L.* | HT | MON88913 | Monsanto Company | 2004 | ✓ | 2005 | | |
| Cotton | *Gossypium hirsutum L.* | HT | LLCotton 25 | Bayer CropScience | 2003 | ✓ | 2003 | | |
| Cotton | *Gossypium hirsutum L.* | HT | MON1445/1698 | Monsanto Company | 1995 | ✓ | 1995 | | |
| Cotton | *Gossypium hirsutum L.* | IR | 15985 | Monsanto Company | 2002 | ✓ | | 2002 | |
| Cotton | *Gossypium hirsutum L.* | IR | MON531/757/1076 | Monsanto Company | 1995 | ✓ | 1995 | | |
| Cotton | *Gossypium hirsutum L.* | HT + IR | 31807/31808 | Calgene Inc. | 1997 | ✓ | 1998 | | |
| Cotton | *Gossypium hirsutum L.* | HT | BXN | Calgene Inc. | 1994 | ✓ | 1994 | | |
| Cotton | *Gossypium hirsutum L.* | HT | 19-51A | DuPont Canada Agricultural Products | 1996 | ✓ | 1996 | | |
| Creeping Bentgrass | *Agrostis stolonifera* | HT | ASR368 | Scotts Seeds | | | | | 2003 |
| Flax, Linseed | *Linum usitatissimum L.* | HT | FP967 | Univ of Saskatchewan | 1999 | ✓ | 1998 | | |
| Maize | *Zea mays L.* | IR | DAS-06275-8 | Dow AgroSciences LLC | 2004 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | DAS-59122-7 | Dow AgroSciences LLC | 2005 | ✓ | 2004 | | |
| Maize | *Zea mays L.* | HT + IR | MON88017 | Monsanto Company | 1995 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | IR | MON80100 | Monsanto Company | 1995 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | IR + HT | MON802 | Monsanto Company | 1997 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | IR + HT | MON809 | Pioneer Hi-Bred International Inc. | 1996 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | HT | B16 (DLL25) | Dekalb Genetics Corporation | 1995 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | HT | T14,T25 | Bayer CropScience | 1995 | ✓ | 1995 | | |
| Maize | *Zea mays L.* | HT | GA21 | Monsanto Company | 1997 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | HT | NK603 | Monsanto Company | 2000 | ✓ | 2000 | | |
| Maize | *Zea mays L.* | HT +F | 676, 678, 680 | Pioneer Hi-Bred International Inc. | 1998 | ✓ | 1998 | | |
| Maize | *Zea mays L.* | HT + F | MS3 | Bayer CropScience | 1996 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | HT + F | MS6 | Bayer CropScience | 1999 | ✓ | 2000 | | |
| Maize | *Zea mays L.* | HT + IR | 176 | Syngenta Seeds | 1995 | ✓ | 1995 | | |
| Maize | *Zea mays L.* | HT + IR | Bt11 | Syngenta Seeds | 1996 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | HT + IR | CBH-351 | Aventis Crop Science | 1998 | ✓ | | | 1998 |
| Maize | *Zea mays L.* | HT + IR | DBT418 | Dekalb Genetics Corporation | 1997 | ✓ | 1997 | | |
| Maize | *Zea mays L.* | HT + IR | TC1507 | Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont) | 2001 | ✓ | 2001 | | |
| Maize | *Zea mays L.* | IR | MON810 | Monsanto Company | 1995 | ✓ | 1996 | | |
| Maize | *Zea mays L.* | HT | MON832 | Monsanto Company | | | 1996 | | |
| Maize | *Zea mays L.* | IR | MON863 | Monsanto Company | 2003 | ✓ | 2001 | | |
| Maize | *Zea mays L.* | LYS | LY038 | Monsanto Company | 2006 | ✓ | 2005 | | |
| Melon | *Cucumis melo* | DR | A.B | Agritope Inc | 1996 | | 1997 | | |
| Papaya | *Carica papaya* | VR | 55-1/63-1 | Cornell University | 1996 | ✓ | 1996 | | |
| Potato | *Solanum tuberosum L.* | IR | ATBT04-6, ATBT04-27, ATBT04-30, ATBT04-31, ATBT04-36, SPBT02-5, SPBT02-7 | Monsanto Company | 1996 | ✓ | 1996 | | |
| Potato | *Solanum tuberosum L.* | IR | BT6, BT10, BT12, BT16, BT17, BT18, BT23 | Monsanto Company | 1995 | ✓ | 1994 | | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT15-101, SEMT15-02, SEMT15-15 | Monsanto Company | 1999 | ✓ | 1998 | | |
| Potato | *Solanum tuberosum L.* | IR + VR | RBMT21-129, RBMT21-350, RBMT22-082 | Monsanto Company | 1998 | ✓ | 1998 | | |
| Potato | *Solanum tuberosum L.* | IR +VR | HLMT15-3, HLMT15-15, HLMT15-46 | Monsanto Company | 1999 | | 1998 | | |
| Potato | *Solanum tuberosum L.* | IR + VR | SEMT15-07 | Monsanto Company | 1999 | | 2000 | | |
| Rice | *Oryza sativa* | HT | LLRICE06, LLRICE62 | Aventis Crop Science | 1999 | ✓ | 2000 | | |
| Rice | *Oryza sativa* | HT | LLRICE601 | Bayer CropScience | 2006 | ✓ | | | |
| Soybean | *Glycine max L.* | HT | ACS-GMØØ5-3 (A2704-12, A2704-21, A5547-35) | Aventis Crop Science | 1996 | ✓ | 1998 | | |
| Soybean | *Glycine max L.* | HT | A5547-127 | Bayer CropScience | 1998 | ✓ | 1998 | | |
| Soybean | *Glycine max L.* | HT | GU262 | Bayer CropScience | 1998 | ✓ | 1998 | | |
| Soybean | *Glycine max L.* | HT | W62,W98 | Bayer CropScience | 1996 | ✓ | 1998 | | |
| Soybean | *Glycine max L.* | HT | GTS 40-3-2 | Monsanto Company | 1994 | ✓ | 1994 | | |
| Soybean | *Glycine max L.* | Oil content | G94-1, G94-19, G168 | DuPont Canada Agricultural Products | 1997 | ✓ | 1997 | | |
| Squash | *Cucurbita pepo* | VR | ZW20 | Seminis Vegetable Seeds (Upjohn/Asgrow) | 1994 | ✓ | 1997 | | |
| Squash | *Cucurbita pepo* | VR | CZW-3 | Asgrow (USA); Seminis Vegetable Inc. (Canada) | 1996 | ✓ | 1994 | | |
| Sugar Beet | *Beta vulgaris* | HT | H7-1 | Monsanto Company | 2005 | ✓ | 2004 | | |
| Sugar Beet | *Beta vulgaris* | HT | T120-7 | Bayer CropScience | 1998 | ✓ | 1998 | | |
| Sugar Beet | *Beta vulgaris* | HT | GTSB77 | Novartis Seeds; Monsanto Company | 1998 | ✓ | 1998 | | |
| Tobacco | *Nicotiana tabacum L.* | Nic | Vector 21-41 | Vector Tobacco Inc. | 2002 | ✓ | | | |
| Tomato | *Lycopersicon esculentum* | DR | 1345-4 | DNA Plant Technology Corporation | 1995 | ✓ | 1994 | | |
| Tomato | *Lycopersicon esculentum* | DR | 35 1 N | Agritope Inc | 1996 | ✓ | 1996 | | |
| Tomato | *Lycopersicon esculentum* | DR | 8338 | Monsanto Company | 1995 | ✓ | 1994 | | |
| Tomato | *Lycopersicon esculentum* | DR | B, Da, F | Zeneca Seeds | 1995 | ✓ | 1994 | | |
| Tomato | *Lycopersicon esculentum* | DR | FLAVR SAVR | Calgene Inc. | 1992 | ✓ | 1994 | | |
| Tomato | *Lycopersicon esculentum* | IR | 5345 | Monsanto Company | 1998 | ✓ | 1998 | | |
| Wheat | *Triticum aestivum* | HT | MON71800 | Monsanto Company | | | 2004 | | |

US $ 50.00

ISBN 1-892456-40-4