ISAAA
International Service for the Acquisition of Agri-biotech Applications

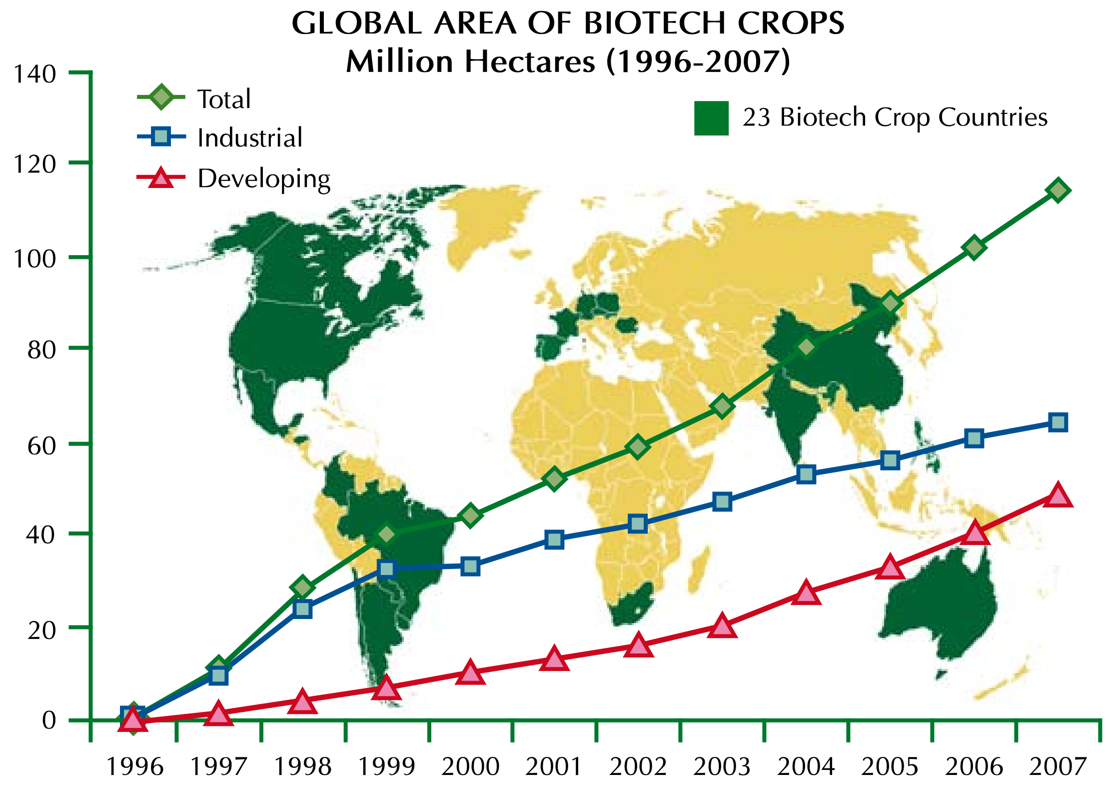
ISAAA Briefs

BRIEF 37

Global Status of Commercialized Biotech/GM Crops: 2007

by

Clive James
Chair, ISAAA Board of Directors



Increase of 12%, 12.3 million hectares (30 million acres), between 2006 and 2007.

Source: Clive James, 2007.

No. 37 - 2007

BRIEF 37

Global Status of Commercialized Biotech/GM Crops: 2007

by

Clive James
Chair, ISAAA Board of Directors

No. 37 - 2007

Co-sponsors: Fondazione Bussolera-Branca, Italy
Ibercaja, Spain
The Rockefeller Foundation, USA
ISAAA

ISAAA gratefully acknowledges grants from Fondazione Bussolera-Branca, 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 co-sponsors, 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. 2007. Global Status of Commercialized Biotech/GM Crops: 2007. *ISAAA Brief* No. 37. ISAAA: Ithaca, NY.

ISBN: 978-1-892456-42-7

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 37 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: 2007
The First Dozen Years, 1996 to 2007

As a result of consistent and substantial benefits during the first dozen years of commercialization from 1996 to 2007, farmers have continued to plant more biotech crops every single year. In 2007, for the twelfth consecutive year, the global area of biotech crops continued to soar. Remarkably, growth continued at a sustained double-digit growth rate of 12%, or 12.3 million hectares (30 million acres) – the second highest increase in global biotech crop area in the last five years – reaching 114.3 million hectares (282.4 million acres). The first dozen years of biotech crops have delivered substantial economic and environmental benefits to farmers in both industrial countries and developing countries, where millions of poor farmers have also benefited from social and humanitarian benefits which have contributed to the alleviation of their poverty. In order to more accurately account for the prevalent and increasing use of two or three "stacked traits", which confer multiple benefits in a single biotech variety, adoption growth is more precisely measured when expressed as "trait hectares", rather than hectares – this is similar to measuring air travel in "passenger miles" rather than miles. Growth measured in "trait hectares" between 2006 (117.7 million) and 2007 (143.7 million) was 22%, or 26 million hectares, reflecting the actual growth between 2006 and 2007, which is approximately double the apparent growth of only 12%, or 12.3 million hectares, when conservatively measured in hectares.

In 2007, the number of countries planting biotech crops increased to 23, and comprised 12 developing countries and 11 industrial countries; they were, in order of hectarage, USA, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Spain, Mexico, Colombia, Chile, France, Honduras, Czech Republic, Portugal, Germany, Slovakia, Romania and Poland. Notably, the first eight of these countries grew more than 1 million hectares each – the strong growth across all continents in 2007 provides a very broad and stable foundation for future global growth of biotech crops. The two new biotech crop countries in 2007 were Chile producing over 25,000 hectares of commercial biotech crops for seed export, and Poland, an EU country, growing Bt maize for the first time. The accumulated hectarage from 1996 to 2007 exceeded two thirds of a billion hectares for the first time at 690 million hectares (1.7 billion acres), with an unprecedented 67-fold increase between 1996 and 2007, making it the fastest adopted crop technology in recent history. 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 from approximately 55 million individual decisions by farmers in 23 countries over a 12-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. Notably, 2007 marks the first year when the accumulated number of farmer decisions to adopt biotech crops has exceeded 50 million.

In 2007, the USA, followed by Argentina, Brazil, Canada, India and China continued to be the principal adopters of biotech crops globally, with the USA retaining its top world ranking with 57.7 million hectares (50% of global biotech area) spurred by a growing market for ethanol with the biotech maize area increasing by a substantial 40% – this was partially offset by smaller decreases in biotech soybean and cotton. Notably, 63% of biotech maize, 78% of biotech cotton, and 37% of all biotech crops in the USA in 2007 were stacked products containing two or three traits that delivered multiple benefits. Stacked products are a very important feature and future trend, which meets the multiple needs of farmers and consumers and these are now increasingly deployed by ten countries – USA, Canada, the Philippines, Australia, Mexico, South Africa, Honduras, Chile, Colombia, and Argentina, with more countries expected to adopt stacked traits in the future.

Biotech crops achieved a very important milestone in 2007 with humanitarian implications – the number of small and resource-poor farmers benefiting from biotech crops in developing countries exceeded 10 million for the first time. Of the global total of 12 million beneficiary biotech farmers in 2007, (up from 10.3 million in 2006), over 90% or 11 million (up significantly from 9.3 million in 2006) were small and resource-poor farmers from developing countries; the balance of 1 million were large farmers from both industrial countries such as Canada and developing countries such as Argentina. Of the 11 million small farmers, most were Bt cotton farmers, 7.1 million in China (Bt cotton), 3.8 million in India (Bt cotton), and the balance of 100,000 in the Philippines (biotech maize), South Africa (biotech cotton, maize and soybeans often grown by subsistence women farmers) and the other eight developing countries which grew biotech crops in 2007. This initial modest contribution of increased small farmer income from biotech crops towards the Millennium Development Goals of reducing poverty by 50% by 2015 is a very encouraging and important development, which has enormous potential in the second decade of commercialization, 2006 to 2015.

During the period 1996 to 2007, the proportion of the global area of biotech crops grown by developing countries has increased consistently every single year. In 2007, 43% of the global biotech crop area, (up from 40% in 2006), and equivalent to 49.4 million hectares, was grown in developing countries where growth between 2006 and 2007 was substantially higher (8.5 million hectares or 21% growth) than industrial countries (3.8 million hectares or 6% growth). It is noteworthy that the five principal developing countries committed to biotech crops, span all three continents of the South; they are India and China in Asia, Argentina and Brazil in Latin America and South Africa on the African continent – collectively they represent 2.6 billion people or 40% of the global population, with a combined population of 1.3 billion who are completely dependent on agriculture, including millions of small and resource poor farmers and the rural landless, who represent the majority of the poor in the world. The increasing collective impact of the five principal developing countries is an important continuing trend with implications for the future adoption and acceptance of biotech crops worldwide. Each of the five countries, reviewed in the following paragraphs, have benefited in a different way from biotech crops.

India

India, the largest cotton growing country in the world, where 60 million people are impacted by cotton, reported 54,000 farmers growing 50,000 hectares of Bt cotton in 2002. Five years later in 2007 the Bt cotton area has soared to 6.2 million hectares grown by 3.8 million small and resource-poor farmers. Notably, more than 9 out of 10 farmers who grew Bt cotton in 2005 also grew it in 2006 and similarly for 2006 and 2007 – this confirms the trust and confidence of farmers in Bt cotton after experiencing its superior performance in their own fields. For the third consecutive year, India has reported the highest proportional increase of any biotech crop country in the world with an impressive gain of 63% in 2007. The reason for the spectacular growth in Bt cotton is that it has consistently delivered unprecedented benefits to farmers and to the nation. Bt cotton has increased yield by up to 50%, reduced insecticide sprays by half, with environmental and health implications, and increased income by up to US$250 or more per hectare, which has contributed to social benefits and the alleviation of their poverty. At the national level, increased farmer income from Bt cotton in 2006 was estimated at US$840 million to US$1.7 billion, production has almost doubled, and India, which used to have one of the lowest cotton yields in the world, is now an exporter rather than an importer of cotton. **India's Minister of Finance** recently cited the success of Bt cotton and advocated that ***"It is important to apply biotechnology in agriculture – what has been done with cotton must be done with food grains. The success achieved in cotton must be used to make the country self sufficient in rice, wheat, pulse and oilseed production."*** Mrs. Aakkapalli Ramadevi, is a woman subsistence farmer from Andhra Pradesh, who laboriously tills 3 acres (1.3 hectares), and is typical of a small and resource-poor farmer in India who has benefited from Bt cotton. Before the advent of Bt cotton she said ***"The yields were very low and we used to incur losses, so we were perpetually losing money – to sum it up, we were badly off and unable to afford anything properly".*** After planting Bt cotton for two years she says, ***"Finally, cotton cultivation has actually turned profitable."*** A study conducted in 2006 of 9,300 Bt cotton and non-Bt cotton households in 456 villages in India reports that women and children in Bt cotton households already have slightly more access to social benefits than non-Bt cotton households. Compared with women in non-Bt cotton households, women in Bt cotton households report slightly more antenatal visits and assistance with births at home, and their children have higher school enrollment and a higher proportion vaccinated. The story of Bt cotton in India is remarkable. With political will and farmer support in place, adoption is projected to continue increasing with Bt cotton plantings escalating from the current 66% to 80% or more. Coincidentally, new biotech products such as Bt eggplant, an important food and cash crop that can benefit up to 2 million small and resource-poor farmers, is in advanced large scale field trials, with expectations of approval in the near term.

China

China, the biggest producer of cotton in the world introduced Bt cotton in 1996/1997, six years ahead of India. The story of Bt cotton in China is a remarkable experience of massive adoption of biotech crops by small farmers who represent some of the poorest people in the world – something that many critics of biotech crops in the early 1990s predicted could never happen. India, with 9.4 million hectares has almost twice the cotton area of China at 5.5 million hectares. Although India introduced Bt cotton in 2002, six years later than China, by 2006 India had planted 0.3 million hectares more Bt cotton than China, and 2.4 million hectares more than China in 2007. However, because cotton holdings are much smaller in China (average is 0.59 hectare) than India (1.63 hectares), the number of small farmers benefiting from Bt cotton in China in 2007 is almost twice as numerous (7.1 million) as in India (3.8 million). In 2007, Bt cotton was planted in China by 7.1 million small and resource-poor farmers on 3.8 million hectares, (up from 3.5 million hectares in 2006) which is equivalent to 69% of the 5.5 million hectares of all cotton planted in China. One of the important indicators that reflect farmers' confidence in any new technology is the extent to which farmers repeat the planting of Bt cotton in the following season. In 2006 and 2007, of 240 cotton growing households surveyed in 12 villages in three provinces – Hebei, Henan and Shandong, by the Center for Chinese Agricultural Policy (CCAP) of the Chinese Academy of Sciences, it is notable that every single family that reported growing Bt cotton in 2006, also elected to grow Bt cotton in 2007 – thus, the repeat index for farmers growing Bt cotton between 2006 and 2007 in three provinces in China was 100%. Interestingly, of the 240 farmers surveyed, a few farmers in one village also grew one variety of non-Bt cotton in 2006 that they also grew in 2007. This confirms the fact that farmers wisely often want to compare the performance of the old and improved technologies side-by-side in their own fields – the same happened during the introduction of hybrid maize in the corn belt in the USA – farmers planted the best performing varieties next to the new hybrids until they were satisfied that hybrids consistently outperformed their old varieties and it took several years for hybrids to be universally adopted. Based on studies conducted by CCAP, on average at the farm level Bt cotton in China increases yield by 9.6%, reduces insecticide use by 60%, with positive implications for both the environment and the farmers' health, and generates a substantial US$220 per hectare increase in income, which makes a significant contribution to their lives as income of many cotton farmers is less than US$1 per day. **Niu Qingjun** is a typical Chinese cotton farmer, 42 years old, married with two children and 80% of the family income comes from cotton. The total size of his farm is 0.61 hectare and cotton is the only crop that he grows. Niu sums up his experience with Bt cotton: ***"We could not even plant cotton if there is not insect-resistance cotton (Bt cotton). We could not control bollworm infestation before planting insect-resistance cotton, even if spraying 40 times insecticide in 1997."*** Niu only sprayed insecticide 12 times in 2007, approximately half of the number of sprays he used on conventional cotton prior to the introduction of Bt cotton. The story of Bt cotton in China is well documented and is an important case study on the adoption of biotech crops by small and resource-poor farmers. China has also planted about one quarter of a million Bt poplars and in 2006 started to commercialize an approved virus resistant biotech papaya (a fruit/food crop) which has been developed by a Chinese university and grown on approximately 3,500 hectares – a virus resistant sweet pepper and delayed ripening tomato have also been approved for commercialization. With the exception of some varieties of Bt cotton, all the biotech crops commercialized in China have been developed by Chinese state institutions with public sector funding. Rice is the most important food crop in the world and importantly, it is also the most important food crop for the poor people of the world. In 2006, China grew 29.3 million hectares of rice equivalent to 20% of the world total of 150 million hectares. There are an estimated 250 million rice households in the world, and the vast majority of them are small and resource-poor farmers. There are an estimated 110 million rice households in China farming an average of 0.27 hectare of rice – these small and resource-poor rice farmers represent some of the poorest people in the world. China has the largest biotech rice program in the world. China's biotech rice is resistant to specific pests (insect borers) and diseases (bacterial blight) and is waiting approval after extensive field tests. Dr. Jikun Huang from the Center for Chinese Agricultural Policy (CCAP) estimates that on the average, biotech rice increased yield by 2 to 6%, and reduced insecticide application by nearly 80% or 17 kg per hectare. At a national level, it is projected that biotech rice could deliver benefits of US$4 billion per year for China, plus environmental benefits that will contribute to a more sustainable agriculture and the alleviation of poverty for small and resource-poor farmers. Thus, together, Bt cotton and biotech rice have the potential of generating economic benefits of US$5 billion per year by 2010, for up to 110 million rice households in China. It is estimated that China has enhanced farm income from biotech cotton by US$5.8 billion in the period 1996 to 2006 and the benefits for 2006 alone are estimated at US$817 million. 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, feed and fiber security. China has a legion of public sector institutes and thousands of researchers devoted to crop biotechnology and over a dozen biotech crops are 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.

Argentina

Argentina is one of the six "founder biotech crop countries", which commercialized RR® soybean in 1996, the first year of global commercialization. Argentina remains the second largest grower of biotech crops in the world, growing 19.1 million hectares in 2007, comprising 19% of global biotech crop hectarage. In 2007, the year-over-year increase, compared with 2006, was 1.1 million hectares, equivalent to an annual growth rate of 6%. Of the 19.1 million hectares of biotech crops in Argentina in 2007/08, 16.0 million hectares were planted to biotech soybean, 2.8 million hectares to biotech maize and approximately 400,000 hectares to biotech cotton. Unlike India and China, farms in Argentina are large and it is a major exporter of grain and oil seeds. A recent analysis concluded that biotech crops in Argentina, particularly RR® soybean, generated a significant increase in farmer income, worth approximately US$20 billion in the decade 1996 to 2005, created a million new jobs, more affordable soybean for consumers, and significant environmental benefits, particularly the practice of no till for conserving soil and moisture which importantly allows double cropping of biotech soybean (Trigo and Cap, 2006). The rapid adoption in Argentina was the result of several factors including: a well-established seed industry; a regulatory system that provided a responsible, timely, and cost-effective system for approving biotech products; and a technology with high impact. The total direct benefits for Argentina in the first decade, 1996 to 2005, were as follows: US$19.7

billion for herbicide-tolerant soybean for the period 1996 to 2005; US$482 million for insect-resistant maize for the period 1998 to 2005; and US$19.7 million for insect-resistant cotton for the period 1998 to 2005 for a total of US$20.2 billion for the three crops. Biotech crops have generated multiple and significant benefits for Argentina in the first decade of commercialization. The challenge for Argentina is to sustain its world ranking at number 2 in the second decade, 2006 to 2015, in the face of increased competition from many more countries which did not participate actively in the first decade of commercialization.

Brazil

Brazil has both large farms, and small and resource-poor farmers, particularly in the poor North East of the country and under the current administration alleviation of poverty in the rural area is a high priority. In 2007, Brazil retained its position as the third largest adopter of biotech crops in the world, estimated at 15.0 million hectares, of which 14.5 million hectares were planted to RR® soybean and 500,000 hectares planted with a single gene Bt cotton, grown for the second time in 2007. Considering both percentage and absolute growth, the year-over-year growth of 30% between 2006 (11.5 million hectares) and 2007 (15.0 million hectares) was the second highest in the world after India; the increase of 3.5 million hectares in 2007 was the largest absolute increase for any biotech crop country in the world. Brazil is currently the second largest producer of soybeans in the world after the USA and expected to become the first in the future – in 2007, Brazil offset a reduction in biotech soybean hectarage in the USA. Brazil is the third largest producer of maize in the world and the first biotech maize varieties have received initial clearance and are expected to have final approval for planting in 2008/09. Brazil is also the sixth largest producer of cotton, the tenth largest grower of rice (3.7 million hectares) and the only major producer of rice outside Asia. In addition, Brazil is also the largest sugarcane producer in the world with 6.2 million hectares and uses approximately half of its national sugarcane area to produce sugar and the other half for the production of ethanol for biofuels. After the USA, Brazil was the second biggest producer of ethanol in the world in 2007 and one of few countries that is self-sufficient in both fossil fuels and biofuels in which it is a world leader. To date, the introduction of biotech crops in Brazil has suffered significant delays because of legal and judicial restraining orders delaying the deployment of approved biotech crops. A 2007 study by Dr. Anderson Galvão Gomes, has estimated the benefits lost to Brazilian farmers because of delayed approval due to a cumbersome approval process, particularly the legal challenges from various interest groups, including Ministries within the Government. Taking the fast adoption rates of RR® soybean in neighboring Argentina as a practical bench mark for adoption, the study concluded that delayed approval of RR® soybean in Brazil for the period 1998 to 2006 cost farmers US$3.10 billion and cost technology developers an additional US$1.41 billion, for a total of US$4.51 billion in lost benefits. The total potential benefits for both farmers and technology developers during the period 1998 to 2006 was US$6.6 billion of which only US$2.09 billion, equivalent to 31%, was realized. Thus, US$4.51 billion was lost due to legal delays which were a significant sacrifice for Brazil as a nation and the major losers were farmers. However, recent commitments by the current administration of funds totaling Real 10 billion equivalent to US$7 billion (60% public and 40% private), and prorated at US$700 million per year for the next ten years, demonstrates strong political will and support for biotechnology by the Brazilian government. Moreover, a significant part of the US$7 billion is to be devoted to biofuels and agriculture. In November 2007 President Luis Inacio Lula da Silva of Brazil announced a US$23 billion investment in a four-year "Plan for Action for Science, Technology and Innovation." One of the four thrusts of the Plan is to support research and innovation in strategic areas particularly biotechnology, biofuels and biodiversity. It is noteworthy that the political will for biotechnology evident in Brazil is also evident in China and India. The troika of Brazil, India and China is a formidable force in agricultural biotechnology that can deliver enormous material and humanitarian benefits. The political will of the troika needs to be integrated to establish a nuclear group that will work together to gain the support of global society for harnessing and optimizing the contribution of biotech crops for the alleviation of poverty and hunger for resource-poor farmers by 2015 – the Millennium Development Goals – when it is expected that all three major staples, maize, rice and wheat as well as several orphan crops will benefit from biotechnology. In summary, Brazil has become a world leader in the adoption of biotech crops with continued significant growth expected in RR® soybean hectarage, rapid expansion in Bt cotton supplemented with herbicide tolerance, substantial opportunities on the 13 million hectares of maize from 2008 onwards, new opportunities for its 3.7 million hectares of rice, as well as the enormous potential with biotech sugarcane for its emerging role as a world leader and exporter of bioethanol.

South Africa

South Africa is the only country on the continent of Africa to commercialize biotech crops. It is ranked number eight in the world with a total biotech crop hectarage of 1.8 million hectares in 2007, almost a 30% increase over the 1.4 million hectares in 2006. Biotech maize, cotton and soybean are grown in South Africa and their area has increased every single year since the first plantings in 1998. The major increase in 2007 was in biotech maize, notably most of it in white maize used for food, which now occupies two-thirds of the total white maize area of 1.7 million hectares. Both small and resource-poor farmers and large farmers grow biotech crops, which have earned their trust and confidence. The Bt cotton grown in KwaZulu Natal region is mainly grown by women subsistence farmers. **Philiswe Mdletshe**, a woman cotton farmer from the Makhathini Flats, KwaZulu-Natal province, increased her yield with Bt cotton from three bales per hectare to eight bales per hectare, earning her a net income of Rand 38,400 (US$5,730). She reduced insecticide sprayings from ten times a season with non-Bt cotton to twice with Bt cotton and saved 1,000 liters of water. She has continued planting Bt cotton for five successive years. **Chief Advocate Mdutshane**, a highly respected chief of Ixopo, whose native language is Xhosa, from the Eastern Cape of South Africa says that 120 emergent poor farmers in his area increased their yields over conventional maize by up to 133% with Bt maize. Yields increased from 1.5 tons per hectare to 3.5 tons per hectare by eliminating the stalk borer, which damaged up to 60% of their crops. They call the Bt maize, ***"iyasihluthisa"***, it is Xhosa for ***"It fills our stomachs."*** Mdutshane said ***"For the first time ever they produced enough food to feed themselves."*** **Richard Sitole**, chairperson, Hlabisa District Farmers' Union, KZN, says 250 emergent subsistence farmers of his Union planted Bt maize on their smallholdings, averaging 2.5 hectares, for the first time in 2002. His own yield increased by 25% from 80 bags for conventional maize to 100 bags, earning him an additional income of Rand 2,000 (US$300). Some of the farmers increased their yields by up to 40%. He pointed out that taking 20 farmers, and there were many more, earning an extra income of Rand 2,000 (US$300) totaled Rand 40,000 (US$6,000) additional disposable income in their small community, boosting small shopkeepers, dressmakers and vegetable producers. ***"I challenge those who oppose GM crops for emergent farmers to stand up and deny my fellow farmers and me the benefit of earning this extra income and more than sufficient food for our families,"*** says Sitole. 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, sponsored by ISAAA, and is engaged in training and human resource development programs with its neighboring African countries. Given South Africa's rich and unique African experience with biotech crops, it can also play an important role as the key country partner on the continent of Africa to facilitate collaboration and cooperate with its counterpart biotech crop countries of China and India in Asia, and Argentina and Brazil in Latin America. The Governments of India, Brazil and South Africa (IBSA) have established a platform for cooperation that includes research collaboration on crop biotechnology. With creative management, IBSA can evolve into an innovative mechanism that can expedite the South-South sharing of biotech crop applications to urgently improve crop productivity in the food insecure nations of Africa. 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 biotech crop 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 maize, soybean and cotton by US$156 million in the period 1998 to 2006, with benefits for 2006 alone estimated at US$67 million.

In 2007, the number of countries planting biotech crops increased to 23 with Poland planting Bt maize for the first time, and bringing the total number of countries planting biotech crops in the EU to 8 out of 27, up from 6 in 2006. Spain continued to be the lead country in Europe planting over 70,000 hectares in 2007, equivalent to a 21% adoption rate and a 40% increase over 2006. Importantly, the collective Bt maize hectarage in the other seven countries (France, Czech Republic, Portugal, Germany, Slovakia, Romania, and Poland) increased over 4-fold from approximately 8,700 hectares in 2006 to approximately 35,700 hectares in 2007, albeit on modest hectarages, and the total Bt maize in the EU exceeded 100,000 hectares for the first time with a year-on-year growth rate of 77%.

It is noteworthy that more than half (55% or 3.6 billion people) of the global population of 6.5 billion live in the 23 countries where biotech crops were grown in 2007 and generated significant and multiple benefits worth US$7 billion globally in 2006. Also, more than half (52% or 776 million hectares) of the 1.5 billion hectares of cropland in the world is in the 23 countries where approved biotech crops were grown in 2007. The 114.3 million hectares of biotech crops in 2007 represents 8% of the 1.5 billion hectares of crop land in the world.

Biotech soybean continued to be the principal biotech crop in 2007, occupying 58.6 million hectares (51% of global biotech area), followed by fast-growing maize (35.2 million hectares at 31%), cotton (15.0 million hectares at 13%) and canola (5.5 million hectares at 5% of global biotech crop area).

From the genesis of commercialization in 1996 to 2007, herbicide tolerance has consistently been the dominant trait. In 2007, herbicide tolerance, deployed in soybean, maize, canola, cotton and alfalfa occupied 63% or 72.2 million hectares of the global biotech 114.3 million hectares. For the first time in 2007, the stacked double and triple traits occupied a larger area (21.8 million hectares, or 19% of global biotech crop area) than insect resistant varieties (20.3 million hectares) at 18%. The stacked trait products were by far the fastest growing trait group between 2006 and 2007 at 66% growth, compared with 7% for insect resistance and 3% for herbicide tolerance.

In the first 12 years, the accumulated global biotech crop area for the first time in 2007 exceeded two-thirds of a billion hectares at 690.9 million hectares or 1.7 billion acres, equivalent to approximately 70% of the total land area of the USA or China, or almost 30 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 benefits for both large and small farmers, consumers and society in both industrial and developing countries.

In 2007, the global market value of biotech crops, estimated by Cropnosis, was US$6.9 billion representing 16% of the US$42.2 billion global crop protection market in 2007, and 20% of the ~US$34 billion 2007 global commercial seed market. The US$6.9 billion biotech crop market comprised of US$3.2 billion for biotech maize (equivalent to 47% of global biotech crop market, up from 39% in 2006), US$2.6 billion for biotech soybean (37%, down from 44% in 2006), US$0.9 billion for biotech cotton (13%), and US$0.2 billion for biotech canola (3%). Of the US$6.9 billion biotech crop market, US$5.2 billion (76%) was in the industrial countries and US$1.6 billion (24%) was in the developing countries. 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 US$42.4 billion. The global value of the biotech crop market is projected at approximately US$7.5 billion for 2008.

The most recent survey of the global impact of biotech crops for the period 1996 to 2006, estimates that the global net economic benefits to biotech crop farmers in 2006 was US$7 billion, and US$34 billion (US$16.5 billion for developing countries and US$17.5 billion for industrial countries) for the accumulated benefits during the period 1996 to 2006; these estimates include the very important benefits associated with the double cropping of biotech soybean in Argentina (Brookes and Barfoot, 2008). The accumulative reduction in pesticides for the period 1996 to 2006 was estimated at 289,000 metric tons of active ingredient, which is equivalent to a 15.5% 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 important and urgent concerns about the environment have implications for biotech crops, which can potentially contribute to a reduction of greenhouse gases and mitigate 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 2006 this was an estimated saving of 1.2 billion kg of carbon dioxide (CO_2), equivalent to reducing the number of cars on the roads by 0.5 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 2006 of 13.6 billion kg of CO_2, or removing 6 million cars off the road. Thus, in 2006 the combined permanent and additional savings through sequestration was equivalent to a saving of 14.8 billion kg of CO_2 or removing 6.5 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 23 countries planted commercialized biotech crops in 2007, an additional 29 countries, totaling 52, 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 615 approvals have been granted for 124 events for 23 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 52 countries that have granted approvals for biotech crops, Japan tops the list followed by USA, Canada, South Korea, Australia, Mexico, the Philippines, New Zealand, the European Union and China. Maize has the most events approved (40) followed by cotton (18), canola (15), and soybean (8). The event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 24 approvals (EU=27 counted as 1 approval only), followed by insect resistant maize (MON810) and herbicide tolerant maize (NK603) both with 18 approvals, and insect resistant cotton (MON531/757/1076) with 16 approvals worldwide.

In 2007, it is estimated that of the 114.3 million hectares of biotech crops grown worldwide, approximately 9% or 11.2 million hectares of biotech crops were used for biofuel production, with over 90% of that hectarage in the USA. It is estimated that in 2007, 7 million hectares of biotech maize was devoted to ethanol production in the USA and approximately 3.4 million hectares of biotech soybean for biodiesel, plus about 10,000 hectares of biotech canola for a USA total of 10.4 million hectares of biotech crops for biofuels. In Brazil, 750,000 hectares of RR® soybean was used to produce biodiesel in 2007 and in Canada approximately 45,000 hectares of biotech canola was used for the production of biodiesel for a total of 11.2 million hectares of biotech crops used globally for biofuel production.

It is evident that much progress has been made in the first twelve years of commercialization of biotech crops but progress to-date is just the "tip of the iceberg", compared with potential progress in the second decade of commercialization, 2006-2015. It is a fortunate coincidence that the last year of the second decade of commercialization of biotech crops, 2015 is also the year of the Millennium Development Goals. This offers the unique opportunity for the global biotechnology community, from the North and the South, the public and the private sectors, to define in 2008 the contributions that biotech crops can make to the Millennium Development Goals and a more sustainable agriculture in the future – this will give the global biotech crop community seven years to work towards implementing an action plan that can deliver on the goals for 2015. Five goals, described in the following paragraphs, deserve consideration given that there is a high probability that crop biotechnology can deliver on these promises by 2015.

1. ***Increasing global crop productivity to improve food, feed and fiber security in sustainable crop production systems that also conserve biodiversity***
   A significant contribution has already been made in the first 12 (dozen) years of commercialization through deployment of biotech crops more tolerant to the biotic stresses caused by pests, weeds and diseases. This sustainable increase in productivity on the same area of cropland allows biodiversity to be conserved because it will help preclude the need for deforestation and slash and burn agriculture. Increases in productivity of maize for feed, the oil seed crops soybean and canola, and the fiber crop cotton have been significant with gains valued at US$34 billion in the period 1996 to 2006. Initial progress has been made with food crops with white maize in South Africa, ingredients of biotech maize, soybean and canola used commonly in processed foods, biotech papaya and squash consumed in the USA, and papaya in China. Progress with control of abiotic stresses is expected in the near term with drought tolerance available within five years and salt tolerance thereafter. A new family of input and output traits will not only increase yield but provide more nutritious food, such as omega-3 oil and golden rice enriched with pro-vitamin A, expected to be approved by 2012. The most important event in the next five years is the expected approval of biotech rice, the most important food crop in the world, already temporarily released in Iran in 2005. Extensive multi-locational field trials of biotech rice have been completed in China and the

product is being considered for commercial release. Field trials are already underway in India and many countries in Asia have research programs, which would be expedited to deliver biotech rice products following approval by China. Biotech rice has enormous potential to coincidentally contribute to food security and alleviation of poverty.

2. ***Contributing to the Alleviation of Poverty and Hunger***
   Fifty percent of the world's poorest people are small and resource-poor farmers, and another 20% are the rural landless dependent on agriculture for their livelihoods. Thus, increasing income of small and resource-poor farmers contributes directly to the poverty alleviation of a large majority of the world's poorest people. Biotech cotton has already made a significant contribution to the income of poor farmers in the first decade, 1996 to 2005, and this can be enhanced significantly in the second decade. Biotech maize is already delivering benefits to a modest number of small farmers and holds enormous potential by 2015. Crops such as biotech eggplant, being developed in India, the Philippines, and Bangladesh are expected to be approved in the near term and used almost exclusively by up to 2 million small farmers. Focusing on a pro-poor agenda for orphan crops such as cassava, sweet potato, sorghum, and vegetables will allow a diversified and balanced crop biotech program to be developed that is specifically targeted at alleviation of poverty and hunger.

3. ***Reducing the Environmental Footprint of Agriculture***
   Conventional agriculture has impacted significantly on the environment and biotechnology can be used to reduce the environmental footprint of agriculture. Progress in the first decade includes a significant reduction in pesticides, saving on fossil fuels and decreasing CO_2 emissions through no/less ploughing, and conserving soil and moisture by optimizing the practice of no till through application of herbicide tolerance. Increasing efficiency of water usage will have a major impact on conservation and availability of water globally. Seventy percent of fresh water is currently used by agriculture globally, and this is obviously not sustainable in the future as the population increases by almost 50% to 9.2 billion by 2050; in developing countries the current agricultural usage of fresh water is even higher at 86%. Other biotech crop applications that will become available towards the end of the second decade 2006 to 2015 are crops with increased nitrogen efficiency, which has implications in mitigating global warming and the pollution of aquifers and deltas, such as the Mekong, with nitrogen related pollutants. The first biotech maize varieties with drought tolerance are expected to be commercialized by around 2011 and the trait has already been incorporated in several other crops. Drought tolerance is expected to have a major impact on cropping systems worldwide, particularly in developing countries where drought is more prevalent and severe than industrial countries.

4. ***Mitigating Climate Change and Reducing Greenhouse Gases (GHG)***
   Droughts, floods, and temperature changes are predicted to become more prevalent and

more severe, and hence there will be a need to expedite improvement of crops that are well adapted to changing climatic conditions. Several biotech crop tools, including diagnostics, genomics, molecular marker-assisted selection (MAS) and biotech crops can be used for 'speeding the breeding' and mitigating the effects of climate change. Biotech crops are already contributing to reducing CO_2 emissions by precluding the need for ploughing a significant portion of cropped land, conserving soil and moisture, reducing pesticide spraying as well as sequestering CO_2.

5. ***Contributing to the Cost-effective Production of Biofuels***
   Biotechnology can be used to cost effectively optimize the productivity of biomass/hectare of first generation food/feed and fiber crops and also second generation energy crops. This can be achieved by developing crops tolerant to abiotic stresses (drought/salinity) and biotic stresses (pests, weeds, diseases) and also to raise the ceiling of potential yield per hectare through modifying plant metabolism. There is also an opportunity to utilize biotechnology to develop more effective enzymes for the downstream processing of biofuels.

The Future

The future for biotech crops looks encouraging. The number of biotech crop countries, crops and traits and hectarage are projected to double between 2006 and 2015, the second decade of commercialization; in the developing countries, Burkina Faso and Egypt, and possibly Vietnam are potential candidates for adopting biotech crops in the next one or two years. The lifting of the four-year ban on biotech canola in late November 2007 in the states of Victoria and New South Wales was a very important development for the future of biotech crops in Australia, where drought tolerant wheat is already being field tested. By 2015, the number of farmers adopting biotech crops could increase up to ten fold to 100 million, or more, assuming that only biotech rice will be approved in the near term. Genes conferring a degree of drought tolerance, expected to become available around 2011 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 vital 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. Other products, including pharmaceutical products, oral vaccines, and specialty products will also be featured. The use of biotechnology to increase efficiency of first generation food/feed crops and second-generation energy crops for biofuels is likely to have significant 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. The key role of crop biotechnology is to cost-effectively optimize the yield of biomass/biofuel per hectare, which in turn will provide more affordable fuel. However by far, the most important potential contribution of biotech crops will be their contribution to the humanitarian Millennium Development Goals (MDG) of reducing poverty and hunger by 50% by 2015. 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.

The most important message in the recently published 2008 World Bank Development Report "Agriculture for Development" is that ***"Agriculture is a vital development tool for achieving the Millennium Development Goals that calls for halving by 2015 the share of people suffering from extreme poverty and hunger"*** (World Bank, 2008). The Report offers an important reminder that three out of every four people in developing countries live in rural areas and most of them depend directly or indirectly on agriculture for their livelihoods. It recognizes that overcoming abject poverty cannot be achieved in Sub Saharan Africa without a revolution in agricultural productivity for the millions of suffering subsistence farmers in Africa, most of them women. However, it also draws attention to the fact that Asia's fast growing economies, where most of the wealth of the developing world is being created, are also home to 600 million rural people (compared with 770 million total population of Sub Saharan Africa) living in extreme poverty, and that rural poverty in Asia will remain life-threatening for millions of rural poor for decades to come. It is a stark fact that poverty today is a rural phenomenon where 50% of the poorest people in the world are resource-poor farmers and another 20%, the rural landless, who are completely dependent on agriculture for their livelihoods. Thus, the majority, 70%, of the world's poorest people are small and resource-poor farmers and the rural landless labor who live and toil on the land. The challenge is to transform this concentration of poverty in agriculture into an opportunity for alleviating poverty by sharing with resource-poor farmers the knowledge and experience of those from industrial and developing countries which have successfully employed biotech crops to increase crop productivity, and in turn, income. The World Bank Report specifically recognizes that the revolution in biotechnology and information offer unique opportunities to use agriculture to promote development, but cautions that there is a risk that fast-moving crop biotechnology can easily be missed by developing countries if the political will and international assistance support is not forthcoming, particularly for the more controversial application of biotech/GM crops which is the focus of this ISAAA Review. It is encouraging to witness the growing "political will" and conviction of visionary politicians and lead farmers for biotech/GM crops in several of the lead developing countries highlighted in this Review. The challenge for the international community and the lead biotech crop developing countries of India, China, Argentina, Brazil, and South Africa, which have already benefited from biotech crops, is to openly share their experience and knowledge with the legion of developing countries that have yet to have first-hand experience with biotech crops. To implement this will require urgent but modest financial support from the philanthropic foundations, the bilateral and multilateral AID organizations and from all the multinationals in the private sector that are benefiting from the US$7 billion biotech crop industry today. Failure to provide this critical support at this time will risk many developing countries missing out on a one-time window of opportunity and become permanently disadvantaged and non-competitive in crop productivity, with all its dire implications for the hope of alleviating poverty. There is no substitution for sharing the collective experience of a "national team of practitioners" who have been involved in a successful national crop biotech program such as Bt cotton in India or China or biotech maize in South Africa or the Philippines. The national team sharing the experience should include all the key resource personnel, including politicians, policy makers, agronomists, biotechnologists, economists and farmers who have been directly engaged with all aspects of biotech crops. Both the pros and the cons must be frankly shared so that there is no need for newcomers to the technology to reinvent the wheel. One key question that must be asked of the team sharing the experience is "how would you implement a crop biotech program differently, the second time around " i.e. what have been the lessons and learning of the first generation of biotech crop adopters that can be shared with second generation adopters so that the latter can gain from the experience.

The most important constraint to biotech crops in most developing countries, that deserves highlighting, is the lack of appropriate cost-effective and responsible regulation systems that incorporate all the lessons of a dozen years of regulation. Current regulatory systems in most developing countries are usually unnecessarily cumbersome and in many cases it is impossible to implement the system to approve products which can cost up to US$1 million or more to deregulate – this is beyond the means of most developing countries. The current regulatory systems were designed more than ten years ago to meet the initial needs of industrial countries dealing with a new technology and with access to significant resources for regulation which developing countries simply do not have – the challenge for developing countries is "how to do a lot with little." With the accumulated knowledge of the last dozen years it is now possible to design appropriate regulatory systems that are responsible, rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries – this should be assigned top priority. Today, unnecessary and unjustified stringent standards designed to meet the needs of resource-rich industrial countries are denying the developing countries timely access to products such as golden rice, whilst millions die unnecessarily in the interim. This is a moral dilemma, where the demands of regulatory systems have become "the end and not the means", overriding common sense, and where "the regulatory surgery may be successful but the patient died."

Global Status of Commercialized Biotech/GM Crops: 2007

by

Clive James
Chair, ISAAA Board of Directors

Introduction

2007 marks the twelfth year of the commercialization, 1996-2007, 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 eleven years of commercialization, 1996 to 2006, has confirmed that the early promise of crop biotechnology has been fulfilled. Biotech crops have delivered 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 2006, developing and industrial countries, contributed to over a 60-fold increase in the global area of biotech crops from 1.7 million hectares in 1996 to 102 million hectares in 2006. Adoption rates for biotech crops during the period 1996 to 2006 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 demonstrate 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 10.3 million farmers in 22 countries grew biotech crops in 2006 and derived multiple benefits that included significant agronomic, environmental, health, social and economic advantages. ISAAA's 2006 Global Review (James 2006) predicted that the number of farmers planting biotech crops, as well as the global area of biotech crops, would continue to grow in 2007. Global population was approximately 6.5 billion in 2006 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 the Millennium Development Goals 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, fiber and fuel 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;

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

- **mitigating climate change and reducing greenhouse gases** by using biotech applications for "speeding the breeding" in crop improvement programs to develop well adapted germplasm for changing climatic conditions and optimize the sequestering of CO_2;

- **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 cost-effective 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 (James 2006, James 2005, James 2004, James 2003, James 2002, James 2001, James 2000, James 1999, James 1998, James 1997, James and Krattiger 1996). 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 2007 and the changes that have occurred between 2006 and 2007 are highlighted. The global adoption trends during the last dozen years from 1996 to 2007 are also illustrated and the contribution of biotech crops to 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 2007, and in the Appendix there are 3 sections: 1) details of principal events in India in 2007; 2) a comprehensive inventory 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, 3) useful tables and charts on the international seed trade – these have been reproduced with permission of the International Seed Federation (ISF).

Note that the words, rapeseed, canola, and Argentine canola are synonymously used, as well as, transgenic, genetically modified crops, GM crops, and biotech crops, 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 2007 information for Argentina, Brazil, Australia, South Africa, and Uruguay is hectares usually planted in the last quarter of 2007 and harvested in the first quarter of 2008 with some countries like the Philippines planting more than one season per year.

Over the last 11 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 2007

In 2007, the 12th year of commercialization, the global area of biotech crops continued to grow at a sustained growth rate of 12% reaching 114.3 million hectares (282.4 million acres) (Table 1). The accumulated hectarage during the first dozen years, 1996 to 2007, has reached almost 700 million hectares (690.9 million hectares). Biotech crops have set a precedent in that the biotech area has grown by double-digit rates every single year for the past 12 years, since commercialization first began in 1996. The number of farmers growing biotech crops in 2007 reached 12 million (up from 10.3 million in 2006) of which 90% or 11 million, up from 9.3 million in 2006, were small and resource-poor farmers from developing countries.

Thus, in 2007, 114.3 million hectares of biotech crops were planted by 12 million farmers in 23 countries, compared with 102 million hectares grown by 10.3 million farmers in 22 countries in 2006. **It is notable that 12.3 million hectares more were planted in 2007 by 12 million farmers in the 12th year of commercialization at a double digit growth rate of 12%.** Two additional countries, Chile and Poland have been added to the global list of biotech countries in 2007, bringing the total to 23. The total number of EU countries now growing biotech crops is eight and includes Spain, France, Czech Republic, Portugal, Germany, Slovakia, Romania and Poland.

Table 1. Global Area of Biotech Crops, the First 12 Years, 1996 to 2007

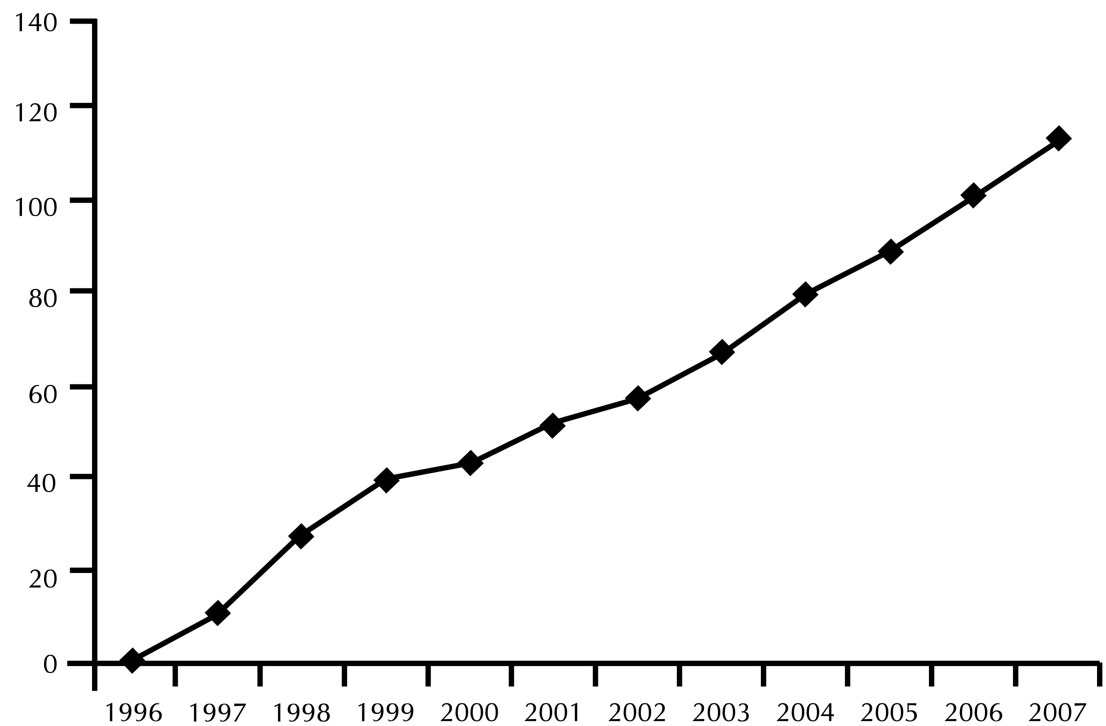
Year	Hectares (million)	Acres (million)
1996	1.7	4.3
1997	11.0	27.5
1998	27.8	69.5
1999	39.9	98.6
2000	44.2	109.2
2001	52.6	130.0
2002	58.7	145.0
2003	67.7	167.2
2004	81.0	200.0
2005	90.0	222.0
2006	102.0	252.0
2007	**114.3**	**282.0**
Total	**690.9**	**1,707.3**

Increase of 12%, 12.3 million hectares (30 million acres) between 2006 and 2007.
Source: Clive James, 2007.

To put the 2007 global area of biotech crops into context, 114.3 million hectares of biotech crops is equivalent to more than 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 2006 and 2007 of 12% is equivalent to 12.3 million hectares or 30 million acres.

During the first dozen years of commercialization 1996 to 2007, the global area of biotech crops increased sixty-seven fold, from 1.7 million hectares in 1996 to 114.3 million hectares in 2007 (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 as well as small and resource-poor 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 23 in 2007. This year was also the first time that more than 10 million small and resource-poor farmers from the developing countries benefited from biotech crops. The year 2007 also marked the first year when more than 100,000 hectares of biotech crops were grown in the EU where biotech crops increased by more than 75% between 2006 and 2007.

Figure 1. Global Area of Biotech Crops, 1996 to 2007 (Million Hectares)



Source: Clive James, 2007.

Brazil reported the largest absolute increase in biotech crops at 3.5 million hectares, followed by the USA at 3.1 million hectares and India at 2.4 million hectares. The largest proportional increase in 2007 was in India with a 63% increase in Bt cotton area from 3.8 million hectares in 2006 to 6.2 million hectares in 2007; India with 6.2 million hectares now grows significantly more Bt cotton (2.4 million hectares) than China with 3.8 million hectares. Notably, large proportional increases in biotech crops were also reported by the Philippines 50%, Brazil 30%, Paraguay 30%, South Africa 29%, Uruguay 25% and Canada 15%. In fact, only one country, Australia, registered a significant decrease in biotech crops and this was due to the severe drought which is the worst in the history of the country, and which resulted in total plantings of cotton decreasing by more than two-thirds.

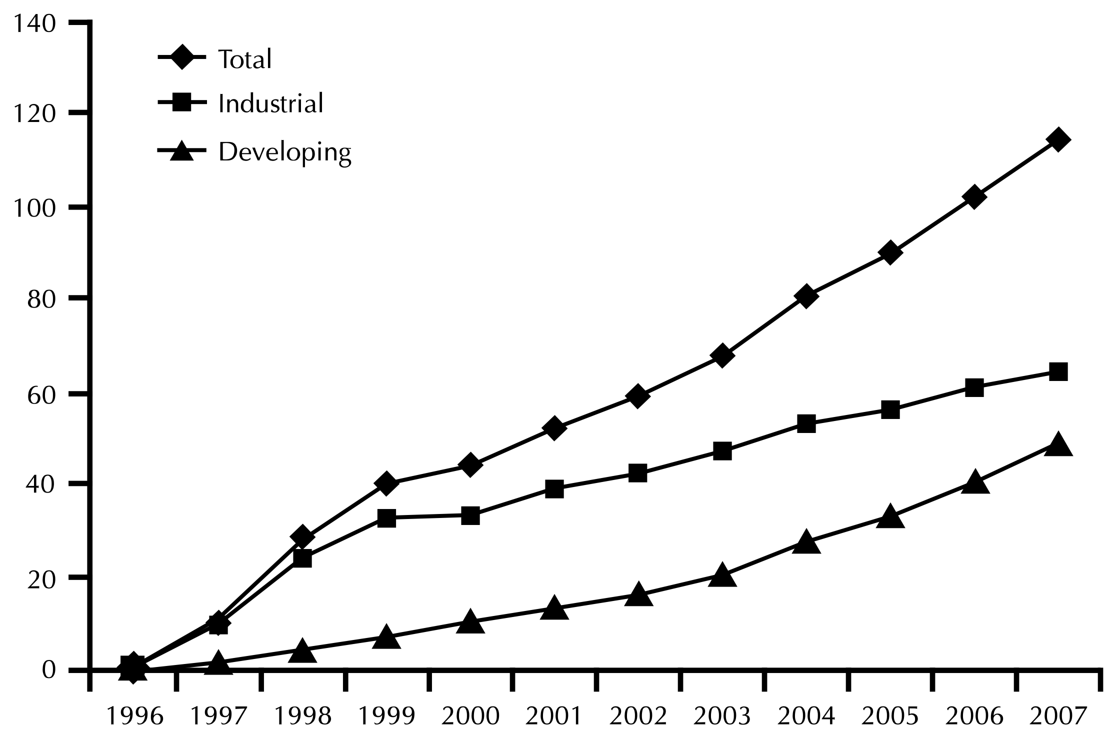
In summary, during the first dozen years of commercialization 1996 to 2007, an accumulated total of approximately 700 million hectares or 1.7 billion acres of biotech crops have been successfully grown, accumulatively since 1996, as a result of approximately 55 million repeat decisions by farmers to 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 23 in the same 12-year period. However, the significant hectarage of 114.3 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 approximately 20% of the 114.3 million hectares planted primarily in the US, but also increasingly in nine other countries, Canada, the Philippines, Australia, Mexico, South Africa, Honduras, Colombia, Argentina and Chile had two or three traits, the true global area of biotech crops in 2007 expressed as "trait hectares" was 143.7 million compared with 117.7 million "trait hectares" in 2006. Thus, the actual growth rate measured in "trait hectares" between 2007 (143.7million) and 2006 (117.7 million) was 22% compared with only 12% when measured conservatively in hectares between 2006, (102.0 million hectares) and 2007 (114.3 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 2007. It clearly illustrates that whereas the substantial but consistently declining share (57% in 2007 compared with 60% in 2006) of biotech crops continued to be grown in industrial countries in 2007, 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, 40% in 2006, and 43% in 2007. Thus, in 2007, more than 40%, of the global biotech crop area of 114.3 million hectares, equivalent to 49.4 million hectares, was grown in 12 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, Brazil, Paraguay and Uruguay, in Latin America, and South Africa on the African continent. In fact, all the top 5 countries with the highest year on year percentage growth between 2006 and 2007 were developing countries. It is also noteworthy that for the third year in succession, the absolute growth in the biotech crop area between 2006 and 2007 was more than twice as high in the developing countries (8.5 million hectares) than in industrial countries (3.8 million hectares). Equally important to note is that the percentage growth was more than three times higher (21%) in the developing countries of the South, compared to 6% in the industrial countries of the North.

Of the US$34 billion additional gain in farmer income generated by biotech crops in the first 11 years of commercialization (1996 to 2006), it is noteworthy that approximately US$16.5 billion, equivalent to almost half (49%) was in developing countries and US$17.5 billion in industrial countries. It is notable that developing countries had a slightly higher share (54.2%) of the US$7 billion gain in 2006, with industrial countries at slightly less than half of the share at 45.8%.

Figure 2. Global Area of Biotech Crops, 1996 to 2007: Industrial and Developing Countries (Million Hectares)



Source: Clive James, 2007.

Table 2. Global Area of Biotech Crops, 2006 and 2007: Industrial and Developing Countries (Million Hectares)

	2006	%	2007	%	+/-	%
Industrial countries	61.1	60	64.9	57	3.8	+6
Developing countries	40.9	40	49.4	43	8.5	+21
Total	**102.0**	**100**	**114.3**	**100**	**12.3**	**+12**

Source: Clive James, 2007.

Distribution of Biotech Crops, by Country

The eight principal countries that grew biotech crops on 1 million hectares or more in 2007, listed by hectarage, were the USA which grew 57.7 million hectares, (50% of global total), Argentina with 19.1 million hectares (17%), Brazil 15.0 million hectares (13%), Canada 7.0 million hectares (6%), India 6.2 million hectares (5%), China 3.8 million hectares (3%), Paraguay with 2.6 million hectares (2%), and South Africa with 1.8 million hectares (2%). An additional 15 countries grew a total of 1 million hectares in 2007 (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 grew 50,000 hectares, or more, of biotech crops) numbered 13 in 2007. Notably, 9 of the 13 mega-countries are developing countries from Latin America, Asia and Africa. The high proportion of biotech mega-countries in 2007, 13 out of 23, equivalent to approximately 57%, 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 12 years.

It is noteworthy that, compared with 2006, there were two additional countries, which grew biotech crops in 2007. Poland grew approximately 300 hectares of Bt maize for the first time bringing the total number of EU countries to eight. Poland joins Spain, by far the largest grower of Bt maize in the EU, along with France, Czech Republic, Portugal, Germany, Slovakia and Romania, which collectively grew approximately 110,000 hectares of biotech maize in 2007, an increase of approximately 50,000 hectares over 2006, equivalent to a 77% increase. Chile is also listed for the first time in 2007 as a country that now grows approximately 28,000 hectares of biotech crops for seed export and is now considering legislation to also plant for domestic consumption. Iran has not been listed in 2007 as a biotech country because adoption data was not available.

The five countries with the largest increase in absolute area of biotech crops of 0.5 million hectares or more, between 2006 and 2007 were Brazil with a 3.5 million hectare increase, USA with a 3.1 million hectare increase, India with a 2.4 million hectare increase, Argentina with 1.1 million hectares, and Canada with an increase of 0.9 million hectares. Modest growth in crop biotech area was reported in Paraguay, South Africa, and China. In fact, Australia was the only country to report significant negative growth of biotech crops, due to the continuing very severe drought which drastically decreased cotton plantings in Australia, by 75% from 200,000 hectares in 2006 to 50,000 hectares in 2007.

Based on proportional year-to-year annual growth in biotech crop area, five countries (notably, all mega-biotech developing countries), India, Philippines, Brazil, Paraguay, South Africa had exceptionally high rates of growth, resulting in 63% to 29% annual growth in biotech crop area. India, for the third consecutive year, had the highest year-on-year proportional growth of all countries in

Table 3. Global Area of Biotech Crops in 2006 and 2007: by Country (Million Hectares)

Country	2006	%	2007	%	+/-	% Increase
1. USA*	54.6	53	57.7	50	+3.1	+6
2. Argentina*	18.0	18	19.1	17	+1.1	+6
3. Brazil*	11.5	11	15.0	13	+3.5	+30
4. Canada*	6.1	6	7.0	6	+0.9	+15
5. India*	3.8	4	6.2	5	+2.4	+63
6. China*	3.5	3	3.8	3	+0.3	+9
7. Paraguay*	2.0	2	2.6	2	+0.6	+30
8. South Africa*	1.4	1	1.8	2	+0.4	+29
9. Uruguay*	0.4	<1	0.5	<1	+0.1	+25
10. Philippines*	0.2	<1	0.3	<1	+0.1	+50
11. Australia*	0.2	<1	0.1	<1	-0.1	-50
12. Spain*	0.1	<1	0.1	<1	<0.1	- -
13. Mexico*	0.1	<1	0.1	<1	<0.1	- -
14. Colombia	<0.1	<1	<0.1	<1	<0.1	- -
15. Chile	- -	- -	<0.1	<1	<0.1	- -
16. France	<0.1	<1	<0.1	<1	<0.1	- -
17. Honduras	<0.1	<1	<0.1	<1	- -	- -
18. Czech Republic	<0.1	<1	<0.1	<1	<0.1	- -
19. Portugal	<0.1	<1	<0.1	<1	<0.1	- -
20. Germany	<0.1	<1	<0.1	<1	<0.1	- -
21. Slovakia	<0.1	<1	<0.1	<1	<0.1	- -
22. Romania	<0.1	<1	<0.1	<1	-0.1	- -
23. Poland	- -	- -	<0.1	<1	<0.1	- -
TOTAL	**102.0**	**100**	**114.3**	**100**	**+12.3**	**+12**

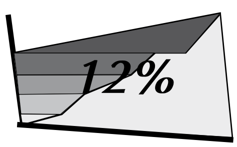
*** Mega-biotech countries growing 50,000 hectares, or more, of biotech crops.**
Source: Clive James, 2007.

Figure 3. Global Area (Million Hectares) of Biotech Crops, 1996 to 2007, by Country, and Mega-Countries, and for the Top Eight Countries.

Biotech Mega-Countries	
50,000 hectares, or more	
USA	57.7 million
*Argentina**	19.1 million
*Brazil**	15.0 million
Canada	7.0 million
*India**	6.2 million
*China**	3.8 million
*Paraguay**	2.6 million
*South Africa**	1.8 million
*Uruguay**	0.5 million
*Philippines**	0.3 million
Australia	0.1 million
Spain	0.1 million
*Mexico**	0.1 million

Less than 50,000 hectares	
*Colombia**	Portugal
*Chile**	Germany
France	Slovakia
*Honduras**	Romania
Czech Republic	Poland

Increase over 2006

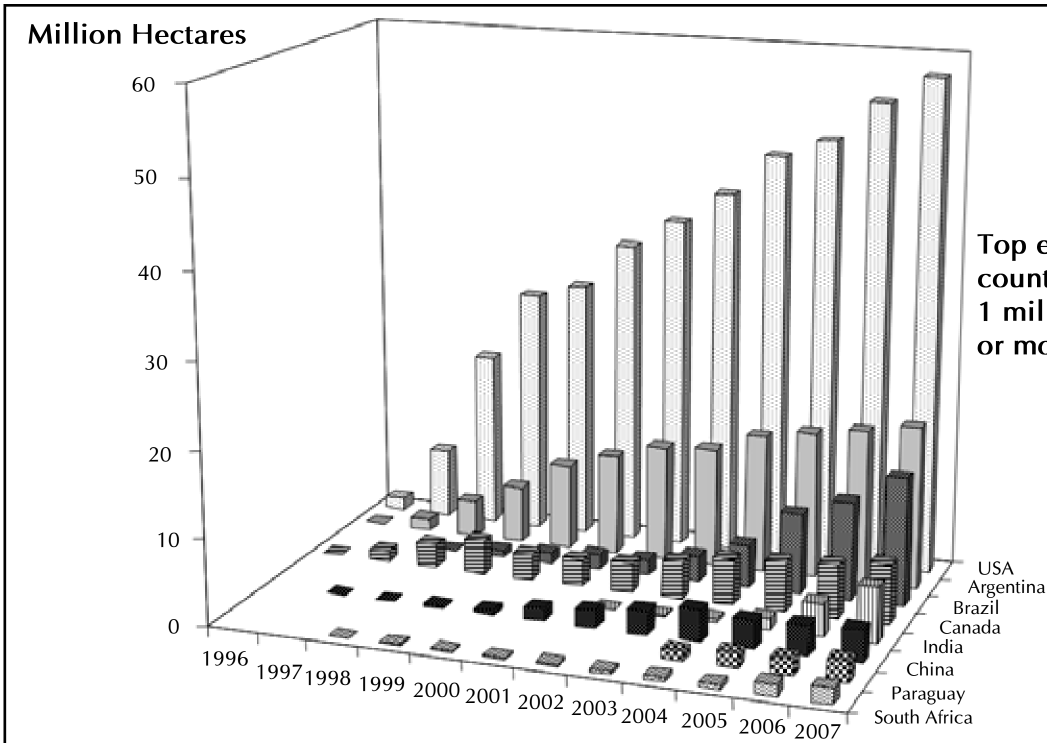


23 countries which have adopted biotech crops

In 2007, global area of biotech crops was 114.3 million hectares, representing an increase of 12% over 2006, equivalent to 12.3 million hectares.

Source: Clive James, 2007.

** Developing countries*



Top eight countries growing 1 million hectares, or more in 2007

Source: Clive James, 2007.

2007, with a 63% increase in Bt cotton area over 2006. Notably, Philippines increased its biotech crop area by 50% and Brazil and Paraguay both increased their biotech area by 30%. South Africa increased by 29% with most of the increase due to biotech maize, mainly white maize, used for food.

The six principal countries that have gained the most economically from biotech crops, during the first 11 years of commercialization of biotech crops, 1996 to 2006 are, in descending order of magnitude, the USA (US$15.9 billion), Argentina (US$6.6 billion), China (US$5.8 billion), Brazil (US$1.9 billion), India (US$1.3 billion), Canada (US$1.2 billion), Paraguay (US$0.3 billion) and others (US$0.7 billion) for a total of approximately US$34 billion, US$16.5 billion for developing countries and US$17.5 billion for industrial countries (Brookes and Barfoot, 2008).

The countries that have gained the most economically from biotech crops in 2006 are, in descending order of magnitude, the USA (US$2.9 billion), Argentina (US$1.3 billion), India (US$0.8 billion), China (US$0.8 billion), Brazil (US$0.5 billion), Canada (US$0.3 billion), Paraguay (US$0.1 billion) and others (US$0.3 billion) for a total of US$7 billion. In 2006 developing countries gained slightly more than industrial countries – US$3.75 billion or 54% for developing countries and US$3.25 billion or 46% for industrial countries.

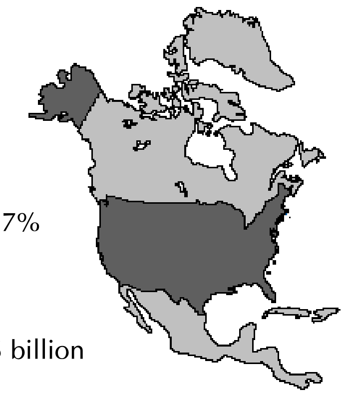
The 23 countries that grew biotech crops in 2007 are listed in descending order of their biotech crop areas in Table 3. There were 12 developing countries, and 11 industrial countries including Romania, the Czech Republic, Slovakia and Poland from Eastern Europe. No data was available for Iran for 2007. In 2007, 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 2007, 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 the global biotech crop hectarage with the balance of 2% growing in the other 15 countries listed in decreasing order of biotech crop hectarage – Uruguay, Philippines, Australia, Spain, Mexico, Colombia, Chile, France, Honduras, Czech Republic, Portugal, Germany, Slovakia, Romania and Poland. The following paragraphs provide a more detailed analysis of the biotech crop situation in each of the 23 biotech crop countries, with more detail provided for the 13 mega-biotech countries growing 50,000 hectares, or more, of biotech crops.

USA

The USA 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 USA continued to be the lead biotech country in 2007 with impressive continued growth, particularly in terms of biotech maize and of stacked traits. The total hectarage planted to biotech soybean, maize, cotton, canola, alfalfa, squash, and papaya was 57.7 million hectares, up 3.1 million hectares or 6%

from the 54.6 million hectares planted in 2006. This 3.1 million hectare increase in 2007 is the second largest increase in absolute terms for any in 2007, despite the fact that adoption of all biotech crops are now very high in the USA.

USA



Population: 299.4 million

GDP: US$13,195 billion

% employed in agriculture: 0.7%

Agriculture as % GDP: 1%

Agricultural GDP: US$131.95 billion

Arable Land (AL): 165 million hectares

Ratio of AL/Population*: 2.4

Major crops:
- Maize
- Soybean
- Sugarcane
- Sugarbeet
- Wheat

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

Total area under biotech crops and (% increase in 2007):
57.7 Million Hectares (+6% in 2007)

Farm income gain from biotech, 1996-2006: $15.9 billion

*Ratio: % global arable land / % global population

Total plantings of maize in the USA in 2007 were 37.9 million hectares (the highest ever since 1944 when 38.7 million hectares were planted), up 18% from the 32.2 million hectares in 2006 and 14% from 2005. Maize area is up significantly in the USA due to favorable international prices and vigorously fueled by increasing demand for ethanol and strong export sales, which together have provided farmers with the incentive to plant significantly higher hectarage of maize in 2007. Maize planting started slowly with wet conditions in March and April and this delayed planting in the corn belt and the Great Plains. In April and May, conditions dried out which favored planting and emergence, but with moisture shortages in some areas. Despite the weather delays, producers eventually made rapid progress and planting was completed ahead of the average year.

Total plantings of soybean at 25.8 million hectares, were down 15% from the record plantings of 30.3 million hectares in 2006, and 2007 was the lowest planting of soybean hectarage since 1995. The principal reason for the decline in soybean is that farmers have shifted to maize which is more profitable.

Total plantings of upland cotton at 4.4 million hectares in 2007 was 28% down from the 6.0 million hectares planted in 2006, the lowest hectarage since 1989. The major reasons for the sharp decline in area in 2007 were the lower international price of cotton and the higher price of maize that led growers to switch to the higher profits that could be made with maize which also offered a more secure market. Canola hectarage was up by 12% at 478,947 hectares compared with 422,672 hectares in 2006. The major canola state of North Dakota planted a record 425,000 hectares. Estimates of alfalfa seedings for 2007 will not be available from USDA until the first quarter of 2008, but they are not likely to be very different from 2006 seedings. In 2006, total hectarage seeded for alfalfa forage (includes alfalfa harvested as hay and alfalfa haylage and green chop) was about the same as last year, 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 2007, the USA continued to grow more biotech crops (57.7 million hectares) than any other country in the world, equivalent to 50% of global biotech crop hectarage. In 2007 the gain was 3.1 million hectares of biotech crops, equivalent to 6% year-over-year growth in terms of increased number of hectares. The increase is high 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 was a very substantial increase in total planting of maize for ethanol, however these were offset by decreased plantings in both biotech soybean and cotton, where the percent adoption for the latter two biotech crops are at very high levels exceeding 90% adoption. However, even the significant growth of 3.1 million hectares in 2007 does not fully reflect the real increase in 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 57.7 million hectares of biotech crops planted in the USA in 2007, approximately 21.0 million hectares, equivalent to 37%, compared with 28% in 2006, had either two or three stacked traits. The stacked two-trait products include biotech maize and cotton crops with two different insect resistant genes (for European corn borer and corn root worm control in maize) or two stacked traits for insect resistance and herbicide tolerance in the same variety in both maize and cotton. The maize stacked products with three traits feature two traits for insect control and one for herbicide tolerance. Accordingly, the adjusted "trait hectares" total for the USA in 2007 was approximately 87.1 million hectares compared with 57.7 million "hectares" of biotech crops. Thus, the apparent year-to-year growth for biotech crops in the USA, based on hectares, is 6%, on an increase from 54.6 million hectares to 57.7 million hectares. However, the real growth rate for biotech crops in the USA in 2007 is 25%, due to the number of "trait hectares" increasing from 69.9 million hectares in 2006, to 87.1 million hectares in 2007. The particularly fast growth in "trait hectares" in the USA in 2007 is due to the substantial increase in biotech maize which occupied only 65% of the total maize area of 32.2 million hectares in 2006 but occupied 77% of a much larger maize crop of 37.9 million hectares in 2007. The higher growth in "trait hectares" in 2007 was accentuated by the 20% increase in total plantings of maize and the increased adoption rates for biotech crops in 2007. It is noteworthy that the first triple stacked construct in maize, which the USA introduced in 2005 on approximately half a million hectares, increased to over 2 million hectares in 2006 and more than tripled in 2007. Given that the USA has proportionally much more stacked traits than any other country, the masking effect leading to apparent lower adoption affects the USA more than other countries. In fact, Canada, the Philippines, Australia, Mexico, South Africa, Honduras, Colombia, Argentina, and Chile are the nine other countries that have deployed stacked traits at this time, albeit at much lower proportions than the USA, but this is a trend that will increasingly affect other countries. The total stacked trait hectarage in Canada, the Philippines, Australia, Mexico, South Africa, Honduras, Colombia, Argentina, and Chile was less than 500,000 hectares. In 2007, the global "trait hectares" was 143.7 million hectares compared with only 117.7 million hectares in 2006, equivalent to a growth rate of 22%. Thus, the apparent growth rate of 12%, based on an increase from 102 million hectares in 2006 to 114.3 million hectares in 2007 underestimates the real growth rate of 22%, based on the growth in "trait hectares" from 117.7 million "trait hectares" in 2006 to 143.7 million "trait hectares" in 2007.

The biggest increase in USA biotech crops was for maize with a gain of almost 40% compared to 2006, equivalent to approximately 8 million hectares. In 2007, the area of biotech soybean, 24.2 million hectares, decreased by 3.8 million hectares but which now has the highest adoption rate of any USA biotech crops at 94%, the highest ever. The decrease in biotech cotton of 1.3 million hectares from 5.3 million hectares in 2006 to 4.0 million hectares in 2007 is equivalent to a 33% decrease and biotech cotton now occupies 93% of upland cotton in the USA. Of the 4.3 million hectares of upland cotton in the USA in 2007, 72% was occupied by the stacked traits of Bt and herbicide tolerance, 20% were herbicide tolerance, <1% was Bt, and the balance of 7% was conventional. Total canola plantings in the USA were up by 12% in 2007 compared with 2006 and the area of biotech canola increased to 395,000 hectares from 334,000 hectares in 2006.

The RR® alfalfa hectarage increased from 80,000 hectares in 2006 to just over 100,000 hectares in 2007. This increase would have been much larger had it not been for a court order that suspended further planting in March 2007 until additional information about the product was submitted to regulators for consideration. Herbicide tolerant RR® alfalfa, was approved for commercialization in the USA in June 2005. The first pre-commercial plantings (20,000 hectares) were 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 USA. Whereas there is approximately 11 million hectares of the perennial alfalfa crop in the USA, 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 has been well received by farmers in the USA 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 USA export markets for alfalfa hay including Mexico, Canada, Japan, the Philippines and Australia, and pending in South Korea – these countries represent greater than 90% of the USA alfalfa hay export market. Japan is the major market for alfalfa hay exports, mainly from California and the west coast states. The USA 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 US$105 per ton, worth US$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 USA 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 (2,000 hectares) and virus resistant papaya (2,000 hectares) continued to be grown in the USA in 2007.

In the USA in 2007 biofuel production was assigned very high priority, mainly for ethanol from maize, but also for biodiesel from oil crops. It is estimated that production from 24% of the total maize area in the USA in 2007 was used for ethanol, compared with 19% in 2006. Accordingly, it is estimated that in 2007, 7 million hectares of biotech maize was devoted to ethanol production, up from 4 million hectares in 2006. Corresponding estimates for biodiesel indicate that in 2007 approximately 3.4 million hectares of biotech soybean (14% of total biotech soybean plantings) were used for biodiesel production; this compares with 2.3 million hectares (6% of total plantings) in 2006. It is further estimated that approximately 5,000 hectares of canola was used for biodiesel.

Herbicide tolerant Roundup Ready® sugarbeets has already been deregulated in the USA and Canada. Since the USA is one of the largest importers of sugar in the world, most of the sugar (97%) and by-products are consumed in the USA. However, the sugar, pulp and molasses derived from the RR® sugarbeets has been approved for importation in all the major export markets including Japan and the EU. Starting in 2006, a large scale demonstration was conducted in Idaho to demonstrate the attributes of RR® sugarbeets compared with conventional beets – heavy weed infestations can reduce beet and sugar yield by up to 30%. Due to producer and processor interest, large scale demonstrations were continued in Michigan and Wyoming in 2007. These demonstrations have confirmed the potential benefits that RR® sugarbeets offer over conventional beets. These can include more effective weed control, particularly when there is heavy weed pressure, reduced requirement for herbicides, less damage to beets from herbicide application, reduced need for cultivation which translates to less soil compaction, all of which collectively results in higher yield of sugar per hectare. Seed of RR® sugarbeet was multiplied in 2007 in anticipation of expanded commercial plantings of RR® sugarbeets in 2008. It is important to note that the sugar from RR® sugarbeets does not contain any DNA from the biotech transformation process so the product is the same as conventional sugar and accordingly does not require to be labeled in the USA and in foreign markets like Japan.

Benefits from Biotech Crops in the USA

In the most recent global study on the benefits from biotech crops, Brookes and Barfoot (2008) estimate that USA has enhanced farm income from biotech crops by US$15.9 billion in the first eleven years of commercialization of biotech crops 1996 to 2006, (representing 47% of global benefits for the same period) and the benefits for 2006 alone are estimated at US$2.9 billion (representing 42% of global benefits in 2006) – these are the largest gains for any biotech crop country.

A study by the University of Arizona (Frisvold *et al.*, 2006) examined the impact of Bt cotton in the USA and China in 2001. The two countries increased total world cotton production by 0.7% and reduced world cotton price by US$0.31 per kg. Net global economic effects were US$838 million worldwide with consumers benefiting US$63 million. Chinese cotton farmers gained US$428 million and USA farmers gained US$179 million whereas cotton farmers in the rest of the world lost US$69 million because of the reduced price of cotton.

Farmer Experience

Quote from **Rickey Bearden**, an American farmer growing biotech soybean:
"Biotechnology is important to agriculture producers in the United States and the world. Biotech crops will continue to be a great tool for global agriculture use. If wisely used, this tool can help sustain the future of the agriculture industry" (Bearden, 2006).

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 (19.1 million hectares) in 2007 comprising 17% of global crop biotech hectarage. In 2007, the year-over-year increase, compared with 2006, was 1.1 million hectares, equivalent to an annual growth rate of 6%. Of the 19.1 million hectares of biotech crops in Argentina in 2007/08, 16.0 million hectares were planted to biotech soybean, an increase of 200,000 hectares in biotech soybean area over 2006. Virtually all of the soybean crops in Argentina is now herbicide tolerant RR® soybeans. Total plantings of maize in Argentina in 2007 increased significantly from 3.1 million hectares in 2006 by 0.8 to a total of 3.9 million hectares, of which 3.6 million hectares were hybrid. The higher hectarage of national maize plantings in 2007 resulted in approximately 920,000 hectares more biotech maize. Of the 3.68 million hectares of hybrid maize, 2.45 million hectares were planted to Bt maize and 350,000 to herbicide tolerant maize, with a negligible area of the stacked gene Bt /HT which has been approved but adequate seed supply was not available for 2007/08. The adoption rate in

ARGENTINA

Population: 39.9 million

GDP: US$214.3 billion

% employed in agriculture: 1%

Agriculture as % GDP: 9.5%

Agricultural GDP: US$20.35 billion

Arable Land (AL): 28.2 million hectares

Ratio of AL/Population*: 3.1

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

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

Total area under biotech crops and (% increase in 2007):
19.1 Million Hectares (+6% in 2007)

Farm income gain from biotech, 1996-2006: US$6.6 billion

*Ratio: % global arable land / % global population

the 3.6 million hectares of hybrid maize was approximately 66% for Bt and 10% for herbicide tolerant maize. Argentina reported the total area of cotton for 2007 at close to 400,000 hectares. Of the 400,000 hectares of total cotton plantings in 2007, 195,000 hectares were Bt cotton and 185,000 hectares were herbicide tolerant cotton – the stacked gene Bt/HT has been submitted for approval but, unlike stacked maize, is yet to be approved. The increase in biotech cotton during the last two years 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.

Benefits from Biotech Crops in Argentina

A detailed analysis by Eduardo Trigo from the FORGES Foundation and Eugenio Cap of the Institute of Economics and Sociology of the National Institute of Agricultural Technology (INTA, Trigo and Cap, 2006), estimated that the total global direct and indirect benefits from RR® soybean in Argentina for the first 10 years of commercialization, 1996 to 2005 was US$46 billion. This was generated from increased farmer incomes, a million new jobs and more affordable soybean for consumers and significant environmental benefits, particularly the practice of no till for conserving soil and moisture and double cropping. Of the global US$46 billion indirect and direct benefits, Argentina gained approximately US$20 billion in direct benefits from RR® soybean in the decade 1996 to 2005 (Table 4). The study estimated 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.

Table 4. Beneficiaries of Direct Benefits of Biotech Soybeans in Argentina, 1996 to 2005.

	Gross Value	Farmer	Technology Developers	Argentine Government
Total (Billion US$)	**19.7**	**15.3**	**1.8**	**2.6**
% Share	100%	77.4%	9.2%	13.4%

Source: Trigo and Cap, 2006.

Herbicide tolerant RR® soybean was first planted in Argentina in 1996, and after a decade they account for virtually 100% of the total soybean hectarage. In addition an estimated 65% of maize and 60% of cotton planted in Argentina were also biotech varieties. The remarkably rapid adoption was the result of several factors including: a well-established seed industry; a regulatory system that provided a responsible, timely and cost-effective approval of biotech products; and a technology with high impact. The total direct benefits were as follows: US$19.7 billion for herbicide-tolerant soybean for the decade 1996 to 2005; US$482 million for insect-resistant maize for the period 1998 to 2005; and US$19.7 million for insect-resistant cotton for the period 1998 to 2005 for a total of US$20.2 billion.

The direct benefits from herbicide tolerant soybeans are from lower production costs, an increase in planted hectarage, plus the very important practice of second-cropping soybeans after wheat, that RR® soybean facilitated. It is noteworthy that it was the farmers that captured the majority of the benefits equivalent to 77.4% of the total gains, with the Argentine government and technology developers only capturing 13.4% and 9.2%, respectively (Table 4).

The major findings of the study were:

Herbicide tolerant RR® biotech soybeans delivered substantial direct and indirect benefits totaling US$46 billion to the global economy during the decade 1996 to 2005. More specifically:

- In the period 1996 to 2005, US$20 billion was created in direct benefits in Argentina.
- The majority of the benefits from biotech soybean was captured by farmers (77.4%), approximately 13.4% for the Argentine government and only 9.2% for the technology developers.
- Herbicide-tolerant soybeans accounted for 1 million new jobs equivalent to 36% of all new jobs created in the decade 1996 to 2005.
- Indirect benefits of increased biotech soybean production generated consumer savings of US$26 billion.

Biotech soybeans greatly facilitated fast adoption of low/no-till systems which conserved both soil and water.

- No/low till hectarage increased from 120,000 hectares in 1991 to over 7.5 million hectares in 2005.
- Herbicide-tolerant soybeans were a principal factor in the adoption of no/low-till practices.
- No/low till practices mitigated the serious problems with soil erosion and conservation of moisture in the Pampas in the 1980s resulting from intensification of conventional agriculture.

A more detailed account by the senior author, Dr. Trigo, is detailed in the following paragraphs from Trigo and Cap (2006).

Ten years of biotech crops in Argentinean agriculture by Dr. Eduardo Trigo

"The first genetically modified (GM)/biotech crop incorporated into Argentina's agriculture was herbicide-tolerant soybeans in 1996. Since 1996, almost 900 field tests have been conducted on different crops and traits and nine additional events have been released commercially, both for maize and cotton (herbicide tolerance and insect resistance). A rapid diffusion process of these technologies followed. In the 2006 growing season, biotech varieties represented over 90% of planted area with soybeans, 70% in the case of maize and 60% for cotton. Along this process, Argentina has become the second largest producer of biotech crops, after the United States, with over 19 million hectares planted in 2007.

The magnitude of the area with GM technologies constitutes an important fact by itself, but the speed at which the adoption process evolved is even more significant. In Argentina, these new technologies were made available to farmers at the same time as in the countries of origin in 1996 and their adoption occurred at surprisingly high rates, exceeding the ones recorded for other successful technologies that preceded them, such as hybrid maize and wheat varieties with Mexican germplasm. In the case of soybeans, it took only seven years for the biotech varieties to occupy virtually all the areas planted with soybean in Argentina. This outcome was the result of a number of determinants that converged to make it possible. Among them, it is worth mentioning a number of policy changes that improved the dynamics of the growth process in the agricultural sector but, most of all, the fact that by the time when these technologies were made available, Argentina had already in place a set of institutions, such as standards for risk and biosafety analysis. On the other hand, the special synergy resulting from the interaction between no-till practices and biotech soybeans has been another determining factor of its rapid adoption, since it allowed a "virtual" expansion of the agricultural frontier, by means of expanding the area suitable for double cropping, in which soybeans follows wheat in the same season.

This process of incorporation of new technologies has had a deep transforming impact, not limited to Argentina's agricultural sector, but including the economy as a whole. Benefits generated by all three biotech crops were estimated, based on results from a mathematical simulation model, SIGMA, developed by INTA, in excess of US$20 billion. In the case of herbicide tolerant soybeans, total accumulated benefits for the 1996 to 2005 period, net of substitution for other activities (sunflower, cotton, pastures) were estimated at US$19.7, distributed as follows: 77.45% to the farmers, 3.90% to seed suppliers, 5.25% to herbicide suppliers and 13.39% to the National Government (revenues collected through an export tax, imposed in 2002). In the case of maize with insect resistance, total accumulated benefits for the 1998 to 2005 periods were estimated at US$481.7 million, distributed among farmers (43.19%), seed suppliers (41.14%) and the National Government (15.67%). Finally, for insect-resistant cotton, total accumulated benefits for 1998 to 2005, were estimated at US$20.8 million, with the following distribution: 86.19% to farmers, 8.94% to seed suppliers and 4.87% to the National Government.

A process of this nature and magnitude is not, of course free both of costs, particularly related to both the quality and the productivity of the natural resources involved and of indirect effects on the rest of the economy. With respect to the magnitude of the area planted with soybeans and its negative implications on the fertility of soils, the cost of "restocking" the soils with the phosphorus exported with the beans over the 10-year period, was estimated at US$2.3 billion (11.6% of total benefits). This means that, even if corrective measures to compensate for the loss of fertility were to be taken, net benefits would still exceed US$17 billion.

As to the indirect impacts, the document discusses the mechanisms by which the expansion of the soybean crop, attributable to the release of materials with tolerance to herbicides, induced positive effects on the productivity of livestock production systems, both, beef and dairy. In this regard, it was estimated that, during the period 1996 to 2005, the area with pastures has suffered a reduction of more than 5 million hectares, without a decrease in output of beef and a strong recovery in the production of milk (in both cases, there is a net positive balance for those 10 years). These increases in productivity have not been recorded by the statistics, due to the fact that the yield indicators commonly used, that is, extraction rate (slaughtered heads per year/stock), in the case of beef and volume of milk for dairy, are computed without reference to the area on which that output is produced.

From a more general perspective, the impacts of the above described process on the gross domestic product (GDP) and other economic variables, such as job creation, were analyzed. It was concluded that the release of herbicide tolerant soybeans may have contributed to the creation of almost 1 million jobs (whole economy-wide), representing 36% of the total increase in employment over the period under study. Following the same line of thought, it was estimated that the total benefits of this technology would have been enough to finance the construction of 28 million square meters, almost a 22% of the total area for which permits were issued.

All of these aspects, when taken together, highlight the fact that the first decade of biotech crops in Argentine agriculture has been a period of large benefits, not only for the agricultural sector, but for the economy as a whole. By now it has become clear that this process has not been one free of both costs and uncertainties, issues that remain open and should be addressed and widely debated from now on. On the other hand, it would have been surprising if a transformation process of the magnitude of the one above described did not have consequences of this nature. The tremendous expansion of the soybean crop has lead to a strong repositioning of agriculture within both the economy and the foreign trade of the country, which has raised concerns about the possible negative impacts of the "soyafication" process, on the one hand, due to the excessive dependence of exports on one single commodity and, on the other, due to its implications associated with the future fertility of the country's soils and the potential detrimental effects of the crop expansion on fragile ecosystems. These concerns, as well as others that have not been addressed in the document, like, for instance, the future evolution of the international context for this type of technologies, are totally legitimate, but they should not be considered as a demerit of the clearly positive balance of the first decade of biotech crops in Argentina".

In the most recent global study on the benefits from biotech crops, Brookes and Barfoot (2008) estimates that Argentina has enhanced farm income from biotech crops by US$6.6 billion in the first eleven years of commercialization of biotech crops 1996 to 2006, and the benefits for 2006 alone are estimated at US$1.3 billion.

Farmer Experience

Johnny Avellaneda, a farmer from Argentina cultivates soybean, maize and wheat on 4,000 hectares. He said if it wasn't for the access to the technology he wouldn't be working on the farm. For the past ten years he has cultivated biotech soybean and maize. He says:

"I chose to use biotech crops because the technology is innovative, provides food security for humanity and generates higher yields. This kind of technology allows you to cut half the time your tractors are in the field, allowing us more time to be with our families" (Avellaneda, 2006).

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 the approved use of Bt cotton (event BC 531) as the first registered variety DP9B. However, the latter was not planted as officially approved registered seed in 2005, because of unavailability of seed; the first planting of Bt cotton in Brazil was in 2006 and expanded in 2007.

Projecting the adoption rate for RR® soybean in Brazil for 2007/08 is a challenge involving factors that are unrelated to biotech crops per se. The major uncertainties are the hangover from the significant debt accumulated from losses in soybean production in the 2004/05 and 2005/06 seasons, estimated at approximately US$2 billion. However, opinion regarding RR® soybeans in Brazil is changing as higher soybean prices provide the incentive that drives increased adoption of RR® soybean. The strength of the Brazilian Real against the US dollar is offset by increasingly higher prices for soybean, which are forecast to remain high. 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 need to be addressed, including the inadequate supply of fully adapted RR® soybean germplasm with optimal yield, particularly for the Central West region. Another factor is the short supply of expensive glyphosate in 2007, which has to compete with less expensive generic pre-and post emergence herbicides. Despite these constraints RR® soybean is attractive to farmers in Brazil because cost of production is less than for conventional soybeans requiring less credit for inputs. Also, RR® soybean is less prone to economic losses from Asian Soybean Rust because effective weed control allows more aeration between rows, resulting in decreased humidity which can delay 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 US$25 per application, which can make soybean production less profitable.

BRAZIL

Population: 186.8 million

GDP: US$1,067.4 billion

% employed in agriculture: 20%

Agriculture as % GDP: 8.4%

Agricultural GDP: US$89.66 billion

Arable Land (AL): 58.6 million hectares

Ratio of AL/Population*: 1.4

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

Commercialized Biotech Crops:
- HT Soybean
- Bt Cotton

Total area under biotech crops and (% increase in 2007):
15.0 Million Hectares (+30% in 2007)

Farm income gain from biotech, 2003-2006: US$1.9 billion

*Ratio: % global arable land / % global population

Many farmers expressed a strong intent to plant more hectares of RR® soybean in 2007/08 than 2006/07. It is estimated that there are now well over 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 2007, Parana is expected to plant around 65% to 70% of its 4.0 million hectares of soybean to RR® soybean, and the port of Paranagua is now exporting significant tonnages of RR® soybean. According to the Brazilian External Trade Secretariat (Secex), in 2006 China bought 10.8 million metric tons of soybeans from Brazil. In 2007, the figure increased to 25.0 million metric tons worth US$2.4 billion, representing 43% of total soybean exports. China is by far the most important market for the export of Brazilian soybeans. The export and trade figures in Table 5 confirm the importance of agricultural exports in Brazil which constituted almost US$50 billion in 2006 with a growth of over 13% between 2005 and 2006, with RR® soybean playing a major role. Similarly, the trade data indicates net agricultural trade of US$42.6 billion, growing at a vigorous 10% per year and agricultural trade constituting 92.4% of total trade, and again RR® soybean playing a major role. The three soybean products: grain, meal, and oil have different markets. China is the major destination for soybean grain, Europe for the soybean meal, with soybean oil exported to vegetable oil deficit countries like India. The total soybean export market for Brazil in 2006 was worth US$9.4 billion, comprising US$5.7 billion for the soybean grain, US$2.4 billon for the meal and US$1.3 billion for the oil (Figure 4).

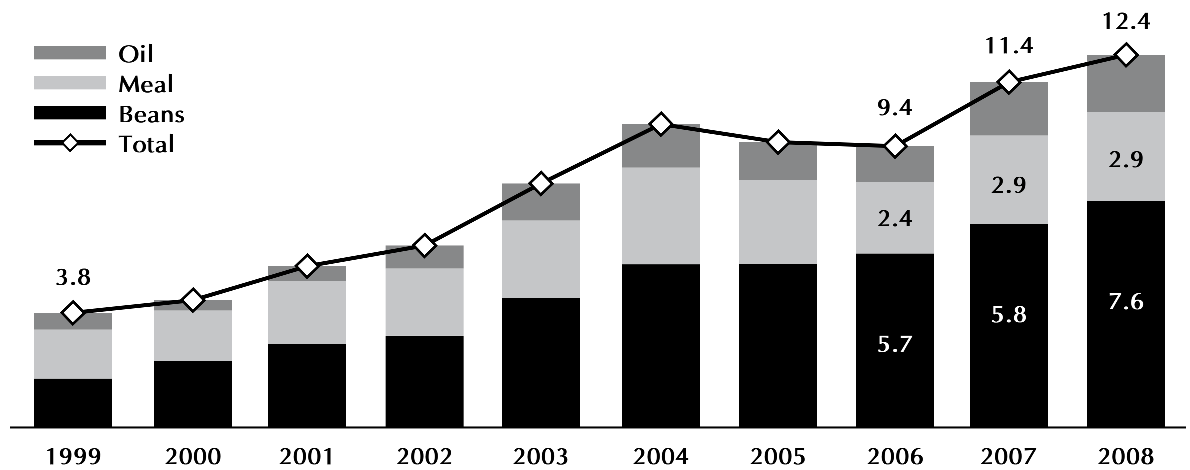
In March 2006, Brazilian authorities confirmed that China had authorized importation of Brazilian soybeans for the next five years, as opposed to the usual annual authorization. This was an important development and provides Brazil with the assurance of longer-term future markets and stable supply for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

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 world's largest producer of sugarcane and oranges, 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

Table 5. Agricultural Exports and Net Agricultural Trade in Brazil, in US$ Billions, for 2005 to 2006

	2005 (a)	2006 (b)	Change	Share
Ag exports	43.6	49.4	+13.6%	35.9%
Total exports	118.3	137.5	+16.2%	
Net trade				
Ag trade	38.4	42.6	+10.9%	92.4%
Total trade	44.7	46.1		

Figure 4. Brazilian Soybean Export Revenue (US$ billion) for 1999 to 2008 Estimates



Source: SECEX. Elaboration and Projection: Céleres.

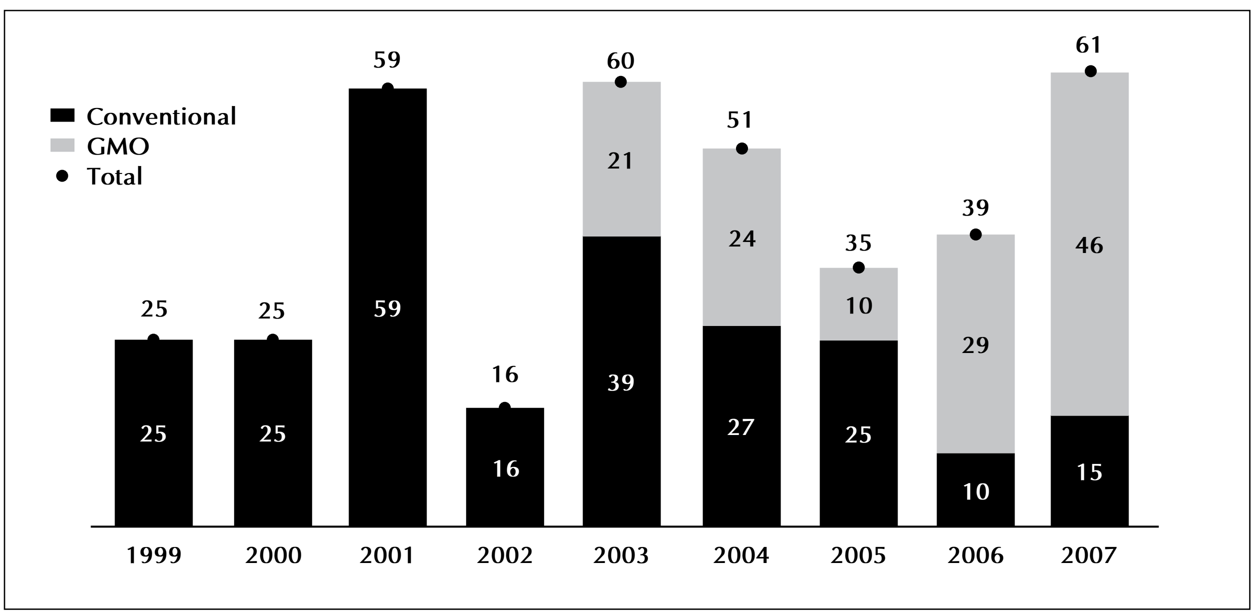
world and agricultural exports reached US$50 billion in 2006, comprising a substantial 36% of total exports (Table 5 and Figure 4). Brazil has several factors in its favor that will likely stimulate strong growth in the agricultural sector in the next decade. These include an enormous area of new land 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.

In 2007, some hectarage of RR® soybean in million hectares were planted in virtually all of the states in Brazil with the largest plantings in the states of Rio Grande do Sul (3.8 million hectares), Parana (2.8), Matto Grosso (2.6), Goias (1.2), and Matto Grosso do Sul (1 million hectares). Given farmer options and profitability of alternate crops, total planting of soybean in Brazil in 2007/08 is expected to increase to 22.5 million hectares, about 2 million more than the 20.6 million hectares planted in 2006. 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 early December 2007, approximately three-quarters of the soybean crop had been planted in Brazil.

It is provisionally projected that biotech soybean will occupy approximately 14.5 million hectares of the 22.5 million hectare crop in the 2007/08 season, equivalent to almost two-thirds of the area planted to soybean in 2007/08 — this is over 25% more than the 11.4 million hectares of RR® soybean planted in Brazil in 2006/07. This is the second year when a significant quantity of certified RR® soybean has been available. A total of 61 varieties were registered for sale in 2007 of which 46, equivalent to 75% were RR® soybean with the remaining 15 varieties (25%) conventional (Figure 5). Two years ago in 2005, the number of conventional varieties (25) exceeded the number of RR® soybean (10) but for the last two years, 2006 and 2007, there were more RR® soybean varieties than conventional and this trend is expected to continue. 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 of Bt cotton were available for planting in 2007. 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 US$100 to US$300 per hectare and accordingly Bt cotton is expected to offer significant benefits to Brazil, particularly for the large cotton growing states of Matto Grosso

Figure 5. Soybean Cultivars registered in Brazil, November 2007



Source: Ministry of Agriculture (MAPA-RNC) compiled by Ivo Carrero; November 2007.

and Bahia. Brazil is expected to grow approximately 1.1 million hectares of cotton in 2007 making it the sixth largest grower of cotton, by area, in the world after India, USA, China, Pakistan, and Uzbekistan. The adoption of biotech cotton in Brazil in 2007/08 is 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 the impoverished North East (NE) region of Brazil significant socio-economic benefits, similar to those experienced in China and India. In fact the heavy losses from insects in the North East led to the collapse of cotton production by small farmers – Bt cotton offers the opportunity to revive the cotton plantings in the NE and provide critically important benefits to small farmers which will allow the national policy related to poverty alleviation to be realized at the grass root level. Thus, the potential for biotech Bt cotton in Brazil is significant because economic losses from insect pests have resulted in a reduction in the cotton area from 4 million hectares to the current 1 million hectares. There is the potential for reversing the decline in cotton area in Brazil with the adoption of Bt cotton and establish Brazil as an exporter of cotton to meet growing world market needs. The area of single gene Bt cotton in Brazil in 2007 is estimated at 500,000 hectares, an increase of 380,000 hectares over 2006, when 120,000 hectares were planted to Bt cotton.

In 2007, Brazil retained its position as the country with the third largest hectarage of biotech crops in the world, provisionally estimated at 15.0 million hectares, of which 14.5 million hectares were planted to RR® soybean and 500,000 hectares planted with a single gene Bt cotton, grown officially for the second time in 2007. The year-over-year growth between 2006 (11.5 million hectares) and 2007 (15.0 million hectares) was 30%. The increase of 3.5 million hectares in 2007 is the largest absolute increase for any biotech crop country. The increase of 30% is the third highest percent increase after India (63%) and the Philippines (50%). Brazil is currently the second largest producer of soybeans in the world after the USA and expected to become the first in due course and in 2007 offset reductions in hectarage in the USA. Brazil is also 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 (3.7 million) outside Asia. Brazil is also the largest sugarcane producer in the world with 6.2 million hectares and uses approximately half of its sugar production for generating ethanol for biofuels. In the coming five years the sugarcane hectarage in Brazil is expected to increase by more than 35% to approximately 8.5 million hectares by 2012. By 2012 Brazil will produce 643 million tons of sugarcane. The share of sugarcane hectarage devoted to bioethanol is expected to increase from the current 50% to 64% by 2012. Thus, Brazilian ethanol production should reach 29.5 billion liters of which 4.3 billion liters will be exported in 2012.

The re-enstatement of authority by Comissao Tecnica Nacional de Biosseguranca (CTNBio) 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. In

2007, CTN Bio approved several Bt maize products for commercialization and the intent was to deploy these Bt maize varieties in the 2007/08 season. However, subsequent to CTNBio's approval a judicial intervention required an environmental impact study to be completed and approved before deployment, and this has precluded planting of biotech maize in the 2007/08 season. Biotech maize has significant potential in Brazil to meet domestic demand for feed, food, and to meet demand of new export markets for maize. It is notable that Brazil exported its first consignment of 10 million tons of maize in 2007. The lessons learnt from delayed approvals of RR® soybean should be applied to expedite the approvals of new events of biotech maize. Long delays in the approval of pending applications could result in Brazil losing out on the benefits of first and second generations of biotech crops. An incomplete list of CTNBio approved and pending applications for products is detailed in Table 6. Other biotech crop products in the pipeline include new varieties of biotech sugarcanes,

Table 6. Approved and Pending Biotech Crop Products from CTNBio Brazil, November 2007

Product	Trait	Status
Maize Bt11 Syngenta	Bt11	Approved
Maize insect resistance Monsanto	Mon810	Approved
Maize herbicide tolerance Liberty Link Bayer	Liberty Link	Approved
Cotton herbicide tolerance RR® Monsanto	Cotton RR® event 1445	Pending
Cotton herbicide tolerance Liberty Link Bayer	Cotton Liberty Link Event LLCotton 25	Pending
Rice herbicide tolerance Liberty Link Bayer	Rice Liberty Link event LLRice 62	Pending
Maize insect resistance and herbicide tolerance Syngenta	ICP-4	Pending
Maize herbicide tolerance Monsanto	RR2	Pending
Maize herbicide tolerance	GA21	Pending
Soybean high oil		Pending

Source: CTNBio Brazil, 2007.

virus resistant papaya and potatoes from Empresa Brasileira de Pesquisa Agropecuaria (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 (Figure 6). Brazil has approximately 350 sugar mills/distilleries, another 46 under construction and yet another 46 being considered for construction. Brazil produces 19% of the 164.4 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 has completed sequencing the crop's 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 per hectare 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 US$2 billion per year. Currently, 85% of the biodiesel produced in Brazil is from soybean, which in 2007 is estimated to require 1.2 million hectares, equivalent to 5.8% of the total hectarage of 22.5 million hectares. Thus, about 750,000 hectares of RR® soybean in Brazil will be used to produce biodiesel in 2007. There are no estimates of how much soybean exports are used for biodiesel production. Cotton seed is a potentially important source of vegetable oil and biodiesel in Brazil and the revival of the cotton industry through biotech could be very important strategically.

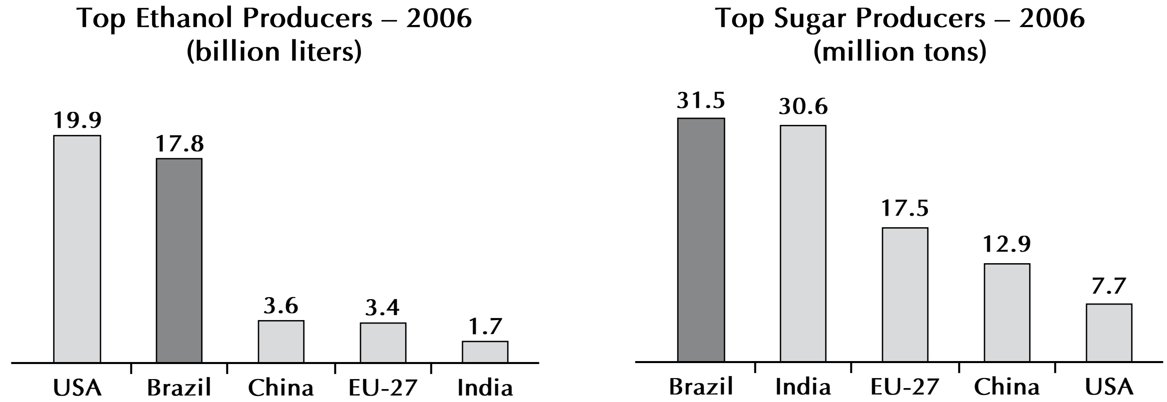
The Status of Investments in Bioethanol in Brazil

Brazil is the top producer of sugar in the world and the second producer of ethanol in the world. In 2006, Brazil produced 17.8 billion liters of ethanol compared with 19.9 billion liters for the USA. In terms of sugar production, Brazil is also the top world producer at 31.5 million tons followed closely by India at 30.6 million tons and distally by the EU 27 at 17.5 million tons (Figure 6). Brazil is the most efficient producer of sugar in the world at US$240 per ton, compared with US$470 per ton in Europe, US$600 in the USA and US$830 in Japan. Brazil is also the most efficient producer of ethanol from sugarcane at US$0.20 cents per liter – this compares with US$0.30 a liter for India from molasses, US$0.32 for the USA from maize and US$0.68 for the EU from wheat (Figure 7).

In Brazil flex fuel cars already represent 75% of all new car sales and it is the fastest technology adopted by the Brazilian car industry. This technology assures an enormous domestic market for ethanol in Brazil placing the country as the global leader re the blending of petroleum with bioethanol. Many Brazilian and a few foreign companies are investing heavily in the Brazilian bioethanol sector. Companies like Brenco, formed by Brazilian investors and foreign investors such as Vinod Khosla (founder of Sun Microsystem), are launching greenfield projects in Brazil seeking the long-term opportunities in that market. Key agricultural corporations such as Bunge, Cargill, Louis Dreyfuss are also buying sugar and ethanol assets in Brazil aiming to assume a strategic position in this market. However, by and large, foreign participation in the sugar and ethanol industry in Brazil is still quite

Figure 6. Top Ethanol and Sugar Producers in the World

Brazil is the main sugar producer in the world and the second largest ethanol producer



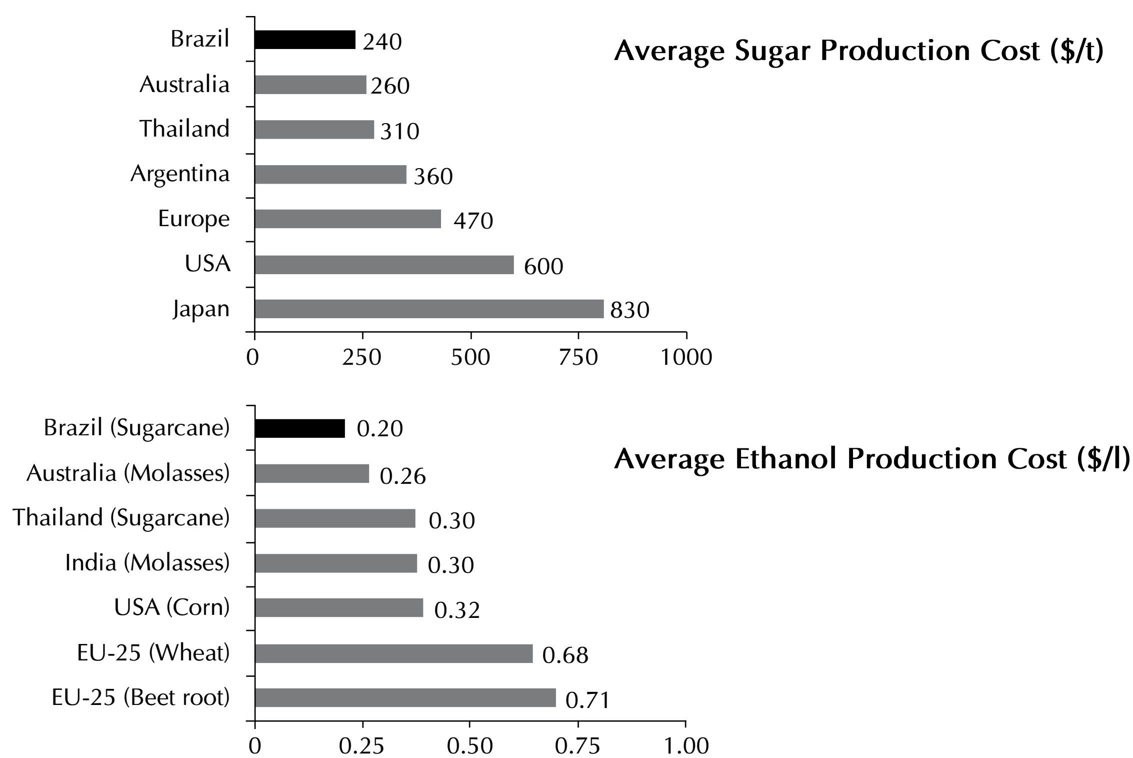
Source: F.O. Licht (in Renewables Fuels Association).

Source: USDA/FAS.

World Production: 51.1 billion liters

World Production: 164.4 million tons

Figure 7. Cost of Sugar Production and Ethanol Production in Top Countries



Source: IDEA, CELERES, 2007.

low. Less than 10% of the sector belongs to foreign companies or institutional investors. The next wave of investors is likely to be the traditional oil companies that are expected to participate in the near term. Petrobras, the national petroleum company of Brazil, is exploring the creation of a world ethanol market and has just bought an oil refinery in Japan, from Exxon Mobil at US$50 million – the aim is to enter the Japanese gasoline market with a blend of 3% ethanol. Petrobras has also created a joint venture with a Japanese company, Japan Ethanol Trading, forming Brazil-Japan Ethanol Company. All the initiatives of Petrobras are aimed at increasing confidence and support for Brazilian ethanol as a reliable alternative for oil in selected markets. In Brazil, on the supply side, discussion and speculation continues over the question of how many hectares will be required to ensure adequate supply to meet increasing demand for both sugar and ethanol in the future. Biotechnology is of strategic importance in this discussion because its key role is to cost-effectively increase the "yield" of ethanol per hectare and also increase efficiency of the industrial process to provide competitively priced ethanol. In the near term, the goal is to have biotech-based insect resistance and herbicide tolerant traits for sugarcane and in the longer term to use biotech to improve sugar content and to increase the industrial yield with biotech enhanced enzymes.

The Status of Investments in Biodiesel in Brazil

The biodiesel industry is just in its infancy in Brazil and is being supported by the Brazilian Government and the private sector, which is investing in the establishment of biodiesel facilities throughout the country. In spite of the Government goal to promote the use of other oilseeds, such as castor oil, palm oil, and *Jatropha*, soybean oil is currently, the key feedstock used to produce biodiesel in Brazil. In 2007, it is estimated that 85% of biodiesel will be produced from soybean oil. Cotton seed is likely to be the second source for biodiesel in the future in Brazil. In 2008, it will be mandatory to blend mineral diesel with 2% of biodiesel and the blend will increase to 5% by 2013. Brazilian and foreign companies are taking urgent action to meet the legal requirement for the biodiesel blend standards by next year, 2008. ADM, Caramuru, Granol and others have already operational biodiesel facilities in the country. However, the current high prices of soybean oil in the international market makes cost-effective production of biodiesel a challenge and current Government support may not be adequate. The soybean crushing companies in Brazil prefer to sell the crude soybean oil in the traditional soybean oil markets, rather than sell it for biodiesel production. European countries, notably Germany, France, and Holland have increased their soybean oil purchases in Brazil in the last two years, maybe some of it destined for biodiesel production whereas historically the traditional export of Brazilian soybean oil has been to the vegetable oil deficit countries in Asia and Africa. In 2006, soybean oil for biodiesel production, was produced on 1.2 million hectares of soybean in Brazil but when the 5% mix becomes mandatory in 2013, it is estimated that at least 3.2 million hectares out of a projected soybean area of 31.7 million hectares will be dedicated to biodiesel production. Of the 2007 national hectarage of 22.5 million hectares, 1.2 million hectares equivalent to 5% will be used to produce biodiesel in 2007, of which 750,000 hectares will be RR® soybean. In 2013, it is estimated that the hectarage required for biodiesel production will increase to 3.2 million which will represent 10% of the projected hectarage of 31.7 million hectares. Thus, the hectarage of soybean required in Brazil for biodiesel production will almost triple from 1.2 million hectares to 3.2 million hectares in 2013. However, this will be offset by an increase in the national hectarage of soybean from 22.5 million hectares in 2007 to a projected 31.7 million hectares, resulting in the percentage of soybean hectarage used for biodiesel increasing from 5% in 2007 to 10% in 2013.

It is important to note that although Brazil is investing heavily in biofuel, the country is also one of few countries self sufficient in fossil fuel oil; it recently discovered a significant new reserve in its coastal waters. The Tuli oil field has reserves of 5 to 8 billion barrels of oil, the second biggest oil reserve found in the last 20 years.

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, which is a strong national agricultural research organization, with significant public sector investments in crop biotechnology.

Benefits from Biotech Crops in Brazil

Brazil is estimated to have enhanced farm income from biotech soybean by US$1.9 billion in the four-year period 2003 to 2006 and the benefits for 2006 alone is estimated at US$561 million (Brookes and Barfoot, 2008).

In addition to economic benefits there are also environmental benefits associated with RR® soybean, (Carneiro, 2007, Personal Communication) which have been determined by modeling. A study by Carneiro indicated that 62.7 million liters of diesel have been saved since 1997 as a result of a saving of 1.5 herbicide sprays on RR® soybean. In addition, it is estimated that 7.5 billion liters of water have been saved (through reduced herbicide sprays) plus a reduction of 160,000 tons of CO_2 emissions. For the next 10 years, 2007/08 to 2016/17, assuming a cumulative hectarage of 262 million hectares of biotech soybean in Brazil, savings of 393.3 million liters of diesel are projected in addition to a savings of 47.2 billion liters of water and a reduction of 1 million tons of CO_2 emissions.

Environmental benefits can also be generated from biotech crops other than soybean. Assuming an accumulated area of 16.5 million hectares of biotech cotton in the period 2007/08 to 20016/17 it is projected that biotech cotton will save 28.2 million liters of diesel, save 4.9 billion liters of water, and reduce CO_2 emissions by 72.3 thousand tons. Similar environmental benefits will accrue from the deployment of other biotech crops such as biotech maize, expected to be deployed in 2008 and other biotech crops such as sugarcane in the near-term.

In a detailed study (Galvão Gomes, 2007, Personal Communication) the economic benefits were calculated for RR® soybean for the period 1998 to 2006/07; RR® soybean was planted unofficially from 1998 to 2002 and officially from 2003 onwards. The data shows (Table 7) that farmers gained US$1.5 billion in the period 1998 to 2006 and technology developers gained US$0.59 billion – thus, the farmers gained 72% of the profits and technology developers 28% – this is consistent with other analyses which confirm that farmers usually gain the major share, about two-thirds or more, of the benefits from biotech crops. Galvão Gomes (2007, Personal Communication) also estimated the benefits lost to Brazilian farmers because of delayed approvals due to a cumbersome approval process, particularly the legal challenges from various interest groups, including Ministries within the Government. Taking the fast adoption rates of RR® soybean in neighboring Argentina as an optimal bench mark, it was concluded that delayed approval of RR® soybean in Brazil for the period 1998 to 2006 cost farmers US$3.10 billion and technology developers an additional US$1.41 billion for total lost benefits of US$4.51 billion. Thus, the total potential benefits for both farmers and technology developers in the period 1998 to 2006 was US$6.6 billion of which only US$2.09 billion equivalent to 31% was realized – US$4.5 billion was lost due to legal/regulatory delays which is a significant sacrifice for Brazil and the major losers were farmers (Table 7) .

Applying the implications of the 1998 to 2006 study to the next decade, Galvão Gomes, (2007, Personal Communication) further projected that if biotech cotton suffers the same delay as RR® soybean in the 1998 to 2006 period, then the potential loss for cotton in the period 2006 to 2015 would be US$2.1 billion for biotech cotton, and US$6.9 billion for biotech maize for a total of US$9 billion (Table 8). These projections of loss are a sobering reminder of the real risks involved if the technology is not accessed in a timely and responsible manner. The recent commitments, totaling Real 10 billion (US$7 billion) equivalent to US$700 million per year (60% public and 40% private) for each of the next ten years to biotechnology is therefore reassuring. Moreover, a significant part of the US$7 billion is to be devoted to biofuels and agriculture – this is a welcome development reflecting the political will and support of the current Government to biotechnology (Brazilian Government, 2007). The key points of the new Brazilian Program of Biotechnology are as follows:

- Launched by President Luis Inacio Lula da Silva on February 8, 2007, the executive decree creates the Brazilian Policy for Development of Biotechnology and also creates the National Committee for Biotechnology.

Table 7. Benefits and "Lost Benefits" ($US Billions) from RR® Soybean in Brazil, 1998 to 2006

Beneficiary	Realized Benefits	Lost Benefits	Total Potential Benefits
Farmer Benefits	1.50	3.10	4.60
Tech Developer Benefits	0.59	1.41	2.00
Total	**2.09**	**4.51**	**6.60**

Source: Galvão Gomes, 2007, Personal Communication.

Table 8. Loss to Brazilian Farmers if Biotech Maize and Cotton Not Adopted in Reasonable Time Frame in Next Decade

Crop	Value of Loss (US$ Billions)
Maize	6.9
Cotton	2.1
Total	**9.0**

Source: Galvão Gomes, 2007, Personal Communication.

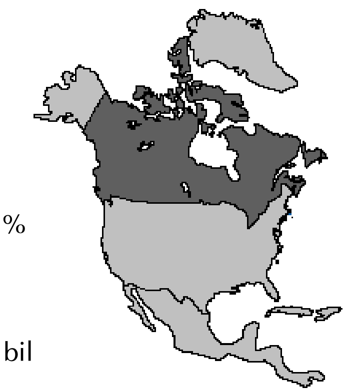
- One of the key goals of this policy is to replicate in the biotechnology field, the success Brazil has achieved with biofuel production, especially ethanol from sugarcane.
- The executive decree projects public and private investment of Real 10 billion (US$7 billion) over the next 10 years, from 60% public resources and 40% private resources.
- The policy aims to coordinate activities among the national agricultural, environmental, health and industry and trade Ministers.
- Being part of a national policy, the Brazilian Bank of Development (BNDS) will provide special credit lines to the biotech companies to invest in research and development.
- The Brazilian Association of Biotech Companies (ABRABI), which represents the private biotech sector in Brazil, has estimated that its current investment in biotech is between Real 5.4 billion (US$3.8 billion) and Real 9.0 billion (US$6.3 billion) and employing 28,000 workers nationwide.

In November 2007, Brazilian President Luis Inacio Lula da Silva announced a US$23 billion investment in a four-year "Plan for Action for Science, Technology and Innovation." One of the four thrusts is to support research and innovation in strategic areas particularly biotechnology, biofuels and biodiversity. It is noteworthy that the political will for biotechnology evident in Brazil is also evident in China and India. The troika of Brazil, India and China is a formidable force in agricultural biotechnology that can deliver enormous humanitarian benefits that can be mobilized to alleviate poverty and hunger for poor resource poor farmers by 2015 the Millennium Development Goals, when it is expected that all three major staples, maize, rice and wheat, as well as several orphan crops, to benefit from biotechnology.

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 2007 Canada retained its number four ranking worldwide in terms of biotech crop area. Growth in biotech crop area continued in Canada in 2007 with a net gain of approximately 900,000 hectares, approximately three times the gain in 2006 and equivalent to a 15% year-over-year growth, with a total biotech crop area of 7 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. The total land area planted to canola in Canada in 2007 was 5.9 million hectares, up 11% on 2006 when 5.24 million hectares were planted. In 2007, the national adoption rate for biotech canola was the highest ever at 87%, up from 84% in 2006, 82% in 2005 and 77% in 2004. In 2007, biotech herbicide tolerant canola was grown on approximately 5.1 million hectares, 15% more than the 4.5 million hectares of biotech canola area grown in 2006; this compares with 4.2 million hectares of biotech canola in 2005. Thus, in Canada there has been an impressive steady and significant increase both in the total land area planted to canola and in the percentage planted to herbicide tolerant biotech canola which has now reached a national adoption rate of almost 90%.

CANADA



Population: 32.6 million

GDP: US$1,1275 billion

% employed in agriculture: 2%

Agriculture as % GDP: 2.2%

Agricultural GDP: US$28.05 bil

Arable Land (AL): 41.6 million hectares

Ratio of AL/Population*: 5.6

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 2007):
7 Million Hectares (+15% in 2007)

Farm income gain from biotech, 1996-2006: US$1.2 billion

*Ratio: % global arable land / % global population

In Ontario and Quebec, the major provinces for maize and soybean hectarage, the total plantings of maize in 2007 were 1.3 million hectares and total plantings of soybean were 1.1 million hectares. In 2007, the area of biotech maize was up by a significant 320,000 hectares to 1,174,000 hectares and soybean was slightly lower at 688,000 hectares, compared with 750,000 hectares in 2006. Canada is one of only six countries (the others are the USA, Argentina, Chile, the Philippines, and Honduras) which grow maize with stacked traits for herbicide tolerance and Bt for insect resistance. The stacked trait maize hectarage in Canada in 2007 was approximately 290,000 hectares compared with over 18 million hectares of stacked maize in the USA. The continued growth of biotech crops in Canada in 2007 occurred with significantly higher total plantings of canola (5.9 million hectares), and slightly higher plantings of maize (1.4 million hectares) and similar soybean hectarage (1.2 million hectares).

According to the Canola Council of Canada approximately 90,000 tons, or 1% of the 9 million tons of canola production was used for biodiesel production in 2007 – this production required about 45,000 hectares of biotech canola. This area is expected to increase to about 100,000 hectares of biotech canola in 2008 when 200,000 tons or 2% of production in 2008 will be used when new biodiesel facilities come into operation.

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 RR® alfalfa from the USA has been approved for import to Canada.

Benefits from Biotech Crops in Canada

Canada is estimated to have enhanced farm income from biotech canola, maize and soybean of US$1.2 billion in the period 1996 to 2006 and the benefits for 2006 alone is estimated at US$261 million (Brookes and Barfoot, 2008).

A detailed benefit study of biotech canola, conducted by the Canola Council of Canada is summarized below. Biotech canola was by far the largest hectarage of biotech crops in Canada in 2007 representing approximately 75% of the total biotech crop area of 7 million hectares in Canada. The detailed study (Canola Council of Canada, 2007) involved 650 growers; 325 growing conventional and 325 growing herbicide tolerant biotech canola. The study covered the period 1997 to 2000 and the major benefits were the following.

- More cost effective weed management was the most important advantage attributed by farmers to herbicide tolerant canola with herbicide cost 40% lower for biotech canola (saving of 1,500 MT of herbicide in 2000) compared with conventional canola.
- A 10% yield advantage for biotech canola over conventional and a dockage was only 3.87% for biotech canola compared with 5.14% for conventional.
- Less tillage and summer fallow required for biotech canola which required less labor and tractor fuel (saving of 31.2 million liters in 2000 alone) and facilitated conservation of soil structure and moisture and easy “over the top” spraying for weeds after crop establishment.
- Increased grower revenue of US$14.36 per hectare and a profit of US$26.23 per hectare for biotech canola over conventional.
- At a national level the direct value to growers from 1997 to 2000 was in the range of US$144 to US$249 million.
- The indirect value to industry of biotech canola was up to US$215 million for the same period 1997 to 2000.

- The total direct and indirect value to industry and growers for the period 1997 to 2000 was US$464 million.
- Extrapolating from the period 1997 to 2000 when 8,090 hectares of biotech canola were grown for a gain of US$464 million and the additional 19,809 hectares grown during the period 2001 to 2007, the total direct and indirect value to industry and growers for the period 1997 to 2007 is of the order of US$1.6 billion.

Farmer Experience

Jim Pallister, is a canola farmer from Canada. He says:

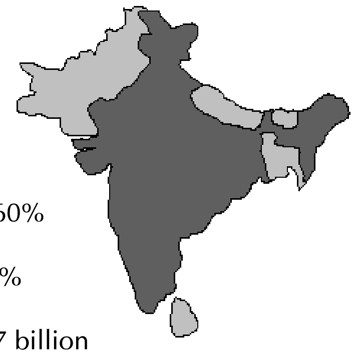
"The biotech varieties deliver excellent yields and are a good marketable quality product. Our yields have increased with this production method, which is partly due to very clean crops, better seed bed and soil and superior plant breeding" (Pallister, 2006).

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 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 (National Sample Survey India, 2003). Sixty percent of the farming households own less than 1 hectare of land, and only 5% own more than 4 hectares. Only 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 40 Rupees per US Dollar) was US$50 per month and the average consumption expenditures was US$70. Thus, of the 90 million farmer households in India, approximately 85 million, which represent about 95% of all farmers, are small and 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 to 9.5 million hectares (estimated at 9.2 million hectares in 2006 and 9.4 in 2007) 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.

Approximately 65% of India's cotton is produced on dryland and 35% on irrigated lands. In 2006, hybrids occupied 80% (7.4 million hectares) of the cotton area and 20% (1.8 million hectares) were occupied by 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 which have out–performed 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 cottons), *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*.

INDIA



Population: 1.09 billion

GDP: US$923 billion

% employed in agriculture: 60%

Agriculture as % GDP: 18.6%

Agricultural GDP: US$171.7 billion

Arable Land (AL): 145.2 million hectares

Ratio of AL/Population*: 0.60

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

Commercialized Biotech Crop: Bt Cotton

Total area under biotech crops and (% increase in 2007):
6.2 Million Hectares (+63% in 2007)

Farm income gain from biotech, 2002-2006: US$1.3 billion

*Ratio: % global arable land / % global population

Bt cotton, which confers resistance to important insect pests of cotton was first adopted in India as hybrids in 2002. In 2002, 54,000 farmers grew approximately 50,000 hectares of officially approved Bt cotton hybrids for the first time 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 the area of Bt cotton to 3.8 million hectares. This tripling in area was the highest percentage year-on-year growth for any country planting biotech crops in the world in 2006. Notably in 2006, India's Bt cotton area (3.8 million hectares) exceeded for the first time, that of China's 3.5 million hectares. In 2007, the Indian cotton sector continued to grow with a record increase of 63% in adoption of Bt cotton area from 3.8 to 6.2 million hectares; this is the third consecutive year for India to have the largest year-on-year percentage growth of all biotech cotton growing countries in the world; a 160% increase in 2005, followed by a 192% increase in 2006 and a 63% increase in 2007. In addition, in 2006/07 India overtook the USA to become the second largest cotton producing country in the world, after China (USDA/ FAS, 2007).

Table 9. Adoption of Bt Cotton in India, by Major States, 2004 to 2007 (Thousand Hectares)

State	2004	2005	2006	2007
Maharashtra	200	607	1,840	2,880
Andhra Pradesh	75	280	830	1,190
Gujarat	122	150	470	818
Madhya Pradesh	80	146	310	500
Northern Zone*	- -	60	215	592
Karnataka	18	30	85	145
Tamil Nadu	5	27	45	70
Other	- -	- -	5	5
Total	**500**	**1,300**	**3,800**	**6,200**

* Punjab, Haryana, Rajasthan
Source: ISAAA, 2007.

Of the estimated 9.4 million hectares of cotton in India, in 2007, 66% or 6.2 million hectares were Bt cotton – a remarkably high proportion in a fairly short period of six years. Of the 6.2 million hectares of hybrid Bt cotton grown in India in 2007, 35% was under irrigation and 65% rain-fed. A total of 131 Bt cotton hybrids were approved for planting in 2007 compared with 62 in 2006, 20 in 2005 and only 4 Bt cotton hybrids in 2004. Over the years, India has diversified deployment of Bt genes and genotypes which are adapted to different agro-ecological zones and to ensure equitable distribution to small and resource-poor cotton farmers. The distribution of Bt cotton in the major growing states in 2004, 2005, 2006, and 2007 is shown in Table 9. The major states growing Bt cotton in 2007, listed in order of hectarage, are Maharashtra (2.8 million hectares representing almost half, 46% of all Bt cotton in India in 2007) followed by Andhra Pradesh (1.19 million hectares or 19%), Gujarat (818,000 hectares or 13%), Northern Zone (592,000 hectares or around 10%), Madhya Pradesh (500,000 hectares or 8%), and the balance in Karnataka and Tamil Nadu and other states.

It is conservatively estimated that approximately 3.8 million small and resource-poor farmers planted on average 1.65 hectares of Bt cotton in 2007. 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 to 2.3 million farmers in 2006 and to 3.8 million farmers in 2007; this is the largest increase in number of farmers planting biotech crops in any country in 2007. The adoption of Bt cotton by 3.8 million small and resource-poor farmers represent around 70% of the total of 5.5 million cotton farmers in India who are reaping significant benefits from Bt cotton.

Coincidental with the steep increase in adoption of Bt cotton between 2002 and 2007, the average yield of cotton in India, which had one of the lowest yields in the world, increased from 308 kg

Table 10. Cotton Area, Production and Yield in India, 2001-2008

Year	Area (Million Hectares)	Production (Million Bales)	Yield (kg lint per hectare)
2001 - 02	8.73	15.8	308
2002 - 03	7.67	13.6	302
2003 - 04	7.63	17.9	399
2004 - 05	8.92	24.3	463
2005 - 06	8.87	24.4	467
2006 - 07	9.158	28.0	520
2007 - 08	9.400*	31.0*	560*

1 bale = 170 kg
*Cotton Advisory Board (CAB) projections for 2007-08 season
Source: CAB, Office of Textile Commissioner, Ministry of Textile, Government of India.

per hectare in 2001-02, to 520 kg per hectare in 2006-07, with most of the increase in yield of up to 50% or more, attributable to Bt cotton (Table 10). At a national level, Bt cotton is a major factor contributing to higher cotton production which increased from 15.8 million bales in 2001-02, to 24.4 million bales in 2005-06, to 28 million bales in 2006-07, which was a record cotton crop for India (Cotton Advisory Board, India, 2007). In 2007-08, it is estimated that cotton production will increase again to 31.0 million bales from 28 million bales in 2006-07. This quantum leap in cotton production since 2002-03 has been triggered by improved seeds and particularly the ever-increasing plantings of improved Bt cotton in the nine cotton growing states (Textile Commissioner Office, India, 2007).

With the boom in cotton production in the last five years, India has become transformed from a net importer to a net exporter of cotton. Exports of cotton have registered a sharp increase from 0.92 million bales in 2004-05 to 4.7 million bales in 2005-06. The Cotton Advisory Board of the Government of India expects cotton exports to increase again to over 4.8 million bales in 2007-08 (Lok Sabha India, 2007).

Notably, cotton is the major raw material for the domestic textiles industry, which is pre-dominantly in favor of cotton, compared with other fibers. With the dismantling of the Multi Fiber Agreement (MFA) under the aegis of the World Trade Organization, this will favor cotton relative to synthetic fibers. Thus, as a result of the boom in cotton, India's Ministry of Textiles has projected that the value of the Indian textile industry will grow from US$47 billion in 2005-2006 to US$95 billion by 2010. In 2012, it is expected to escalate further to US$115 billion comprising the domestic market of US$60 billion and US$55 billion for exports. The cotton textiles, which constitute more than two-thirds of all textile exports of India, reached US$4.49 billion in 2005-06 recording a substantial increase of 26.8% over 2004-2005. The significant increase in cotton production during the last five or six years has increased the availability of raw cotton to the domestic textiles industry at affordable prices, and provided the textile industry with a competitive edge in the global market (Ministry of Textile, Government of India, 2007).

Concurrent with the boom in cotton production the Indian biotech and seed industry has also been growing at an unprecedented rate with high year-on-year growth because of the high adoption of Bt cotton by Indian farmers. According to the survey conducted by BioSpectrum-ABLE in 2006-07, the Indian biotech sector exceeded the US$2 billion benchmark in 2006-07 with industry reporting nearly 31% growth over 2005-06; it is projected to be a US$5 billion industry by 2010. More specifically the agricultural biotech (BioAgri) sector grew almost ten-fold from US$26.8 million in 2002-03 to an impressive US$225.85 million in 2006-07 following one of the highest periods of year-on-year growth on record. The BioAgri sector grew 54.9% in 2006-07 over 2005-06 with 95% of revenue generated from the domestic market while in general the entire biotech sector generated 58% revenues from the export.

Approval of events and Bt cotton hybrids in India

The number of events, as well as the number of Bt cotton hybrids and companies marketing approved hybrids have all increased from 2002, the first year of commercialization of Bt cotton in India. The number of Bt cotton hybrids increased by more than two-fold from 62 hybrids in 2006 to 131 hybrids in 2007. This has provided much more choice than previous years to farmers in the North, Central and Southern regions, where specific hybrids have been approved for cultivation in specific regions (Figure 8). A total of four events were approved for incorporation in a total of 131 hybrids offered for sale in 2007.

The first event, 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 96 hybrids in 2007 for use in the North, Central and South zones – this compares with 48 BG-I hybrids in 2006.

The second event, Bollgard® II (BG-II with event MON15985) also developed by Mahyco and sourced from Monsanto, featured the stacked genes *cry1Ac* and *cry2Ab*, was approved for sale for the first time in 2006 in a total of seven hybrids for use in the Central and South regions. This event was approved for commercial cultivation for the first time in the Northern region in 2007 and the number of hybrids for sale increased from 7 in 2006 to 21 in 2007 in the North, 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. The event was approved for sale for the first time in 2006 in a total of four hybrids for use in the North, Central and South regions. Whereas this event was approved in four hybrids in 2006, the total doubled to 8 hybrids in 2007.

Figure 8. Approval of Events and Bt Cotton Hybrids in India, 2007

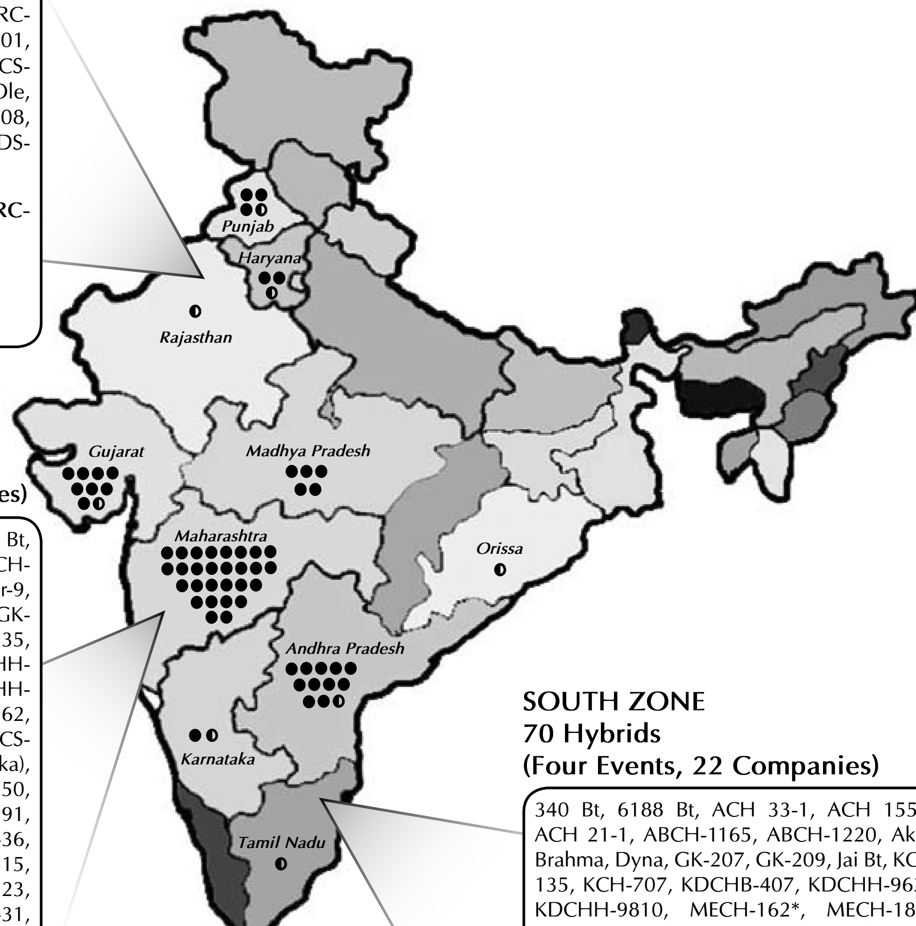
NORTH ZONE
32 Hybrids (Four Events, 15 Companies)

6317 Bt, 6488 Bt, Ankur-651, Ankur-2226, Ankur-2534, GK-206, IT-905, KDCHH-9810, MRC-6025, MRC-6029, MRC-6301, MRC-6304, NAMCOT-402, NCS-138, NCS-913, NCS-950, Ole, PCH-406, RCH-134, RCH-308, RCH-314, RCH-317, Sigma, SDS-9, SDS-1368

ACH 33-2, MRC-7017, MRC-7031, NCS-145 (Bunny)

JKCH-1947, JK-1050

NCEH-6R



CENTRAL ZONE
84 Hybrids
(Four Events, 23 Companies)

322 Bt, 110 Bt, 6188 Bt, 563 Bt, ACH 33-1, ACH 155-1, ABCH-1165, ABCH-1220, Akka, Ankur-9, Ankur-651, Brahma, Dyna, GK-204, GK-205, Jai Bt, KCH-135, KCH-707, KDCHH-786, KDCHH-9632, KDCHH-9810, KDCHH-9821, MECH-12, MECH-162, MECH-184, MRC-6301, NCS-145 (Bunny), NCS-207 (Mallika), NCS-913, NCS-929, NCS- 950, NCS-954, NCS-955, NCHB-991, NCHB-992, NPH-2171, NSPL-36, NSPL-405, NSPL-999, PCH-115, PCH-207 (PCH-205), PCH-923, PCH-930, PRCH-102, PRCH-31, Rudra, RCH-2, RCH-118, RCH-138, RCH-144, RCH-377, RCH-386, Sigma, SP-504 (Dhanno), SP-923, Tulasi-4, Tulasi-9, Tulasi-117, VBCH-1009, VBCH-1010, VCH-111, VICH-5, VICH-9, VICH-15

Ajeet-11-2, Ajeet-155-2, KDCHH-441, KDCHH-621, MRC-7301, MRC-7326, MRC-7347, MRC-7351, NCS-207 (Mallika), RCH-2, RCH-515

JK-Varuna, JKCH-99, JKCH-226, JKCH-666

Dhruv Bt, Kashinath Bt, NCEH-2R, NCEH-3R, Navkar-5

SOUTH ZONE
70 Hybrids
(Four Events, 22 Companies)

340 Bt, 6188 Bt, ACH 33-1, ACH 155-1, ACH 21-1, ABCH-1165, ABCH-1220, Akka, Brahma, Dyna, GK-207, GK-209, Jai Bt, KCH-135, KCH-707, KDCHB-407, KDCHH-9632, KDCHH-9810, MECH-162*, MECH-184*, MRC-6322, MRC-6918, NCS-145 (Bunny), NCS-207 (Mallika), NCS-913, NCS-929, NCS-950, NCS-954, NCHB-990, NCHB-992, NPH-2171, NSPL-36, NSPL-405, NSPL-999, Ole,PCH-115, PCH-207 (PCH 205), PCH-930, PCH-2270, Rudra, RCH-2, RCH-20, RCH-111, RCH-371, RCH-368, RCHB-708, SP-504 (Dhanno), Sigma, Tulasi-4, Tulasi-117, VICH-5, VICH-9, VCH-111

ACH-33-2, KDCHH-621, MRC-7160, MRC-7201, MRC-7347, MRC-7351, NCS-145 (Bunny), RCH-2, RCH-530, RCH-533

JK-Durga, JKCH-99, JKCH-634 (JK-Iswar)

Dhruv Bt, Kashinath Bt, NCEH-2R, NCEH-3R

Event	Code
BG-I	Normal
BG-II	**Bold**
Event-1	*Italic*
GFM Event	***Italic Bold***

- ● For 100,000 hectares of Bt cotton
- ◐ For <100,000 hectares of Bt cotton

Bt Cotton (2002-2007): 131 Bt cotton hybrids commercially released, which is marketed by 24 companies in India

Compiled by ISAAA, 2007.

Table 11. Deployment of Approved Bt Cotton Events/Hybrids by Region in India, 2007

Event	North (N)	Central (C)	South (S)	North/Central (N/C)	North/South (N/S)	Central/South (C/S)	N/C/S	Total Hybrids
Bollgard-I[1]	19	24	12	2	1	35	3	96
Bollgard-II[2]	3	7	4	-	2	5	-	21
Event 1[3]	2	3	2	-	-	1	-	8
GFM Event[4]	1	1	-	-	-	4	-	6
Total	**25**	**35**	**18**	**2**	**3**	**45**	**3**	**131**

[1,2] Mahyco [3] JK Seeds [4] Nath Seeds
Source: Compiled by ISAAA, 2007.

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 in 2006, one in each of the three regions of India. In 2007, double the number of hybrids, 6 were offered for sale in 3 regions. The deployment of these four events is summarized in Table 11.

In 2006, 15 companies offered 62 hybrids for sale in India. In 2007 both the number of hybrids and the number of companies increased significantly from 62 to 131 hybrids and the number of companies from 15 to 24. The following 24 indigenous seed companies from India, listed alphabetically, offered the 131 hybrids for sale in 2007; Ajeet Seeds, Amar Biotech, Ankur Seeds, Bioseeds Research, Emergent Genetics (Monsanto), Ganga Kaveri Seeds, Kaveri Seeds, Krishidhan Seeds, Mahyco, Nandi Seeds, Namdhari Seeds, Nuziveedu Seeds, Prabhat Agri Biotech, Paravardhan Seeds, Pro-agro Seeds (Bayer Cropscience), Rasi Seeds, Tulasi Seeds, Vibha Seeds, Vikki Agrotech, Vikram Seeds, JK Agri-Genetics, Nath Seeds, Navkar Seeds and Zuari Seeds.

The deployment of the four events in 131 hybrids in 2007 is summarized in Table 12 as well as their corresponding distribution in 2002, 2003, 2004, 2005 and 2006. In 2007, the Genetic Engineering Approval Committee (GEAC) approved 69 new Bt cotton hybrids for commercial cultivation in the 2007 season, in addition to the 62 Bt cotton hybrids approved for sale in 2006, for a total of 131 hybrids. This has given farmers in India's three cotton-growing zones significantly more choice of hybrids to cultivate in 2007. Of the 131 Bt cotton hybrids approved for commercial cultivation, 32 hybrids featuring four events were sold by 15 companies in the Northern zone, 84 hybrids featuring four events were sold by 23 companies in the Central Zone, and 70 hybrids featuring four events were sold by 24 companies in the Southern Zone (Table 12).

Similarly, the distribution of the 62 hybrids approved for 2006 is summarized in Table 12 as well as the 20 hybrids approved for 2005, 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

Table 12. Deployment of Approved Bt Cotton Events/Hybrids by Companies in India, 2002 to 2007

Zone	2002	2003	2004	2005	2006	2007
NORTH ZONE				6 Hybrids	14 Hybrids	32 Hybrids
Haryana				1 Event	3 Events	4 Events
Punjab				3 Companies	6 Companies	15 Companies
Rajasthan						
CENTRAL ZONE	3 Hybrids	3 Hybrids	4 Hybrids	12 Hybrids	36 Hybrids	84 Hybrids
Gujarat				1 Event	4 Events	4 Events
Madhya Pradesh				4 Companies	15 Companies	23 Companies
Maharashtra						
SOUTH ZONE	3 Hybrids	3 Hybrids	4 Hybrids	9 Hybrids	31 Hybrids	70 Hybrids
Andhra Pradesh				1 Event	4 Events	4 Events
Karnataka				3 Companies	13 Companies	22 Companies
Tamil Nadu						
Summary						
Total no. of hybrids	**3**	**3**	**4**	**20**	**62**	**131***
Total no. of events	**1**	**1**	**1**	**1**	**4**	**4**
Total no. of companies	**1**	**1**	**1**	**3**	**15**	**24**

*** Some of the 131 hybrids are being grown in multiple regions (see Figure 8)**
Source: ISAAA, 2007.

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 131 Bt cotton hybrids in 2007 as well as their respective events in the three regions is summarized and illustrated in the map in Figure 8.

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 other 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 a country with first-hand experience of the life-saving benefits of the Green Revolution in wheat and rice. In 2007, 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 a large number of indigenous Indian seed companies and subsidiaries of multinationals involved in biotech crops.

Crop biotech investments, from both the public and private sectors in India, currently conservatively estimated at US$100 million per annum, 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. Field trials with Bt biotech rice are already underway. 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 GoldenRice™, and mustard with enhanced levels of beta-carotene plus an initiative to enhance the nutritional value of potatoes with the *ama*1 gene. Research in Germany (Stein *et al.,* 2006) predicts a 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 project is to improve resistance to fruit and shoot borer which are very important pests that require intensive insecticide applications, every other day in some cases, costing US$40 to US$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 Genetic Engineering Approval Committee (GEAC) has approved multilocational large scale field trials which are already underway. 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; the work in the Philippines is being conducted in conjunction with ISAAA. It is noteworthy that this private-public partnership aims to generate affordable seed for resource-poor farmers which will substantially reduce, by approximately half, 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 broad spectrum 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 and resource-poor farmer cultivating eggplant in India has a farm of 1.67 hectares and cultivates 0.26 hectare 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 insecticide sprays, 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 (ABSP II Cornell, USA) have shown that the commercialization of Bt eggplant has the potential to benefit up to 2 million small 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-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. There are now 10 biotech crops in field trials in India and these are listed in Table 13.

In summary, India's increased public and private sector investments including government support for crop biotechnology is progressive. There were several key developments in India during 2007 that merit inclusion in this Brief; 5 events/developments are summarized in the first section of the Appendix quoting the principal official text released by the respective organizations.

Status of Biofuels in India

Fuel security is one of the prime concerns for India, which is ranked sixth in the world in terms

Table 13. Biotech Crops in Field Trial in India, 2007

No.	Crop	Organization	Transgene
1.	Brinjal	IARI, New Delhi Sungro Seeds Ltd., New Delhi Mahyco, Mumbai TNAU, Coimbatore	*cry1Aa and cry1Aabc* *cry1Ac* *cry1Ac*
2.	Cabbage	Nunhems India Pvt. Ltd.	*cry1Ba and cry1Ca*
3.	Castor	Directorate of Oilseeds Research (DOR), Hyderabad	*cry1Aa and cry1Ec*
4.	Cauliflower	Sungro Seeds Ltd., New Delhi Nunhems India Pvt. Ltd.	*cry1Ac, cry1Ba and cry1Ca* *cry1Ac, cry1Ba and cry1Ca*
5.	Corn	Monsanto, Mumbai	*cry1Ab gene (Mon 810 event)*
6.	Groundnut	ICRISAT, Hyderabad	*chitinase gene from rice (Rchit)*
7.	Okra	Mahyco, Mumbai	*cry1Ac, cry2Ab*
8.	Potato	Central Potato Research Institute (CPRI), Shimla	*RB gene derived from Solanum bulbocastanum*
9.	Rice	IARI, New Delhi Mahyco, Mumbai TNAU, Coimbatore	*cry1B-cry1Aa fusion gene* *cry1Ac, cry2Ab* *rice chitinase (chi11) or tobacco osmotin gene*
10.	Tomato	IARI, New Delhi Mahyco, Mumbai	*antisense replicase gene of tomoto leaf curl virus* *cry1Ac*

Source: IGMORRIS NIC INDIA, 2007.

of fuel demand, accounting for 35% of world commercial demand in 2001. During 2004-05, the country imported 95.86 million tons of crude oil valued at US$26 billion. The Indian economy is expected to grow at a rate of over 6% per annum and the petroleum imports are expected to rise to 166 million tons by 2019 and 622 million tons by 2047 (Department of Biotechnology India, 2007). In view of the growing energy demand and to ensure fuel security for the country, the Government of India has initiated several policy actions to promote the development of a robust biofuel sector in the country. The National Policy on Biofuels is being drafted by the Ministry of New and Renewable

Energy (MNRE) and is expected to be released in the near-term. It includes: setting up a National Biofuel Development Board (NBDB); support for R&D and a demonstration of the applications of biofuels; strengthening the existing institutional mechanisms; and facilitating overall coordination between the different ministries involved with biofuels. The Biofuel policy aims to give direction and momentum for the development of biofuels through blending of ethanol with petrol and biodiesel with diesel for transportation, and for fuel-consuming stationery and portable units (Ministry of New and Renewable Energy India, 2007).

Based on the recommendations of the Report of the Committee on Development of Bio-fuels, set up by the Planning Commission of India in 2003, the Ministry of Rural Development is going to launch a National Mission on Biofuels with a special focus on plantations of *Jatropha curcas*. The Ministry is responsible for encouraging plantation of non-edible oil-bearing plants such as *Jatropha curcas* as a feedstock for biodiesel. The proposed US$250-375 million Mission will initiate and promote *Jatropha curcas* cultivation in forest and non-forest areas, especially in wastelands and also establish seed procurement cum oil-extraction centers, oil processing (transesterification) and R&D activities. The Mission will implement activities in close cooperation with the National Oilseeds and Vegetable Oil Development (NOVOD) Board of the Ministry of Agriculture for *Jatropha* cultivation and with the Ministry of Environment and Forests for its cultivation in forest lands. The plans call for about 0.5 million hectares of *Jatropha* to be planted by 2011 in a demonstration phase. Phase-II will be a self-sustaining expansion of the biodiesel program that will utilize 11.2 million hectares to produce the required quantity of *Jatropha curcas* seed that in turn will produce 10.14 million tonnes of biodiesel to be blended with mineral diesel at a 20% blend by 2030. India has also set a target for a 5% blending of bioethanol with petroleum by 2011 (Ministry of Rural Development, India, 2007). The main feed stock for bioethanol is sugarcane and molasses and the major concern is how to meet feedstock demand with the limited supply of feedstock. Accordingly, a decision has been made to vigorously pursue a strategy for developing “Second Generation Biofuels”.

In order to meet the increasing feedstocks demand for biodiesel and bioethanol production, the Department of Biotechnology (DBT) of the Ministry of Science and Technology is pursuing the “Energy Biosciences Strategy for India (DBT’s Energy Biosciences Strategy for India, 2007). The strategy aims to improve feed stock options for lignocellulosic ethanol. This will be achieved by optimally exploiting bioresources for biofuel production by adopting molecular biology and biotechnology tools for tailoring the feedstocks to meet the required needs. This will require: the strengthening of research on recombinant microorganisms and related work; identifying potential areas for collaboration with USA, UK and Israel; expediting algal biofuel research, *Jatropha* production and improvement program; optimization and standardization of processes; setting up a pilot plant for scale up and validation and making available an incubator facility for encouraging small entrepreneurs and promoting strong industrial partnership; and strengthening human resources by setting up energy biosciences centers in India. The DBT spends approximately US$5-7 million every year on R&D of biofuels, which is likely to be increased substantially with the establishment of energy biosciences centers.

The DBT has already initiated a well-defined, focused feedstock development and improvement program for *Jatropha curcas* a few years ago. Nearly 1500 accessions of *Jatropha curcas* have been collected and characterized for oil content and quality, which are stored at the national gene bank. A major effort is now being made towards improvement of the *Jatropha* plants for improved yield, oil content and quality and resistance to biotic and abiotic stress. Biotechnological interventions are being used to develop an integrated breeding program for developing mapping populations for genetic improvement. Work has also been initiated to: develop molecular markers; increasing the oil content of *Jatropha*; reduce free fatty acid content using transgenic approach and oil quality modification to facilitate transesterification. The development of EST's, metabolic pathway engineering, gene isolation, transformation and gene expression projects are being commissioned in close partnership with public and private sector institutions such as Avesthagen, Labland biotech, Barwale Foundation, Vittal Mallya Scientific Research Foundation, MS Swaminathan Research Foundation, Puri Foundation's Indian Institute of Advanced Research, TERI, UICT, MKU, CFTRI, Tamil Nadu Agricultural University and National Botanical Research Institute. Some of the DBT's projects have resulted in: an optimization and enhanced recovery process at the lab scale for conversion of lignocellulosic biomass; the development of two thermo tolerant yeast strains; the development of a recombinant yeast strain for converting starch to ethanol; and the development of recombinant bacteria for enhanced cellulase production. There are many private companies and institutions that are independently undertaking R&D, improvement and planting of *Jatropha curcas* and other potential feedstocks on a large scale; they include Reliance, BP, Shell, Dupont, Indian Oil, Bharat Petroleum, Hindustan Petroleum, Mission Biofuel, ICRISAT etc. Several States have also announced biofuel policies and set up biofuel missions and boards (Department of Biotechnology India, 2007; DBT's Energy Biosciences Strategy for India, 2007).

In order to support the national biofuels effort, the Ministry of Petroleum and Natural Gas announced a policy for national biodiesel purchase, which came into effect in January 2006. This policy allows public sector oil marketing companies (OMCs) to purchase (through select purchase centers in select biofuel producing state) biodiesel that meets the fuel quality standards prescribed by the Bureau of Industrial Standards (BIS), (Ministry of Petroleum and Natural Gas India, 2007). The BIS formulated biodiesel specifications pcd 3(2242)c dated 24 July 2004 and released biodiesel standards as Biodiesel Standards and Specifications, BIS 15607 (Bureau of Indian Standards, 2007). Initially, 5% of bio-diesel would be blended with mineral diesel. The target is to increase the blending of the B100 with diesel at 20% by 2030. In 2003, the Ministry of Petroleum and Natural Gas introduced a mandatory ethanol blended petrol (EBP) program, which envisaged a supply of a 5% ethanol blended petrol in selected bioethanol producing States. The program to blend ethanol with transport fuels is expected to bring better returns to sugarcane farmers, supplement scarce resources of hydrocarbons and bring environmental benefits by reducing pollutants with its properties of helping better combustion (Lok Sabha, Parliament of India, 2007)

Table 14. Seven Studies Conducted by Public Institutes on the Benefits of Bt Cotton in India for the Years 1998 to 2005

Publication	[1]Naik 2001	[2]ICAR field trials 2002	[3]Qaim 2006	[4]Bennet 2006	[5]IIMA 2006	[6]ICAR FLD 2006	[7]Andhra University 2006
Period studied	1998-99 & 00-01	2001	2002-2003	2002 & 2003	2004	2005	2005
Yield increase	38%	60-90%	34%	45-63%	31%	30.9%	46%
Reduction in no. of sprays	4 to 1 (75%)	5-6 to 1 spray (70%)	6.8 to 4.2 (50%)	3 to 1	39%	—	55%
Increased profit	77%	68%	69%	50% or more gross margins	88%	—	110%
Average increase in profit/hectare	$76 to $236/ Hectare	$96 to $210/ hectare	$118/hectare	—	$250/hectare	—	$223/hectare

Source: Compiled by ISAAA, 2007.

1. Naik, G. (2001), "An analysis of socio-economic impact of Bt technology on Indian cotton farmers", Centre for Management in Agriculture, IIMA, India.
2. Indian Council for Agricultural Research (ICAR), 2002, "Report on 2001 IPM trial cost benefit analysis", ICAR, New Delhi, India.
3. Qaim, M. (2006), "Adoption of Bt cotton and impact variability: Insights from India", Review of Agricultural Economics, 28 (2006): 48-58
4. Bennett, R. *et al.,* (2006), "Farm-level economic performance of genetically modified cotton in Maharastra, India", Review of Agricultural Economics, 28 (2006): 59-71 (2006).
5. Gandhi, V. and Namboodiri, N.V. (2006), "The adoption and economics of Bt cotton in India: Preliminary results from a study", IIM Ahmedabad working paper no. 2006-09-04, pp 1-27, Sept 2006.
6. Front line demonstrations on cotton 2005-06, Mini Mission II, Technology Mission on Cotton, Indian Council for Agricultural Research (ICAR), New Delhi, India (2006).
7. Ramgopal, N. (2006), Economics of Bt cotton vis-à-vis Traditional cotton varieties (Study in Andhra Pradesh)", Agro-Economic Research Center, Andhra University, A.P. (2006).

Benefits from Bt cotton in India

The global study of benefits generated by biotech crops conducted by Brookes and Barfoot (2008), estimates that India enhanced farm income from Bt cotton by US$1.3 billion in the period 2002 to 2006 and US$840 million in 2006 alone.

A sample of seven economic studies on the impact of Bt cotton, all conducted by public sector institutes over the period 2001 to 2007 are referenced in Table 14. The studies have consistently confirmed 50 to110% increase in profits from Bt cotton, equivalent to US$76 to US$250 per hectare. These profits have accrued to small and resource-poor cotton farmers in the various cotton growing states of India. The yield increases range usually from 30 to 60% and the reduction in number of insecticide sprays average around 50%. It is noteworthy that the benefits recorded in pre-commercialization field trials are consistent with the actual experience of farmers commercializing Bt cotton in the last five years.

More specifically, the work of Bennett *et al.* (2006) 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 (2007, Personal Communication) estimated that the net economic benefits for Bt cotton farmers in India were US$139 per hectare in 2002, US$324 per hectare in 2003, US$171 per hectare in 2004, and US$260 per hectare in 2005, for a four year average of approximately US$225 per hectare. The benefits at the farmer level translated to a national gain of US$840 million in 2006 and accumulatively US$1.3 billion for the period 2002 to 2006. 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 study by Gandhi and Namboodiri (2006), reports a yield gain of 31%, a significant reduction in the number of pesticide sprays by 39%, and an 88% increase in profit or an increase of US$250 per hectare for the 2004 cotton growing season.

A Front Line Demonstration (FLD) study on cotton for 2005-06 recently released by the Indian Council of Agricultural Research (ICAR, 2006) reconfirms a net 30.9% increase in seed yield of Bt cotton hybrids over non-Bt hybrids and 66.3% increase over open-pollinated cotton varieties (OPV). Data in the study covers 1,200 demonstration and farmers plots in 11 cotton growing states in India. In the demonstration plots, the Bt cotton hybrids proved to be highly productive with an average yield of 2,329 kg/ha of seed cotton compared to the non-Bt cotton hybrids (1,742 kg/ha) and varieties (1,340 kg/ha). Similarly, the average yield of Bt cotton hybrids was higher in farmers' plots at 1,783 kg/ha compared to non-Bt cotton hybrids (1,362 kg/ha) and OPV in farmers' field (1,072kg/ha).

A study in 2005 by University of Andhra (2005) concluded that Bt cotton farmers earned three times more than non-Bt cotton farmers in Guntur district and eight times more in Warangal district of Andhra Pradesh, India. The Government of Andhra Pradesh commissioned the study three years ago to examine the advantages, disadvantages, cost of cultivation and net return to Bt cotton as compared to other cotton varieties in selected districts. The study confirmed that the average Bt farmer had a 46% higher yield and applied 55% less pesticides than the non-Bt cotton farmer in Guntur district. Bt cotton farmers in Warangal district applied 16% less pesticides and reaped 47% more cotton as compared to non-Bt farmers. Farmers noted that Bt cotton allowed earlier picking due to less pest susceptibility, and boll color was superior.

The only published impact studies of Bt cotton in 2006/07 was conducted by IMRB International (IMRB, 2007) which focused on the agronomic and economic benefits and a parallel study conducted by Indycus Analytics (2007) on the social impact of Bt cotton.

The IMRB study sampled 6,000 farmers from 37 districts and interviewed 4,188 farmers growing Bt cotton and 1,793 farmers who grew non-Bt cotton in 9 cotton growing states in India. The IMRB study reported that Bt cotton (versus non-Bt cotton) resulted in a 50% increase in yield, a reduction of 5 insecticide sprays and a 162% increase in profit equivalent to US$475 per hectare. This estimate for the 2006 season is higher than estimates for the previous years (2002 to 2005) and takes into account the higher prices of cotton, the higher value of the Indian Rupee versus the US dollar, and the most recent cost savings associated with Bt cotton in 2006. The IMRB study estimates that the value of Bt cotton at the national level in 2006 was US$1.7 billion.

The IMRB study reports that 90.6% of farmers who planted Bt cotton in 2005 also elected to repeat the planting of Bt cotton in 2006 because they were satisfied with the performance of Bt cotton in 2005. Thus, 9 out of 10 farmers who planted Bt cotton in 2005 also elected to plant Bt cotton in 2006 – this is a very high level of repeat adoption for any technology in agriculture by any industry standard and reflects the trust and confidence that farmers have in Bt cotton. The projected repeat figure for planting of Bt cotton from 2006 to 2007 is 93.1%, even higher than that for 2005/06, and is consistent with the remarkably high adoption rate of Bt cotton by small and resource-poor farmers in India.

The parallel study conducted by Indicus Analytics (2007) on Bt cotton in India in 2006 is the first study to focus on the social impact as opposed to the economic impact. The study involved 9,300 households growing Bt cotton and non-Bt cotton in 465 villages. The study reported that villages growing Bt cotton had more social benefits than villages growing non-Bt cotton. More specifically, compared with non-Bt cotton villages, Bt cotton villages had more access to permanent markets (44% versus 35%), and banking facilities (34% versus 28%). Bt cotton farmers also benefit more from visits from government and private sector extension workers and are more likely to adopt recommended practices such as improved rotation, and change the use of the first generation Bt cotton hybrids for improved 2nd generation Bt cotton hybrids. Notably, there was also a consistent difference between

Bt cotton households and non-Bt cotton households in terms of access and utilization of various services. More specifically compared with non-Bt cotton household, women in Bt cotton households had a higher usage of antenatal check ups, more and higher use of professionals to assist with births at home. Similarly, children from Bt cotton households had a higher proportion which had benefited from vaccination (67% versus 62%) and they were more likely to be enrolled in school. It is noteworthy that the socio-economic advantages enjoyed by Bt cotton households is already evident despite the fact that the first Bt cotton was only adopted in 2002. Thus, the economic benefits associated with Bt cotton is already starting to have a welfare impact that provides a better quality of life for Bt cotton farmers and their families in India.

Given the significant and multiple agronomic, economic and welfare 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 2008. It is projected that the adoption rate will plateau at 80% or more, similar to the USA, which was 93% in 2007. Despite unprecedented high adoption of Bt cotton by almost 4 million farmers, who have first-hand experience over a five year period 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.

Political support for Bt cotton in India

There is strong and growing political support for Bt cotton in India and in turn for other biotech crops. This is due to the remarkable progress that has been achieved in a relatively short period of time, with yields almost doubling in five years and multiple material and welfare benefits evident to farmers, the textile industry, exports, and at the national level. This progress has been recognized by leading politicians and policy makers who have become advocates of biotechnology because of the multiple benefits it offers. A sample of the public statements of leading Indian politicians follows.

Smt. Pratibha Devisingh Patil, President of India

"The success story of the First Green Revolution has run its course. We cannot afford to rest on our laurels. The fruits of the Green Revolution and the momentum generated by it, needs to be sustained. Efforts towards sustainable agriculture can be greatly augmented with the help of space technology and biotechnology advances" (Patil, 2007).

Dr. Manmohan Singh, Prime Minister of India

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 to strike a balance between using the potential of biotechnology to meet the requirements of hungry people while addressing concerns about interfering with nature"*** (Singh, 2006).

Dr. P. Chidambaram, the Minister of Finance

Finance Minister P. Chidambaram has called for emulation of the cotton production success story, through the use of genetically modified Bt cotton, in the area of food crops to make the country self sufficient in its food needs. ***"It is important to apply biotechnology in agriculture. What has been done with Bt cotton must be done with food grains,"*** Chidambaram said at the opening of the seventh edition of Bangalore's annual biotechnology event Bio-2007 on 7-9 June 2007 at Bangalore.

Concerns over the safety of genetically modified products ***"must be faced at an intellectual level by scientists. It cannot be brushed aside by emotion and political arguments,"*** he said. ***While the biotechnology sector is growing in India fuelled by the growth of the bio-pharma and bio-services sectors, the real need is for the growth of agri-biotech"***, Chidambaram said referring to the stagnant production of rice and wheat.

"Bt cotton has made India a cotton exporting country. We thought of ourselves as exporters of wheat and rice, but today we import wheat. No country as large as India can survive on imports for its food needs," the Finance Minister pointed out. ***The production figures for rice and wheat are far below the world average and yield gaps vary dramatically across different states,"*** he said. ***"The success achieved in cotton must be used to make the country self sufficient in rice, wheat, pulse and oil seed production."***

Mr. Sharad Pawar, the Minister of Agriculture and Consumer Affairs

Mr. 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 at 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 (MON531 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"*** (Pawar, 2007a).

Mr. Sharad Pawar, Union Minister of Agriculture and Consumer Affairs, Food and Public Distribution on the occasion of 78th Annual General Meeting of the ICAR Society on 17 May 2007, stated that the ***"Indian Agriculture today is facing several challenges. Recent phenomena of climatic changes***

pose serious threat to production and productivity of crops. There has been decline in the growth of productivity of some crops, which does not augur well for food security, exports, growth, and poverty alleviation. Therefore, there is an urgent need for policies and programs that can invigorate productivity, so as to ensure that the declining share of food grain crop area gets compensated. Fourteen highly innovative projects in strategic research areas have been supported covering bio-technology to mitigate biotic and abiotic stresses in cereals, pulses and oilseeds, increasing feed and energy efficiency of dairy animals, reproductive efficiency of buffalo and small ruminants to saving seeds and agri-produce from spoilage under the National Fund for Basic and Strategic Research in agriculture" (Pawar, 2007b).

Farmer Experience

Experience of a woman cotton farmer from Andhra Pradesh, farming 3 acres:
Mrs. Aakkapalli Ramadevi, is a woman cotton farmer from Thimmampeta Village, Duggondi Mandal of Warangal District, Andhra Pradesh, India. She is a typical small and resource-poor farmer who owns only 3 acres of land (1.3 hectares) in her village. Prior to the introduction of Bt cotton she said that:

"My entire family had to stay in the farm and we had to spend 50 % of the yield on pesticides alone. The yields were very low and used to incur losses, so we were perpetually losing money. Our family suffered a great deal and I had to go for labor work. My children also worked in the farm. We always looked forward to the rice distributed by government public distribution system. To sum it up, we were very badly off and not able to afford anything properly."

"Initially, I used to hate Bt cotton because there were NGOs who protested very loudly against Bt cotton. NGOs were pulling out any trials planted in the farms. Despite the protest, the good effects of the technology were very visible and I noticed it. I decided to experiment with it since I observed that it was able to control pests and reduce spraying considerably. I could also see the benefits being reaped by fellow farmers and the profits that were coming with usage of Bt cotton. I somehow managed to convince my husband and told him that it was worth a try. Due to financial reasons I couldn't get into agriculture but in 2005-06, I got into it with determination and planted Bt cotton in three acres.

First and foremost, our yield increased drastically. We got a profit of Rs.10,000-15,000 per acre. The work in the farm decreased a lot bringing comfort. Because I also work as a daily wage-worker for 10-12 days in a month, I am able to also earn additional Rupees 500-600 per month. Now I am able to send my boy to school and actually spend some additional money on his new education per year. Finally, cotton cultivation has actually turned profitable" (Ramadevi, 2007).

Experience of a farmer and local leader from Haryana:
Mr. Balbir Khichad is a seasoned cotton farmer and the local people representative of a small village Bansudhar located in Sirsa district of Haryana State in India. He is in his late 50's and the head of an extended family (Mukhya of Khichad) comprising 3 principals who own 52 acres of land (17 acres per person). The following is his story of cotton farming which he is proud to narrate with a smiling face.

"I started cotton farming in 1966. Over the years I grew some variety called LS-320 which used to yield a meager 4.5-5 quintal per acre. Later when I changed to LH-900 variety, I got only a marginal increase in yield. However, I had to spray near 12-15 sprays for controlling bollworm (Sundi) and some additional sprays for other insects and pests. The cotton farming was very costly.

In 1990s my family suffered unmanageable losses as boll eating sundi invaded my cotton crop. As a result, my cotton yield reduced to just 1-2 quintal although I sprayed additional pesticides of more than Rs 3,000 per acre. At times there was no cotton left for picking. This type of farming led to huge debts to me and my fellow farmers. We used to approach local money lenders for household needs such as marriage of children, construction of house or to do any other needs. We had to pledge our land to the money lender.

But in the last three years, Bt Cotton has dramatically transformed cotton farming. I planted Bt Cotton in 2005 when the government approved the same in my region. Today I am convinced that cotton farming can be profitable. Because my 15 acres of Bt Cotton farm on an average yielded 8-10 quintals per acre in 2005. Bollworm infestation is well controlled and I needed few sprays to control sucking pests.

Last year I have planted Bt Cotton in 48 acres which yielded 11-12 quintal per acre. Today I earn a net profit of around Rs 10,000 per acre after meeting all expenses. However, my fellow farmers who are yet to adopt the Bt cotton are still running losses. Bt cotton farming has not only improved cotton farming but also changed my life" (Khichad, 2007).

CHINA

Like the USA, 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 5.3 million hectares in 2006 to 5.6 million hectares in 2007. This increase of 5% in total plantings resulted in a parallel increase in area of Bt cotton from 3.5 million hectares in 2006 to 3.8 in 2007, with percentage adoption of Bt cotton increasing to the highest ever at 69% up from 66% in 2006. An estimated 7.1 million

CHINA

Population: 1.314 billion

GDP: US$2,765.4 billion

% employed in agriculture: 49%

Agriculture as % GDP: 12.5%

Agricultural GDP: US$345.67 billion

Arable Land (AL): 138.6 million hectares

Ratio of AL/Population*: 0.5

Major crops:

- Rice, paddy
- Sugarcane
- Sweet potato
- Maize
- Vegetables, fresh
- Cotton

Commercialized Biotech Crops:

- Bt Cotton
- Bt Poplar
- PRSV Papaya
- FC Petunia
- VR Sweet Pepper
- DR, VR Tomato

Total area under biotech crops and (%increase in 2007):
3.8 Million Hectares (+9% in 2007)

Increased farm income for 1997-2006: US$5.8 billion

*Ratio: % global arable land / % global population

small and resource-poor farmers grew Bt cotton in China in 2007, up from 6.8 million in 2006 (an increase of around 5% over 2006, in line with the 5% increase in total cotton plantings in 2007). The size of farms in China is very small; in a recent survey of cotton farms the average size of farm, as determined by the area of cultivable land, was 0.8 hectare and the average size of a cotton holding was 0.6 hectare.

One of the important indicators that reflect farmers' confidence in any new technology, including Bt cotton, is the extent to which farmers repeat the planting of Bt cotton in the following season. In 2006 and 2007, of 240 cotton growing households surveyed in 12 villages in three provinces – Hebei, Henan and Shandong by the Center for Chinese Agricultural Policy of the Chinese Academy of Sciences, it is notable that every single family that reported growing Bt cotton in 2006, also elected to grow Bt cotton in 2007 – thus, the repeat index for farmers growing Bt cotton in 2006 and 2007 in three provinces in China was 100%. Interestingly, of the 240 farmers surveyed, a few farmers in one village also grew one variety of non-Bt cotton in 2006 that they also grew in 2007. This reflects the fact that farmers often want to compare the performance of old and improved technologies side-by-side in their own fields. The same happened during the introduction of hybrid maize in the corn belt in the USA – farmers planted the best performing varieties next to the new hybrids until they were satisfied that hybrids consistently outperformed their old varieties, and it took several years before the full adoption of hybrids.

The level of Bt cotton adoption in China seems to have plateaued at around 66% to 69%. This plateauing may be in part due to the fact 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. In 2007, it is estimated that about 12% of the cotton area in Xing Xang was planted with Bt cotton.

No additional information was available in 2007 regarding 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. Whereas hybrids are expected to become more prevalent in the near-term no additional information is available at this time about Yinmian 2 plantings in 2007 and its performance. It is estimated that these new Bt cotton hybrids, like Yinmian 2, could boost farmer income by US$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 provide slightly higher yields and 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, China's National Biosafety Committee recommended for commercialization a locally developed biotech papaya resistant to papaya ringspot virus (PRSV). This approval and eventual commercialization in China is a significant development in that papaya is a fruit/food crop which is widely consumed throughout the country. The main province for papaya production in China is the province of Guangdong where there is about 5,100 hectares of papaya of which 3,550 hectares, equivalent to 70% adoption, are PRSV resistant.

Bt poplars (*Populus nigra*) have also been approved for commercialization in China. The first Bt poplars were developed and commercialized in 2003 by the Research Institute of Forestry in Beijing which is part of the Chinese Academy of Forestry. It is estimated that approximately 400 hectares of Bt poplars (240,000 trees) are commercialized in China with the first plantations almost ready for harvest. The Bt poplars confer resistance to leaf pests and damage has decreased from over 80% to less than 10%. Work is underway to test other biotech poplars that have modified lignin and are tolerant to stress. A poplar with the Bt886Cry3A is also undergoing testing for resistance to the pest Asian longhorn beetles which attacks the trunks of poplars (Zhu, 2007, Personal Communication).

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 US$24 million at official exchange rates, or US$120 million per year at a purchasing power parity rate of five, 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 2 to 6%, 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 US$80 to US$100. It is projected that with full adoption, the new biotech rice hybrids could result in a national benefit to China of US$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 US$5.8 billion in the period 1997 to 2006 and by US$816 million in 2006 alone. 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 in 2001 to 2003 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 temporarily 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 US$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 Guanhua 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 USA 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 US$47 billion from only US$200 million in 1975, and is expected to reach US$100 billion by 2010 with biotech crop commodities playing an increasingly important role – this compares with trade of US$180 billion between the two neighbors of USA and Latin America. During President Hu's 2004 visit to Latin America he pledged to invest US$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 Monetary 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, Argentina and Brazil, 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.

It is noteworthy that the African Development Bank had its 2007 Annual Board meeting in Shanghai, China (Miami Herald, 2007). Jeffrey Sachs, who attended the meetings commented that the advice Chinese leaders offered their counterparts was more pragmatic than what they would typically get from the World Bank, that had instituted widespread structural adjustment loans which had led to decreased public investments, including in agriculture, which in turn had impoverished subsistence farmers who account for a majority of the world's poor. The result has been a disaster in Africa where agricultural productivity has been stagnant for decades. More pragmatically the Chinese, drew on their own practical experience in the 1970s and stressed the critical role of public investments in agriculture and infrastructure which led the way to economic growth in China, and in turn paved the way for private sector involvement. The Chinese also stressed the need for investments in electricity and in roads to deliver agricultural inputs for farmers and for transporting farm produce to the urban areas. It is important to note that the Chinese offered to help in agricultural research where they have the largest public sector investments of any country in the world in crop biotechnology. In poor countries an increase in farm productivity is an essential precursor for broad-based sustainable growth at the national level. Africa can gain from the practical experience of China with agricultural research, including crop biotechnology.

Benefits from Biotech Crops in China

Bt cotton - In 2007, Bt cotton was planted by 7.1 million small and resource-poor farmers on 3.8 million hectares, which is 69% of the 5.5 million hectares of all cotton planted in China. Based on studies conducted by the Center for Chinese Agricultural Policy (CCAP), it was concluded that, on average, at the farm level Bt cotton increases yield by 9.6%, reduces insecticide use by 60%, with positive implications for both the environment and the farmers' health and generates a substantial US$220 per hectare increase in income which makes a significant contribution to their living as income of many cotton farmers at less than US$1 per day. At the national level, it is estimated that increased income from Bt cotton is approximately US$800 million per year, projected to increase to US$1 billion per year by 2010.

Biotech rice – The biotech rice is resistant to specific pests (insect borers) or diseases (bacterial blight). The product is waiting approval after extensive field tests where on average, based on CCAP's study, it increased yield by 2 to 6%, reduced insecticide application by nearly 80% or 17 kg per hectare. At a national level, it is projected that biotech rice could deliver benefits of the order of US$4 billion per year in the future, plus environmental benefits that will contribute to a more sustainable agriculture and the alleviation of poverty for small and resource-poor farmers.

Farmer Experience

Niu Qingjun is a typical Chinese cotton farmer in Shandong province in China, one of the largest cotton growing provinces in the country. Niu is 42 years old, is married with two children and 80% of the family income comes from cotton, which represents the livelihood of the whole family. Niu has been growing Bt cotton since 1998. The total size of his farm is 0.61 hectare and cotton is the only crop that he grows on his farm in 2007. Niu's experience with Bt cotton is captured in the following comments. ***"We could not even plant cotton if there is not insect-resistance cotton (Bt cotton). We could not control bollworm infestation before planting insect-resistance cotton, even if spraying 40 times insecticide in 1997."*** Niu harvested 2,680 kg of seed cotton in 2007; given that the price of seed cotton is 6.8 RMB/kg, he would approximately make a profit of 14,000 RMB or US$1,886 (not including labor inputs). Niu only sprayed insecticide 12 times in 2007, approximately half of the number of sprays he used on conventional cotton prior to the introduction of Bt cotton (Qingjun, 2007).

China is estimated to have enhanced farm income from biotech cotton by US$5.8 billion in the period 1996 to 2006 and the benefits for 2006 alone are estimated at US$816 million.

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 2007, Paraguay is expected to increase its biotech soybean area by another 13% to 2.6 million hectares from 2.0 million hectares in 2006, a 40% increase. The

PARAGUAY

Population: 6.5 million

GDP: US$7.281 billion

% employed in agriculture: 45%

Agriculture as % GDP: 22.4%

Agricultural GDP: US$1.63 billion

Arable Land (AL): 3.0 million hectares

Ratio of AL/Population*: 2.0

Major crops:
- Cassava
- Soybean
- Sugarcane
- Maize
- Wheat

Commercialized Biotech Crop: HT Soybean

Total area under biotech crops and (% increase in 2007):
2.6 Million Hectares (+30% in 2007)

Farm income gain from biotech, 2004-2006: US$349 million

*Ratio: % global arable land / % global population percentage adoption of RR® soybean is approximately the same as last year at 94% of the total soybean plantings of 2.8 million hectares of the national soybean crop. 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, South Africa, Mexico, and Chile.

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 2007 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.

Benefits from Biotech Crop in Paraguay

Paraguay is estimated to have enhanced farm income from biotech soybean by US$349 million in the period 2004 to 2006 and the benefits for 2006 alone is estimated at US$82 million.

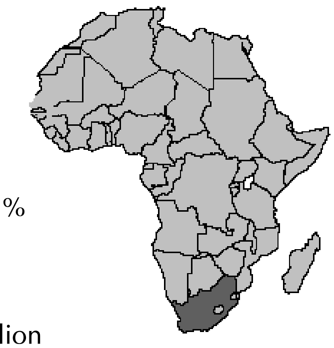
SOUTH AFRICA

The South African GMO Act (Act 15/1995) was amended in 2006 and promulgated in 2007. There were two important amendments relative to biotech/GM crops. Firstly, a change in the composition of the statutory decision-making body, the GMO Executive Council, increased from six representative government departments to eight, with Water Affairs and Forestry and Arts and Culture as the two new members. Secondly, the amended Act specifies that the 10-person scientific Advisory Committee must include one person with expertise in human health and pharmaceuticals, and one person with ecological expertise. Other amendments covered improved definitions and insertions to comply with the Cartagena Biosafety Protocol.

New approvals for commercial planting of biotech crops in 2007 included stacked insect resistance and herbicide tolerance traits in maize; and herbicide tolerance (RR® Flex) in cotton. Approvals were also granted for field trials for stacked insect resistance and RR® Flex traits in cotton; and maize with a drought tolerance trait. Import approvals were granted for contained testing of biotech cassava with enhanced starch. Research is continuing with: tuber moth resistant Bt potatoes and virus resistant potatoes in field trials; high-proline, drought tolerant soybeans and groundnuts; maize containing genes for drought tolerance; and maize with resistance to streak virus.

South Africa has maintained its number eight or higher position in the world ranking for the first eleven years of commercialization of biotech crops, 1996-2006. In 2007, South Africa has a total biotech crop hectarage of 1.8 million hectares, almost a 30% increase over the 1.4 million hectares in 2006. The major increase was in biotech maize. Total plantings of maize in South Africa in 2007 are expected to increase by approximately 100,000 hectares from 2.7 million hectares in 2006 to 2.8 million hectares in 2007, a marginal increase of 4%. The marginally higher hectarage of national maize plantings in 2007 resulted in parallel higher hectarage of both white and yellow biotech maize. In 2007, of the estimated 2.8 million hectares of white and yellow maize, 1.6 million hectares was biotech maize, equivalent to 57% of the total maize area, up from 44% in 2006 (Table 15). Thus, the adoption rate for all biotech maize in 2007 was almost 30% higher at 57% compared with only 44% in 2006. Of the total 1.6 million hectares of biotech maize 72% equivalent to 1.15 million hectares was Bt, 23% or 373,000 hectares herbicide tolerant and 3% or 80,000 hectares had stacked traits for Bt and herbicide tolerance.

SOUTH AFRICA



Population: 47.4 million

GDP: US$255.4 billion

% employed in agriculture: 11%

Agriculture as % GDP: 2.5%

Agricultural GDP: US$6.4 billion

Arable Land (AL): 14.7 million hectares

Ratio of AL/Population*: 1.4

Major crops:
- Sugarcane
- Maize
- Wheat
- Grapes
- Potato

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

Total area under biotech crops and (% increase in 2007):
1.8 Million Hectares (+29% in 2007)

Farm income gain from biotech, 1998-2006: US$156 million

*Ratio: % global arable land / % global population

White maize was expected to comprise 60% or 1.7 million hectares of the total maize area of 2.8 million hectares in 2007. Of the 1.7 million hectares of white maize, 62% was biotech made up of 760,000 hectares of Bt maize and 220,000 hectares of herbicide tolerant maize, and 60,000 hectares with stacked traits of Bt and herbicide tolerance. Yellow maize was expected to comprise 40% or 1.1 million hectares of the total maize area of 2.8 million hectares. Of the 1.1 million hectares of yellow maize 52% was biotech maize made up of 394,000 hectares Bt maize, 153,000 hectares of herbicide tolerant maize, and 20,000 hectares of the stacked traits of Bt and herbicide tolerance.

In 2007, total plantings of soybean, at 180,000 hectares were down slightly from the 2006 plantings at 214,000 with the more profitable maize substituting for soybean. It is estimated that the area under herbicide tolerant soybean in 2007 was 144,000 hectares, equivalent to 80% adoption, compared with about 75% last year. Total cotton plantings in 2007 were estimated at 10,000 hectares, down from 22,000 hectares last year, of which 9,000 hectares or 90% were biotech cotton. Of the 9,000

Table 15. Adoption of Biotech Crops in South Africa, 2001 to 2007 (Thousand 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 %)
2007	1,800	1,607	1,040 (62%)
Total	**5,269**	**4,448**	**2,382**

Source: ISAAA, 2007.

hectares of biotech cotton, 8,000 hectares (90% of biotech cotton hectares) had stacked traits for both Bt and herbicide tolerance, 500 hectares (5% of biotech cotton hectares) were the single Bt and 500 hectares (5% of biotech cotton hectares) were herbicide tolerant, used mostly as refugia in Bt fields. Currently, South Africa grows biotech maize and cotton with stacked traits for herbicide tolerant and Bt for insect resistance. The approval of the stacked traits in maize and cotton is an important policy decision that will allow South Africa to retain its leadership role in biotech crops.

The progressive and steady increase in adoption of biotech crops in South Africa is captured in Table 15 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 1.8 million hectares in 2007. 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 1.6 million hectares in 2007, (89% 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 1.040 million hectares in 2007 equivalent to 62% of the total white maize area of 1.61 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.

Benefits from Biotech Crops in South Africa

South Africa is estimated to have enhanced farm income from biotech maize, soybean and cotton by US$156 million in the period 1998 to 2006, with benefits for 2006 alone estimated at US$67 million (Brookes and Barfoot, 2008).

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 US$35/ha for dry land farmers and US$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 US$120 million, based on a 10 million metric tons (MT) harvest.

A more recent study published in 2005 (Gouse *et al.,* 2005) involved 368 small and resource-poor farmers and 33 commercial farmers, the latter divided into irrigated and dry-land maize production systems. The data indicated that under irrigated conditions Bt maize resulted in an 11% higher yield (from 10.9 MT to 12.1 MT /ha), a cost savings in insecticides of US$18/ha equivalent to a 60% cost reduction, and an increase income of US$117/hectare. Under rain-fed conditions Bt maize resulted in an 11% higher yield (from 3.1 to 3.4 MT/ha), a cost saving on insecticides of US$7/ha equivalent to a 60% cost reduction, and an increased income of US$35/hectare.

For small and resource-poor farmers the benefits were measured using a different set of comparisons using only yield per hectare data. Bt maize hybrids yielded 31% more than the corresponding conventional hybrids, and 134% more than the conventional open-pollinated varieties planted by some small farmers. Conventional non-Bt hybrids also used by some small farmers yielded only 79% more, compared with 134% more for Bt hybrids.

Selected Farmer Experiences with Biotech Crops in South Africa

Chief Advocate Mdutshane, a highly respected chief of Ixopo, whose native language is Xhosa, from the Eastern Cape of South Africa says that 120 emergent poor farmers in his area increased their yields from conventional maize by up to 133% with Bt maize. Yields increased from 1.5 tons per hectare to 3.5 tons per hectare by eliminating the stalk borer which damaged up to 60% of their crops. They call the Bt maize, ***iyasihluthisa***, Xhosa for ***"It fills our stomachs."*** For the first time ever they produced enough food to feed themselves (Mdutshane, 2005).

Richard Sitole, chairperson, Hlabisa District Farmers' Union, KZN, says 250 emergent subsistence farmers of his Union planted Bt maize on their smallholdings, averaging 2.5 hectares, for the first time in 2002. His own yield increased by 25% from 80 bags for conventional maize to 100 bags, earning him an additional income of Rand 2,000 (US$300) – US$1.00 is equal to 6.7 Rand as of November 2007. Some of the farmers increased their yields up to 40%. He pointed out that taking 20 farmers, and there were many more, earning an extra income of R2,000 (US$300) totaled R40,000 (US$6,000) additional disposable income in their small community, boosting small shopkeepers, dressmakers and vegetable producers. ***"I challenge those who oppose GM crops for emergent farmers to stand up and deny my fellow farmers and me the benefit of earning this extra income and more than sufficient food for our families,"*** says Sitole (2004).

Molasi Musi, small scale farmer from Soweto, near Johannesburg farms on 21 hectares where for years he has been battling to make a viable living. Stalkborers took 40% of his harvest. Three years ago he planted Bt maize. With non-Bt maize his yield averaged 7.7t/ha. With Bt maize his average over the past three years has nearly been 9t/ha. With the surplus profit he made last year, he bought himself a secondhand tractor driven mill for his own and that of his fellow farmers' maize harvest earning himself extra income. He donated six bags of his surplus maize meal to an old age home and a hospice in Soweto (Musi, 2007).

Philiswe Mdletshe, cotton farmer on the Makhathini Flats, KwaZulu-Natal province, increased her yield with Bt cotton from three bales per hectare to eight bales per hectare, earning her a net income of R38,400 (US$5,730). She reduced insecticide sprayings from ten times a season with non-Bt cotton to twice with Bt and saved 1,000 litres of water. She has continued planting Bt cotton for five successive years (Mdletshe, 2004).

Thousands of emergent resource-poor farmers are planting Bt cotton year after year on the Makhathini Flats. A scientific study conducted by the University of Reading in the UK and the University of Pretoria concluded that Bt cotton yields were 40% more than conventional cotton. Farmers paid 42% less in spraying costs (Morse *et al.*, 2004).

Trials done by the Agricultural Research Council on the Makhathini Flats over a five-year period noted an average increase yield gain of 349 kg per hectare with Bt cotton. At R3 per kg (US$0.45), this meant an extra profit of R1,047 (US$156) per hectare planted (Sunday Independent Business Report, 2005).

Velapi Mlambo, small-scale cotton farmer on the Makhathini Flats, South Africa has been planting Bt cotton for three years on his 5 ha farm. His yield during one of the worst droughts in many years was 800 kg/ha compared to 600 kg with conventional cotton – an increase of 25%. He sprayed three times for insects compared to15 times with conventional cotton (Mlambo, 2007).

URUGUAY

Uruguay, which introduced biotech soybean in 2000, increased its biotech crop area once again in 2007 to reach approximately 575,000 hectares, up from 420,000 hectares in 2006, with the gain coming from both biotech soybean and maize. A modest increase was recorded in the hectarage of herbicide tolerant soybean which now occupies 100% of the 470,000 hectares (compared with 370,000 hectares in 2006) of the national soybean hectarage. The adoption of Bt maize, which Uruguay first approved in 2003, continued to grow to 75,000 hectares, up from 50,000 hectares in 2006, and occupied almost half of the total maize plantings of 170,000 hectares in Uruguay in 2007.

URUGUAY

Population: 3.4 million

GDP: US$13.24 billion

% employed in agriculture: 13%

Agriculture as % GDP: 9.3%

Agricultural GDP: US$1.23 billion

Arable Land (AL): 1.34 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 2007):
0.6 Million Hectares (+25% in 2006)

Farm income gain from biotech, 2000 to 2006: US$29 million

*Ratio: % global arable land / % global population

Benefits from Biotech Crops in Uruguay

Uruguay is estimated to have enhanced farm income from biotech soybean and maize by US$29 million in the period 2000 to 2006 and the benefits for 2006 alone is estimated at US$9 million (Brookes and Barfoot, 2008).

PHILIPPINES

The adoption of biotech maize in the Philippines has increased consistently every year since it was first commercialized in 2002. The area planted to biotech maize is projected to significantly increase in the wet and dry seasons in 2007 to reach approximately 250,000 hectares, up from 200,000 hectares in 2006. Notably, herbicide tolerant (HT) maize is now planted on 110,000 hectares, an area that is almost double that of last year, and larger than that of Bt maize (75,000 hectares). The area planted to stacked-trait maize (63,000 hectares) which was first grown in 2006 has sharply increased and is now approaching an area comparable to that with Bt maize.

The number of small farmers, growing on average 2 hectares of biotech maize, is estimated at 125,000. A total of four events of biotech maize are approved for commercial planting in the Philippines: MON810 for insect resistance (2002), NK603 for herbicide tolerance (2005), Bt11 for insect resistance (2005) and the stacked gene product of MON810/NK603 (2005). In addition a number of stacked trait maize and cotton products have been approved in 2007 for import, including the triple stacked maize with DAS59122/TC1507/NK603. 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 that are being developed by the Philippine Rice Research Institute (PhilRice). Pest resistant eggplant and biotech papaya with delayed ripening and virus resistance are being developed by the Institute of Plant Breeding at the University of the Philippines Los Baños (IPB-UPLB). New initiatives in other crops include the development of a virus resistant sweet potato through collaborative activities between the Visayas State University (VSU) and IPB-UPLB.

PHILIPPINES

Population: 89.5 million

GDP: US$117.6 billion

% employed in agriculture: 36%

Agriculture as % GDP: 14.1%

Agricultural GDP: US$16.58 billion

Arable Land (AL): 5.66 million hectares

Ratio of AL/Population*: 0.3

Major crops:

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

Commercialized Biotech Crop: Bt/HT/Bt-HT Maize

Total area under biotech crops and (% increase in 2007):
0.3 Million Hectares (+50% in 2007)

Increased farm income for 2003-2006: US$29 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 2.6 million hectares of maize is the only country in Asia to grow a major biotech feed crop, Bt maize, and moreover the Philippines achieved a biotech mega-country status with biotech maize, i.e. 50,000 hectares or more. Asia grows 32% of the global 148 million hectares of maize with China itself growing 26 million hectares, plus significant production in India (7.5 million hectares), Indonesia (3.5 million hectares), Philippines (2.6 million hectares), and Vietnam, Pakistan and Thailand (each with about 1 million hectares).

Benefits from Biotech Crops in the Philippines

Biotech maize has provided a myriad of positive contributions to the health of Filipino maize farmers, their livelihood and the environment. Farms planted with Bt maize in the Northern Philippine provinces were observed to have significantly higher populations of beneficial insects such as flower bugs, beetles, and spiders than those planted with conventional hybrid maize (Javier *et al.*, 2004).

The increase in value of farm income for farmers planting biotech maize in the Philippines in the period 2003 to 2005 is estimated at US$29 million and for 2006 alone is estimated at US$18 million (Brookes and Barfoot, 2008). Another study (Yorobe, 2006) analyzed data from 407 maize farmers in four provinces in the country during the 2003-2004 seasons. The results indicated that a significantly higher income was derived by those planting Bt maize compared with conventional maize. The gain in profit at the farmer level was computed at 10,132 pesos (about US$181) per hectare for farmers planting Bt maize with a corresponding savings of 168 pesos (about US$3) per hectare in insecticide costs. In another socio-economic impact study (Gonzales, 2005) it was reported that the additional farm income from Bt maize was 7,482 pesos (about US$134) per hectare during the dry season and 7,080 pesos (about US$126) per hectare during the wet season of the 2003-2004 crop year. Using data from the 2004-2005 crop year, it was determined that Bt maize could provide an overall income advantage that ranged from 5 to 14% during the wet season and 20 to 48% during the dry season (Gonzales, 2007). Overall, these four studies which looked at net farm income as well as other indicators, confirmed the positive impact of Bt maize on small farmers and maize producers in the Philippines.

Farmer Experience

The Biotechnology Coalition of the Philippines

The Philippines ranks number 10 in the world in area of biotech crops and is the only country in Asia to have approved and adopted a major biotech feed crop – biotech maize. The Biotechnology Coalition of the Philippines, recently prepared a brief summarizing the adoption and impact of biotech maize in the Philippines, since its introduction in 2002. The Brief documented three case studies and articulated policies that would allow the Philippines to benefit from current and future biotech crop applications. The coalition has concluded ***"that the socio-economic benefits of biotech maize, as supported by pre and post commercial studies cannot be under-estimated."*** The three case studies involved: Lydia Lapastora, a typical small farmer; Engineer Roger Navarro, the current director of the Philippine Maize Federation; lead farmers Danilo Ea, Marcelino Jucutan and Edwin Paraluman who have pioneered farmer interest in biotech crops in the Philippines .

Lydia Lapastora, is the recipient of the Gawad Saka award – an annual award given by the Department of Agriculture to the most productive farmers in the Philippines. Like all small farmers, she steadfastly tills the land daily to reap a small but a life-sustaining and vital harvest. She started with one half hectare of land and as a result of good management and biotech maize she now farms 7 hectares with five hectares planted to maize.

Engineer Roger Navarro, and his wife Jasmine have traveled within and outside the Philippines, to witness and learn more about the new technologies in farming, including biotech crops .The family owns approximately 50 hectares of farm land and about 80% of this is planted with maize.

Danilo Ea, **Marcelino Jucutan** and **Edwin Paraluman** are President and former Presidents respectively, of a Farmer Association with 73 members and are themselves lead farmers in sharing knowledge and experience with their fellow farmers about biotech maize. Both Marcelino and Edwin were actively involved with the first Bt maize field trials in 2000 and defended the trial sites against anti-biotechnology groups. Of the 178 hectares of land farmed by 73 small farmer members (average of 2.5 hectares per member) in the Association, approximately 60 hectares are planted to maize.

The Coalition concluded that ***"All of them share the same passion: a passion for searching a better, if not the best, alternative way to success. And they found it in biotech crops, starting with Bt maize for the control of the destructive Asian com borer. Notorious to maize growers as the ultimate pest of all pests, this insect can wipe out fields and fields of maize crops, bring down livelihood, destroy dreams, cause sleepless nights and drown hope into pools of despair. Upon adopting the Bt technology, these farmers are more than satisfied. Bt maize increased yield up to 60% and brought about a surge in profit as high as 86%. With the extra income, Edwin was able to buy a car, Marcelino sent all three of his children to college and Danilo saved up for expansion of land. As scientists come up with more developments in plant biotechnology such as herbicide tolerant (HT) maize these farmers cannot help but rave about the wave of benefits flooding in. Roger speaks of stress-free farming, enabling him more time for his family while performing his various roles in different organizations. Now, the Bt and HT technologies are merged into one, creating, once again, a product farmers can use to their advantage. As Lydia said, with this new variety, farmers are rid of the two major headaches of growing maize.***

Biotechnology provides these farmers with the tools that have helped maximize their harvest. But economic gain is not the only reason why they feel better: being able to avoid insecticide spraying to control borers has greatly improved their health. And it's not only the farmers who are getting healthier; even beneficial insects now thrive in Bt or HT maize farms. Lydia, Roger and the three generations of farmer leaders are all witnesses to these economic and environmental wonders brought about by using biotechnology. Three different stories, the same outcome: Biotechnology can help shape the future of a family, a community and a country. These farmers can't imagine life without biotechnology."

The President and CEO of the Biotechnology Coalition, Dr. Nina Gloriani-Barzaga, MD, PhD is consolidating the rich experience of the Philippines with biotech maize with a view to sharing with society, knowledge about the economic, environmental and social benefits of adopting agricultural biotechnology in the Philippines (Ramon and Malabed, 2007).

Commenting on his experience with growing Bt maize in the Philippines Fernando Lopez, a small Bt maize farmer from the Philippines says, ***"I'm pleased with the results I've seen, including increased production and greater profit. I also have eliminated problems from corn borer damage. I am very happy with the early results including higher production and a greater profit"*** (Lopez, 2006).

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 50,000 hectares of cotton in 2007 (one-quarter of the area in 2006) because of the continuing severe droughts, the worst that Australia has experienced. As a result, irrigators have been allocated limited volumes of water for cotton production and dry-land growers will be completely dependent on late rains for planting. Assuming 50,000 hectares of cotton in 2007, the overall percentage adoption of biotech cotton in 2007 is expected to be 95%, slightly higher than 2006. It is projected that in 2007, about 80% 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 RR Flex®; 12% with the dual Bt gene on its own, compared with 17% in 2006; 3% with a single gene for herbicide tolerance including some of the newly introduced RR® Flex cotton, and the remaining 5% in conventional cotton, compared with 8% in 2006.

AUSTRALIA

Population: 20.3 million

GDP: US$755.3 billion

% employed in agriculture: 3.6%

Agriculture as % GDP: 3.8%

Agricultural GDP: US$28.7 billion

Arable Land (AL): 46.85 million hectares

Ratio of AL/Population*: 10.1

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

Commercialized Biotech Crop:
- Bt/Bt-HT Cotton
- FC Carnation
- HT/F/HT-F Canola

Total area under biotech crops and (increase in 2006):
0.1 Million Hectares (-50% in 2006)

Farm income gain from biotech, 1996-2006: US$184 million

*Ratio: % global arable land / % global population

The Australian biotech cotton program is extremely well managed and it is to the credit of Australia that it achieved complete substitution of the single Bt gene product (Bollgard® I) with the dual Bt gene varieties (Bollgard® II) in only two years 2002/03. This greatly accelerated and enhanced the stability of Bt resistance management, and simultaneously benefited 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.

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.

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 USA-Australian Free Trade Agreement, signed in 2004. This trade agreement opens markets for Australian exports to the USA for manufactured products and services of US$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.

In Australia, where biotech cotton has been very successfully grown for 10 years there has been growing support from the Federal Government and farmer organizations in 2007 to lift the state-level moratoria on commercialization of biotech canola. A 2007 Australian Bureau of Agricultural and Resources Economics (ABARE) Report on the impact of commercializing biotech canola on organic producers in Australia concluded that there would be little or no effect, whereas the organic industry has continued to oppose the commercialization of biotech canola in the absence of data to support their case. Australian farm organizations, including the apex body, the National Farmers

Federation, support the abolition of the biotech canola moratoria based on the following reasoning: Canada, the major producer of biotech canola, has consistently increased its world exports of biotech canola and increased its yield by over 15% over the last ten years, whereas in contrast the area and yield of conventional canola in Australia has decreased. A reality check confirms that conventional canola is not a preferred product over biotech canola in world export markets contrary to the views of those in Australia opposed to biotech canola – there is no price premium in the export market for conventional canola. The ability to dry sow biotech canola and apply less herbicide over-the-top confers a significant yield advantage due to a longer growing season and improved conservation of moisture – the latter can be a critical factor in Australia which is prone to severe droughts.

The former Australian Minister of Agriculture **Peter McGauran** has favored the lifting of the State bans on biotech canola and stated ***"that research is underway into the development of GM oil seed crops that produce healthier oils with better ratios of unsaturated fats, high levels of omega-3 oils which is normally sourced from fish, and increased levels of essential amino acids and vitamins. GM oils have the potential to cut production costs, increase product value and diversify the range of goods produced by the oilseed industry. With acceptance of such GM oil seed varieties, Australia would successfully compete with GM canola and soybean varieties currently produced overseas."*** A survey commissioned by Biotechnology Australia in 2007 indicated that biotechnology is gaining public favor with support for biotech crops increasing from 46% in 2005 to 73% in 2007. The latest information on the lifting of the state bans for biotech canola in Australia, before this Review went to press, is provided in the next section.

Benefits from Biotech Crops in Australia

Australia is estimated to have enhanced farm income from biotech cotton by US$184 million in the period 1996 to 2006 and the benefits for 2006 alone is estimated at US$23 million (Brookes and Barfoot 2007). The results of a federal study released in September 2005 by the Australian Bureau of Agricultural and Resource Economics (ABARE), Apted *et al.* (2005) is consistent with the views of some farmers, and estimates that a ban on biotech canola in Australia over the next 10 years could cost Australian farmers US$3 billion.

In a drought stricken Australia, farmers like **Angus McLaren**, a father of three, who farms wheat and canola is excited about genetic engineering and describes it as ***"the future of Australian agriculture."*** He points out that ***"GM crops are able to adapt to the land and the environment whereas in the last 200 years we have been trying to change the environment to suit our crops."*** He is convinced that ***"there are unlimited possibilities and GM crops use a lot less chemicals".*** McLaren and his colleagues have founded a farmers group "Producers Forum" to increase the awareness of the supportive views of farmers for GM crops in Australia and the critical role that

GM crops can play in ensuring that Australian crop production is competitive in world markets with important export crops like canola and wheat (McLaren, 2007).

Biotech canola in Australia

Biotech canola offers Australia the opportunity of again competing in growing world canola markets responding to increased biofuel needs, and to expand biotech canola production in Australia through the establishment of employment-generating regional canola crushing plants, producing improved meal for the dairy industry (to partially substitute for imports of biotech soybean) and utilizing processed canola oil for the growing domestic biodiesel market. In summary, biotech canola offers Australia a way to increase yield in a sustainable way requiring less herbicides and generating higher profits for farmers and a more affordable product for consumers who are not prepared to pay a premium for conventional canola. In the past 10 years, Canada has successfully produced and marketed the equivalent of 50 years of conventional canola in Australia which has missed out on significant domestic and export opportunities with biotech canola (AgBioview, 2007). The guidance for Australia, which operates the best managed biotech cotton program in the world, is to take the experience with biotech cotton, apply it to correct the mistakes of late commercialization of biotech canola and apply the learnings from both crops to prepare in advance for the successful, and timely introduction of biotech wheat, which is judged to be inevitable – wheat is Australia's most important crop and significant export.

In late November 2007, two Australian state governments, New South Wales (NSW) and Victoria, lifted state bans on the commercialization of biotech herbicide tolerant canola that has been in place for four years, subsequent to approval by the federal gene regulator in 2003. NSW and Victoria are lead states in Australia for canola and produce about half of national production. Lifting the ban will allow farmers in NSW and Victoria to plant biotech canola in April 2008 in Australia. For the first time, Australia will compete on a level playing field with Canada which has been benefiting from biotech canola for the last ten years. Canada is the largest producer and exporter of canola in the world. Australia's largest farmer group, the NSW Farmers Association said the decision was a victory for the future prosperity of agriculture and that a five year trial had confirmed that biotech canola delivered superior weed control, higher yield, improved oil quality and higher profit. The following paragraphs are a useful summary of the facts about biotech canola in Australia and are reproduced with the permission of Paula Fitzgerald, Executive Director, Agrifood Awareness Australia Limited (Fitzgerald, 2007).

AUSTRALIA READY FOR GM CANOLA - LET THE EVIDENCE SPEAK

In 2003-04, a number of canola growing states in Australia introduced moratoria preventing the commercial cultivation of approved GM canola varieties based on supposed marketing and trading uncertainties.

Between 2003 and 2007, the grains industry scoped and addressed these matters, to the extent that it is now ready to incorporate GM canola into the grain supply chain, alongside the many other grades and classifications of cereals, course grains, oilseeds and pulses, upon cessation of the moratoria.

During 2007, moratoria reviews have been conducted in Victoria, South Australia and New South Wales, in addition to Tasmania where a review is still underway. Outcomes from the reviews in Victoria, South Australia and New South Wales are due in the near future.

Considerable data has been collected regarding the marketing and trading considerations for GM canola and Australian agriculture has declared that the moratoria should be lifted while continuing to provide choice to stakeholders right along the grain supply chain – from seed producers to consumers.

The following provides a summary of the evidence, capacity and commitment of the grains industry and highlights why it is time for Australia to catch up with the world.

Fact: GM Canola – A Global Commodity

Genetically modified canola is grown traded and consumed around the world. Approximately 87% of the canola crop in Canada, the world's biggest canola producer, is planted to GM varieties. This canola is marketed around the world including Japan which is often portrayed as a 'non-GM' country. Japan also buys Australian canola and while a very small amount of Australian canola is segregated and sold as non-GM, most is co-mingled with Canada's GM canola.

Canada does not regularly market canola to Europe however it should be noted that (1) Europe is largely self-sufficient and has only been an occasional market, and (2) Europe's biofuel policy will see an increase in demand from Europe for canola which Canada will capitalise on.

GM crops are now being grown in EU countries – for example, GM corn in Spain.

Fact: Australia – GM Crop Experience

Australia has grown GM cotton since 1996 with more than 90% of Australia's cotton crop now consisting of GM varieties. Since the commercial introduction of GM cotton Australia has experienced no negative market or trade implications in relation to the fibre, cottonseed oil or cottonseed meal produced from GM cotton.

Australia has imported GM soybean meal and oil for many years to meet human and animal feed requirements. Due to the ongoing drought, Australian food producers and processors imported more than 50,000 tonnes of GM canola from Canada to overcome local domestic shortages. These imports have been managed through the domestic supply chain and delivered to meet customer specifications.

Fact: Australian Food Producers – Innovation Drivers

Australia's farmers are rapid adopters of new technology, and through their investment in research and development, drive innovation. Since 1996 farm representative bodies, namely national and state farm associations and commodity councils have debated the GM topic and now have a common policy position, agreeing that GM canola should proceed to commercialization and that the moratoria should be lifted. (http://www.afaa.com.au/n_industry_policies_landing.asp)

If the moratoria are not lifted, Australian farmers will be left behind by their counterparts in the USA, Canada, South Africa and South America, China and India – countries where the adoption of GM varieties is both rapid and extensive. In a recent study, ABARE found that "a continuation of the current moratoriums and extension to other GM crops is expected to result in a loss of gross national product of US$3 billion, over the next ten years."

Fact: Clear Benefits from Long Term Study

Canadian canola growers have reported considerable benefits from growing GM canola. A study conducted by the Canola Council of Canada reported that growers chose to grow GM varieties for easier and better weed control, better yields, higher returns and more profit, to reduce costs and to clean up fields.

In Australia, recently published work by Charles Sturt University researchers showed that a GM canola variety consistently delivered superior weed control, higher yields and oil quality and better profits when compared to current varieties in a traditional five year crop rotation system. (http://news.csu.edu.au/director/latestnews.cfm?itemID=363C755F0F03ED5034B67FEC742E1469&printtemplate=release)

A recently released review conducted by the University of Melbourne stated that if half the current canola types grown were replaced with GM canola the impact in Australia would be:

- Around 640 tonnes less triazine herbicide would be used each year.
- An extra 225,000 hectares of canola would be grown each year by direct drilling or minimum tilling.
- Average national canola yields would increase by eight percent - from 1.2 tonnes to 1.3 tonnes per hectare.
- An additional 200,000 tonnes of canola would be grown in low rainfall regions.
- Wheat production, in rotation, would increase by 80,000 tonnes on the additional canola areas. (http://www.jcci.unimelb.edu.au/Canola2007.pdf)

Fact: Choice – Meeting Customer Demands

In August 2007 the Australian grain industry launched a statement entitled "Delivering Market Choice with GM canola." This statement, endorsed by 29 key grain supply chain organisations, recognised:

- the integrity, capacity, and demonstrated ability of the Australian grain supply chain;
- that choice for all supply chain participants is key; and

- that there is a commitment to deliver choice along the supply chain.

This document was underpinned by a 102-page document entitled "Principles for process management of grain within the Australian supply chain" which detailed the principles and processes being utilised or able to be implemented within the Australian grain industry if the moratoria are lifted.

Over recent weeks two food processors have emerged in the media stating their desire for non-GM canola and in doing so, have asked their respective state governments to maintain the moratoria on GM canola. While the moratoria may meet the current commercial interests of these food suppliers, it denies the many other supply chain participants the opportunity to explore the benefits of GM canola. Choice must remain the underlying principle in this decision-making process to ensure that all supply chain participants have equal opportunity to access the products which provide benefits to their business.

Fact: Let the Evidence Speak
Choice, supported by excellent science is the key.

The GM canola types in question were approved by Australia's Federal Regulator in 2003 as safe for human health and the environment. In approving the varieties, the Regulator noted that their safety was comparable to the conventional varieties which Australia produces. These varieties have been grown, traded and consumed for over a decade around the world without concern.

To date, Australian farmers have been denied access to GM canola due to market or trade uncertainties, however, this matter has now been fully explored and addressed by the grain supply chain.

The evidence is clear – the Australian grains industry has recognised that choice is key and is committed to continue delivering it. Australian agriculture has further endorsed the positive potential of gene technology and agreed that Australian agriculture should have access to the approved GM canola varieties with the lifting of the moratoria.

SPAIN

Spain is the only country in the European Union to grow a substantial area of a biotech crop. Spain has grown Bt maize for ten 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 over 50,000 in the last three years, qualifying Spain as one of the 13 biotech mega-countries globally growing 50,000 hectares or more of biotech crops. In 2007, the Bt maize area in Spain reached an all time peak of 75,148 hectares, which represents a 40% increase over 2006 and a 21% adoption of the total maize plantings of 325,000 hectares in 2007 in Spain. The 2007

Table 16. Hectares of Biotech Bt Maize in the Autonomous Communities of Spain, 1998 to 2007

Provinces	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Aragon	11,500	7,300	9,000	4,250	9,200	12,592	25,547	21,259	23,734	35,860
Cataluña	1,700	3,000	4,500	3,250	5,300	5,430	15,699	16,830	20,365	23,013
Extremadura	1,000	2,500	2,500	600	1,500	1,899	2,026	1,171	2,071	6,460
Navarra	1,760	300	220	80	500	1,387	2,446	2,604	2,821	5,327
Castilla-La Mancha	4,500	6,800	5,650	870	4,150	7,682	8,197	7,957	4,176	3,659
Andalucia	780	2,800	1,500	450	1,800	2,067	2,770	2,875	298	592
Madrid	660	1,560	1,970	1.940	780	1,034	1,385	155	80	193
Murcia	0	0	0	0	0	0	12	0	0	24
Castilla Y Leon	200	360	270	0	0	74	0	12	0	13
La Rioja	25	30	30	0	0	0	35	41	122	4
Islas Baleares	2	2	26	0	30	6	29	29	0	3
Asturias	0	0	0	0	0	0	0	0	0	0
Valencia	190	300	150	100	20	72	73	293	0	0
Total	**22,317**	**24,952**	**25,816**	**11,540**	**23,280**	**32,243**	**58,219**	**53,226**	**53,667**	**75,148**

Source: Ministry of Agriculture, Spain, 2007.

hectarage and percentage adoption is the highest on record and compares with 53,667 hectares at 15% adoption in 2006 and 53,226 hectares and a 13% adoption in 2005. The principal areas of Bt maize in Spain are in the provinces of Aragon (35,860 hectares) where the adoption rate for Bt maize is 64%, followed by Cataluña (23,013 hectares) also with an adoption rate of 64%, with significantly less area of Bt maize in Extremadura (6,460 hectares), with an adoption rate of 12% with the balance of Bt maize grown in 8 other provinces in Spain in 2007 (Table 16).

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. MON810 varieties for insect resistance were approved in 2003 and now there are 46 varieties registered with MON810. 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 feedstock deficit country and therefore there is an 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.

Benefits from Biotech Crops in Spain

Spain is estimated to have enhanced farm income from biotech Bt maize by US$40 million in the period 1998 to 2006 and the benefits for 2006 alone is estimated at US$11 million.

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 is US$112 per hectare. Recent data from the Institute of Agro-Food Research and Technology (IRTA) public research institute in Spain indicates 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, up to one-third of the total maize area, and the national gain is estimated at US$13 to US$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.

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. In 2007 the total cotton plantings in Mexico were approximately 115,000 hectares, of which approximately 55% were biotech products with the following allocation of traits: 45,000 hectares of stacked traits for insect resistance and herbicide tolerance, 15,000 hectares of Bt for insect resistance, and 5,000 hectares of herbicide tolerance. This area is approximately the same as that in 2006. After a large increase in 2005 to 120,000 hectares, biotech cotton hectarage in 2006 decreased to approximately 55,000 hectares 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. Mexico is one of five countries to deploy the Bt /HT stacked cotton, the other countries are the USA, Australia, Colombia, 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 has no trade constraints related to biotech crops and is a major importer of food, feed and fiber from the USA. In 2005, Mexico imported US$9.9 billion worth of agricultural products from the USA. 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 USA. 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 facilitated 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 Comision Intersecretarial de Bioseguridad y Organismos Geneticamento Modificados (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.

Benefits from Biotech Crops in Mexico

Mexico is estimated to have enhanced farm income from biotech cotton and soybean by US$70 million in the period 1996 to 2006 and the benefits for 2006 alone is estimated at US$11 million (Brookes and Barfoot, 2008).

COLOMBIA

In 2007, Colombia grew approximately 22,000 hectares of cotton, approximately the same as in 2006. Of the 22,000 hectares approximately 18,000 hectares are Bt, 2,000 hectares are herbicide tolerant and 2,000 with the stacked traits for Bt and herbicide tolerance. The cotton is planted in two seasons, and all of it is in the Costal and Llanos region.

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 approximately 22,000 hectares in 2007, equivalent to 30% of the national cotton crop of 72,000 hectares in 2007.

In 2007, Colombia for the first time planted biotech maize in a "controlled planting program" in two regions, one on the Coast and Llanos region and the other in the interior of the country. Bt maize MON810 and TC5107 were planted on a total of 6,000 hectares, approximately 1,500 hectares in the first planting and the balance of 4,500 hectares in the second planting. Colombia has approximately 630,000 hectares of maize which could be an important new potential application for biotech maize.

Colombia has been growing blue biotech carnation for export only since 2002 and in 2007, 4 hectares are planted in greenhouses, near Bogota.

Benefits from Biotech Crops in Colombia

Colombia is estimated to have enhanced farm income from biotech cotton by US$5 million in the period 2002 to 2006 and the benefits for 2006 alone is estimated at US$900,000.

CHILE

In 2007, Chile is projected to plant over 25,000 hectares of biotech maize, 2,500 hectares biotech soybean and 500 hectares of biotech canola for a total of over 28,000 hectares for seed export. 2007 is the first year when Chile has planted more than 20,000 hectares of biotech crops and there is also legislation in Parliament to allow consumption of domestically grown biotech crops in Chile – for these reasons Chile for the first time is listed as a biotech crop country.

Chile has a population of approximately 16 million and a GDP of close to US$100 billion, 6% of which is generated from agriculture, and forestry is a strong sector in the country. Fruits are major exports worth US$2 billion per year and it has a thriving global export market in wines. A significant 14% of the population is involved in agriculture and the export market requires that the products are of the top quality to compete on the global market.

From a biotech crop standpoint it is important to recognize that Chile is the seventh largest producer of export seed in the world, (Table 1 in Appendix 3). The latest data from Chile indicate that the export market for all seed, conventional and biotech in 2007/08 was valued at US$240 million, of which approximately US$190 million was biotech seed. Chile has been producing biotech seed for export since commercialization began in 1996 and this activity is fully covered by current law. Chile has clearly demonstrated over the last eleven years that like the 22 countries that commercialize biotech crops, it has all the necessary management and skills to responsibly handle all the aspects related to the growing of biotech crops. The only difference between Chile and the other countries planting biotech crops is that the current law only allows commercialization of biotech crops for export. However, there is a new law in passage in the Chilean Parliament that would also allow commercialization and consumption of biotech crops produced in Chile. This is a logical development given that Chile already imports significant quantities of biotech crops such as biotech maize for consumption from its neighboring country Argentina, which is the second largest producer of biotech crops in the world. Chile has 120,000 hectares of maize which could benefit significantly from biotechnology and substitute for some of the imports of biotech maize from Argentina. The recent REDBIO regional meeting on biotechnology recognized this opportunity for Chile to grow biotech maize for domestic consumption.

Table 17. Hectares of Major Biotech Seed Crops Grown for Export in Chile, 2002/03 to 2006/07

Crop	2002/03	2003/204	2004/05	2005/06	2006/07	Total
Maize	10,400	8,450	7,614	12,120	17,981	56,565
Canola	110	140	746	628	444	2,068
Soybean	215	128	273	166	250	1,032
Total	**10,725**	**9,258**	**8,633**	**12,914**	**18,675**	**59,665**

Source: Government of Chile statistics, SAG.

The area of biotech crops grown for seed export in Chile has shown a strong growth trend over the last five years almost doubling from 10,725 hectares in 2002/03 to 18,675 hectares in a 2006/07 (Table 17). Multiplication of biotech seed for export is now a significant business activity worth US$240 million. Maize has always been the most important biotech seed crop grown in Chile and in 07/08, it will exceed 20,000 hectares for the first time. The area of biotech maize in 2007/08 is estimated to be over 25,000 hectares. The area of biotech soybean for seed export in 2007/08 has increased to an all time high of 2,500 hectares and the biotech canola is 500 hectares. Thus, the total biotech crop area for export seed production in Chile in 2007/08 is over 28,000 hectares, the highest ever. The number of biotech seed crops multiplied in Chile is now approximately 10 crops. The country has broad and diversified experience in successfully managing all aspects related to the growing of biotech crops for over 10 years.

Several organizations in Chile have been pursuing the development of biotech crop products for several years, including the following: The Catholic University of Santiago is developing citrus species that are resistant to drought and tolerant to nitrogen deficiency, virus resistant potatoes, and *Pinus radiata* species that are resistant to shoot moth and also tolerant to glyphosate. The National Institute for Agricultural Research (INIA) is developing grapes that are resistant to *Botrytis,* and in a joint program with the University of Santo Tomas they are developing stone fruits (nectarines and peaches) with improved quality and shelf life. Fundacion Chile provides technical and financial support for some of these projects.

Biotech activities in Chile are not restricted to crops but also include forestry products. Recently some Chilean Research Institutes have joined forces to develop drought-tolerant *Eucalyptus.* Chile's Institute for Agricultural Research (INIA) and Chile's Forest Research Institute (INFOR) have announced a joint program to develop varieties of eucalypts, *Eucalyptus globulus*, with increased tolerance to drought. The project aims to provide farmers and forestry industry with plants and trees better adapted to the conditions of the arid interior regions of Chile. It is estimated that currently 1.8 million hectares of land are not realizing their production potential due to the low availability of water. More information can be obtained from INIA Chile (2007).

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 2007, France planted approximately 22,135 hectares compared with only 5,028 hectares in 2006 and only 492 hectares in 2005. Thus, between 2006 and 2007 there was more than a three fold increase in 2007 equivalent to an absolute increase of over 17,000 hectares. The planting of the commercial Bt maize in 2007 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 MON810. As one of the lead member states in the EU, and where opposition to biotech crops is 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 2007 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 USA as the major supplier.

Despite the pleas of French farmers demanding innovative technology and access to improved biotech crops that would allow them to compete in the international market, the French Government decided in October 2007 to suspend planting of Bt maize in France until a review of biotech crops is completed by Government. If the Government Review does not report before the 2008 planting season this will deny French farmers the right to continue to use a technology that they have embraced and from experience know to be an improved technology that can contribute to a more sustainable agriculture. The EU commissioner for agriculture has commented that a full ban on biotech crops would be in contravention of the law and that France would lose in court if it implemented such a ban.

Benefits from Biotech Crops in France

European corn borer and Mediterranean stem borer in France are estimated to affect one million or more hectares of which 0.3 to 0.75 million hectares merit control with insecticide or with *Trichogramma*, a wasp used as biological control. Bt maize provides 95 to 99% control and results in yield increases from 5 to 25% depending on the level of infestation and equivalent to a gain in farmer income of US$150 to US$200 per hectare. In addition to the environmental benefits related to reduction or elimination of insecticides, levels of mycotoxin were up to10 times higher in conventional maize compared with Bt maize. The current maximum limits in the EU for fumonisin B1 is 2 parts per million (2 ppm). Analysis of grain by Grenouillet (2006) reported that applying the 2 ppm to samples of Bt maize and conventional maize, 17 conventional samples would have exceeded the limit, whereas 15 of the Bt maize samples would have been below the 2 ppm limit.

Farmer Experience

Even before **President Sarkosy** of France issued his statement to suspend the planting of Bt maize in France in October 2007, French farmers preempted his statement. They unambiguously said that ***"France risks losing its seat among top food producers if it rejects genetically modified (GMO) crops altogether in an upcoming law on biotech organisms."*** **Philippe Pinta**, President of Orama (representing French grain and oilseed growers) said that what his members feared the most was that rejection of GMOs by France would leave them behind, dependent on other countries' technology. ***"If we discourage research we doom our future."***

Jacques Beauville, a French farmer who has planted Bt maize on his farm for several years comments:
"The Bt maize provided perfect control of corn borer and improved maize quality and yield, while increasing my profit. I believe biotechnology can improve farming, and I hope that farmers, seed companies and consumers continue to share information and talk about its benefits" (Beauville, 2006).

HONDURAS

Honduras introduced herbicide tolerant maize in 2002 with a pre-commercial introductory area of approximately 500 hectares. In the interim, the herbicide tolerant maize area has increased modestly, and in 2007 it was approximately 5,000 hectares, plus 2,000 hectares of Bt maize. 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. In 2007, Czechia increased its Bt maize area by almost 300% to 5,000 hectares. 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).

Benefits from Biotech Crops in Czechia

The Phytosanitary Service of the Government estimates that up to 90,000 hectares are infested with European corn borer (ECB), and that up to 30,000 hectares are being sprayed with insecticide for control of ECB. In trials with Bt maize, yield increases of 5% to 20% were being realized, which is equivalent to an increase of about US$100 per hectare. Based on 30,000 hectares of Bt deployed, the income gain at the national level could be of the order of US$3 million per year.

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 2007, Portugal planted 4,263 hectares of Bt maize, a two and a half fold increase from the 1,250 hectares planted in 2006 which was the MON810 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 acknowledging that 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.

Benefits from Biotech Crop in Portugal

The area infested by ECB in Portugal are in the Alentejo and Ribatejo regions and the estimated infested area that would benefit significantly from Bt maize is estimated at approximately 15,000 hectares, which is equivalent to approximately 10% of the total maize area. The yield increase from Bt maize is of the order of 8 to 17% with an average of 12% equivalent to an increase of 1.2 MT per hectare. Assuming an average increase of US$150 per hectare the gain at the national level for Portugal for Bt maize would be in the order of increase of US$2.25 million per year.

Farmer Experience

Jose Maria Telles Rasquilla, is a Portuguese farmer who has planted Bt maize since 1999. He says that ***"Growing biotech maize offers environmental advantages and economic benefits such as better yields and less spraying, which means reduced costs, larger margins per hectare and good quality products. Developing new technologies and agricultural products can help the environment and have a positive impact on rural development"*** (Rasquilla, 2006).

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 2007 was 2,685 hectares compared with 950 hectares in 2006 – almost doubling 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% 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% 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.

Benefits from Biotech Crop in Germany

The areas infested by ECB in Germany are in the North Rhine, Westphalia, Saxony and Brandenburg regions. It is estimated that the infested area in these regions would benefit significantly from Bt maize, whereas most of the Northern states do not suffer from ECB. An estimated 18% of the 300,000 hectare maize crop could benefit from Bt maize. Given that measured yield gains due to Bt maize were of the order of 12% to 14% the average gain per hectare from Bt maize is US$150 per hectare, the gain on 55,000 hectares at the national level for Germany would be of the order of increase of US$8.25 million per year.

SLOVAKIA

Slovakia grew its first commercial biotech crop, Bt maize in 2006 when thirty hectares of Bt maize were grown for commercial production by several farmers. In 2007, the area increased 30 fold to 900 hectares. As an EU member state, Slovakia can grow maize with the MON810 event which has been approved by the EU for all of its 27 member countries. Slovakia grew approximately 240,000 hectares of maize in 2007.

Benefits from Biotech Crop in Slovakia

It is estimated that from a third to a half of the 240,000 hectares of maize in Slovakia is infested with ECB with the most severe infestations in the south of the country where most of the maize is grown. Yield gains conferred by Bt maize have been measured at 10% to 15%. The average gain per hectare from Bt maize is estimated at US$45 to US$100 per hectare. Thus, at the national level, the income gain for farmers, assuming 100,000 hectares of Bt maize, would be in the range of US$4.5 million to US$10 million annually in Slovakia.

ROMANIA

Up until 2006, Romania successfully grew over 100,000 hectares of RR® soybean, but on entry to the EU in January 2007 had to discontinue the use of an extremely cost-effective technology because RR® soybean is not approved for commercialized planting in the EU. This has been a great loss to both producers and consumers alike. If, as a result of cessation of cultivation of RR® soybean and the commensurate decrease in soybean production, Romania has to import soybean, it is almost certain to be RR® soybean, the very same product which the Government has banned from domestic production – an example of a negative impact from a flawed logic arising from a bureaucratic requirement. However, despite the need for Romania to discontinue the cultivation of RR® soybean it has been able to take advantage of the fact that Bt maize is registered for commercialized planting in the EU and Romania grew its first 350 hectares of Bt maize in 2007, with the expectations that the area will increase in 2008. It is noteworthy that there are 4.5 million small farms in Romania which remarkably represent almost a third of all farms in the EU (The Economist, 2007).

Even though Romania has ceased to grow RR® soybean, it is anticipated that Romania will resume growing RR® soybean when RR® soybean is eventually approved for planting in the EU, thus it is appropriate to report on Romania and RR® soybean. Romania is the third largest producer of soybean in Europe, after Italy and Serbia Montenegro, and ranks equal third with France with approximately 150,000 hectares of soybean planted in 2007. 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 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 over 31%, equivalent to an increase in gross margins, ranging from +127% to +185%, or an average gain of US$239 per hectare that translates to an annual economic gain at the national level of between US$10 and US$20 million. Given that RR® soybean technology is usually yield-neutral in other countries such as the USA 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 started with RR® soybean in 2001, followed by Bt maize in 2007. Romania is 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 2007, in addition to Romania seven other EU countries, Spain, France, Czech Republic, Portugal, Germany, and Poland successfully grew an increasing hectarage of Bt maize on approximately 110,000 hectares in 2007.

Benefits from Biotech Crops in Romania

There has been active debate on the use of biotech crops in Romania. The Romanian Minister of Agriculture strongly supports the resumption of growing biotech soybean, stating that the Ministry of Agriculture will support biotech soybean in the EU. The Romanian Senate has also supported biotech crops with an almost unanimous vote on an Emergency Ordinance to embrace biotech products as food, whereas the Ministry of the Environment has been ambivalent on the subject.

For RR® soybean, cultivated since 2001 and occupying 145,000 hectares in 2006, the yield benefits of 30% was unique – in all other countries RR® soybean is a yield neutral technology. The high yield increases in Romania of +15% to +50% with an average of +31% reflect past low usage of herbicides and ineffective of weed management, particularly of Johnson grass, which is very difficult to control. A 2003 study by PG Economics estimated an average yield gain of 31% or more, equivalent to gross margin gains of +127% to +185% or an average gain of US$239 per hectare – equivalent to a national economic gain of US$10 and US$20 million, respectively.

Romania is estimated to have enhanced farm income from RR® soybean by US$93 million in the period 2001 to 2006 and the benefits for 2006 alone is estimated at US$29 million.

Farmer Experience

The experience of farmers, who are the practitioners of biotech crops are important because they are masters of risk aversion and have no compunction in rejecting any technology that does not deliver benefits. Romanian farmers embraced biotech soybean and, Romanian soybean farmer **Lucian Buzdugan** predicted the fate of Romanian farmers – on entry to the EU Romanian farmers would have to pay the high price of banning the technology.

"I can tell you that soybean farmers in Romania are very interested in biotech seeds. If one day our government says no more GMOs (genetically modified organisms), it's a disaster. Before, yields were just 1,300 to 1,500 pounds per acre with conventional soybeans and are now averaging 2,500 to 3,000 pounds per acre with biotech varieties" (Buzdugan, 2006).

POLAND

Poland has a population of approximately 38.5 million and a GDP (nominal) of US$413 billion, 3% of which is generated from agriculture equivalent to US$12 billion per year. Agricultural products and food stuffs represent about 8% of total exports which is US$6 billion per year. Agriculture provides employment for 16.1% of the population, the highest percentage in the EU of which Poland is a member.

There are approximately 600,000 hectares of maize grown in Poland – 55% is used for grain and 45% used for silage. A few years ago European corn borer (ECB) used to be limited to only a few regions in the South and South East but it is now endemic in all regions of Poland and causes significant damage. Economic thresholds which merit the use of Bt maize as a control measure are at a 15% level of infestation for grain crops and 30% to 40% infestation for silage crops. Insecticide application to control ECB is infrequent due to lack of tradition, equipment, awareness of the significant damage the pest is causing and the small size of holdings and fields. *Trichogramma* is sometimes used as a biological control agent at a cost of US$90 to US$105 per hectare. Insecticide control, which is rarely used, can cost US$35 per hectare.

Some pre-commercial Bt maize was planted in Poland in 2006 on approximately 100 hectares. 2007 was the first time for Poland to commercialize Bt maize when 327 hectares were planted. Based on the positive reaction of farmers who planted Bt maize in 2007 it is expected that the area under Bt maize will increase multifold in 2008 to over 1,000 hectares. Poland has the distinction of becoming the eighth EU country to plant Bt maize. Bt maize is being used for animal feed or for ethanol production. Poland becomes the 27th country in the world to grow approved biotech crops commercially. With the addition of Poland this brings the total number of EU countries growing biotech crops commercially to 8, which is over one-quarter of the 27 EU member states.

Benefits from Bt Maize in Poland

In the 2007 Report entitled "The benefits of adopting genetically modified maize in the European Union; first results form 1998 to 2006 plantings", Graham Brookes (Personal Communication, 2007) reports that benefits from Bt maize based on trials conducted in 2006 were on average approximately 25%, equivalent to an increase of 2.15 tonnes/ha gross margin of using Bt over conventional maize. A significant advantage of Bt maize, not captured in the benefits associated with yield increase is the substantial decrease in mycotoxin level with multifold decreases in the levels of all the various toxins. For example, Fumonisin B1 decreased from a range of 121 to 409 ppm in conventional maize to 0 to 25 ppm in Bt maize. Similarly, Fumonisin B2 decreased from 44 to 103 ppm in conventional maize to 0 to 8 ppm in Bt maize.

THE EUROPEAN UNION (EU)

In 2007, of the 27 countries in the European Union, eight officially planted Bt maize on a commercial basis. Table 18 summarizes the planting of Bt maize in eight countries of the European Union in

Table 18. Hectares of Bt Maize Planted in the 8 EU Countries, 2006 and 2007

Country	2006	2007	Increase 2006/2007	%
1. Spain	53,667	75,148	21,481	40%
2. France	5,028	22,135	17,107	340%
3. Czech Republic	1,290	5,000	3,710	288%
4. Portugal	1,250	4,263	3,013	241%
5. Germany	950	2,685	1,735	183%
6. Slovakia	30	900	870	2,900%
7. Romania*		350		
8. Poland	100**	327	227	227%
Total	**62,315**	**110,808**	**48,143**	**77%**

*Romania grew 145,000 hectares of RR® soybean in 2006 but had to cease growing it after becoming an EU member in January 2007. ** Pre-commercial area of 100 hectares of Bt maize
Source: Clive James, 2007.

2006 and 2007. The eight countries listed in order of biotech hectarage of Bt maize are Spain, France, Czech Republic, Portugal, Germany, Slovakia, Romania and Poland. All eight countries grow Bt maize commercially and provides significant benefits to farmers to the environment and more affordable feed source for animals which in turn benefits consumers who eat meat. The group of eight countries is led by Spain, which was the first country to commercialize Bt maize in 1998 when 22,137 hectares were planted.

The increase in area in Bt maize in the eight EU countries between 2006 and 2007 was 48,143 hectares, equivalent to a 77% increase. 2007 marks the first year for over 100,000 hectares to be planted in the EU, which is a historical milestone. However it should be noted that Romania itself grew 145,00 hectares of RR® soybean in 2006 before it became a member of the EU in January 2007 when it had to cease plantings of RR® soybean because, unlike Bt maize, it has not yet been approved for planting in the EU. The largest absolute increase in Bt maize hectarage in individual countries in 2007 was in Spain, 21,481 hectares, and France, 17,107 hectares. In October 2007, France suspended the commercial planting of Bt maize pending completion of a government review which is not expected to be completed before the end of the year or early next year. The EU commissioner for agriculture has commented that a full ban on biotech crops would be in contravention of the law and that France would lose in court if it implemented such a ban.

In October 2007, the EU Commission approved three biotech maize varieties (TC1507xNK603) with insect resistance and herbicide tolerance; NK603 x MON810 with herbicide tolerance and insect resistance; and 59122 Herculex RW with resistance to the root worm pest of maize for import for feed and food use, and processing. A biotech sugarbeet (H7-1) was also approved import for food/

feed use. All four of the products had been previously cleared with positive safety assessments by EFSA and endorsed by the EU approval process. The products are approved for the usual 10 year period. As in the past the EU Member States failed to register a qualified majority against or in favor in the Standing Committee, and in Council, resulting in the files being sent back to the Commission for a decision.

Sir David King, the UK Government's Chief Scientific Adviser, who finished his term in December 2007 strongly advocated the UK government and Ministers to strongly support adoption of biotech crops which he believes are critical for the UK. Sir David King cautioned that, ***"The world would need all the food it could get to feed over 9 billion people by 2050. We will only do this with the assistance of a third green revolution and GM technologies will be crucial in delivery of this."***

A recent study by a group from the University of Leuven, Belgium (Demont *et al.,* 2007) have documented the potential benefits to Europe from biotech crops. They concluded that the potential annual value of biotech crops for an EU country can be up to US$60 million per year and that biotech sugarbeet alone could generate annual gains in the order of US$1 billion per year for the EU.

Some observers are of the opinion that the EU faces a potential crisis re biotech feed particularly soybean imports if the USA, Argentina and Brazil adopted the new higher yielding RR® soybean in 2009 and 2010 in an asynchronous mode whereby the products would be approved in the three countries, but not in the EU. In a worst case scenario the EU could experience an import feed deficit of 32 million tons, which could only be offset to a maximum of 20% through substituted local production. Given the importance of soybean as feed for pigs and poultry, production of these meats, it is estimated that meat production could fall by 35% and 44% respectively.

IRAN

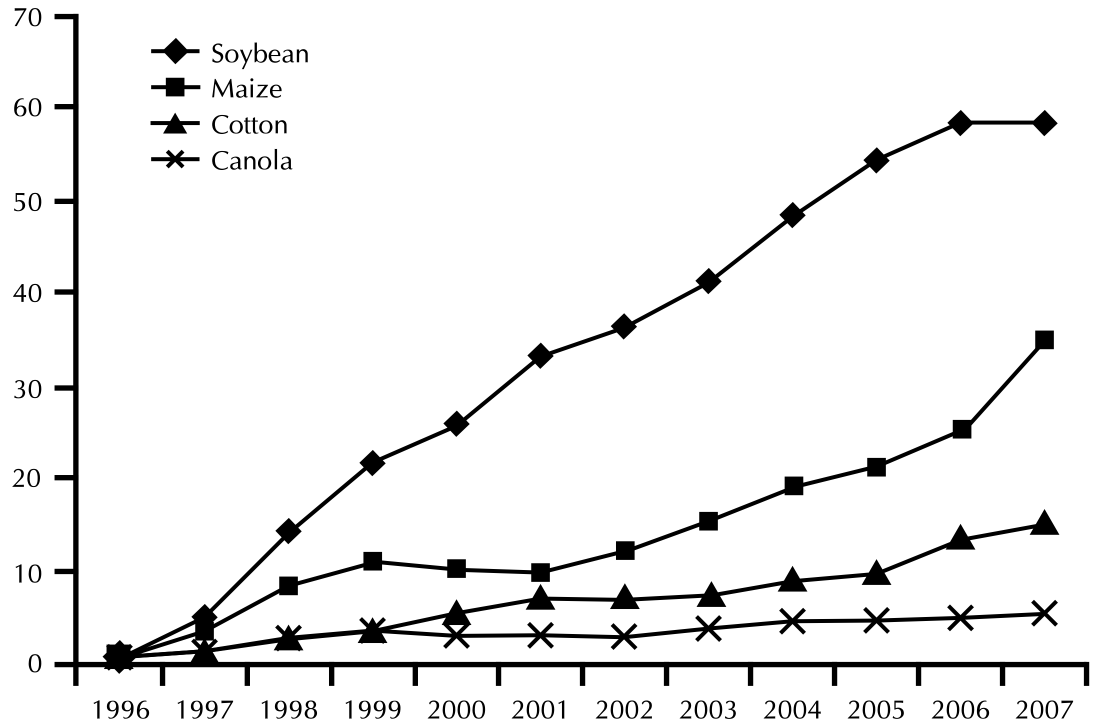
Iran, with a population of 70 million people, has limited land for crop production in an arid environment and this is exacerbated by limited water supplies, which is particularly important for the rice crop where productivity is constrained by abiotic stresses related to drought and salinity and biotic 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 were no confirmed estimates available of the hectares planted to Bt rice in 2006 and 2007 and hence has been withdrawn from the list of biotech crop countries (Table 3) until confirmed official data is available on adoption of Bt rice. In September 2007, ICARDS News reported that "the work on Bt rice is at an advanced stage and it is in the process of getting permission from the National Biosafety Council of Iran for commercial release. It is understood that research continues on biotech crops and that the Bt gene is being 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 future 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 sugarbeet. 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.

Distribution of Biotech Crops, by Crop

The distribution of the global biotech crop area for the four major crops is illustrated in Figure 9 and Table 19 for the period 1996 to 2007. It clearly shows the continuing dominance of biotech soybean occupying 51% of the global area of global biotech crops in 2007; the entire biotech soybean hectarage is herbicide tolerant RR® soybean. Biotech soybean retained its position in 2007 as the biotech crop occupying the largest area globally occupying 58.6 million hectares in 2007, exactly the same area as in 2006. Biotech maize had the second highest area at 35.2 million hectares and had by far the highest year-to-year growth rate at 40% between 2006 and 2007. Biotech cotton reached 15.0 million hectares in 2007 and grew at the third highest rate of 12% between 2006 and 2007 mainly due to the 2.4 million hectare increase in India in 2007, offset by a decrease of 1.3 million hectare decrease in the USA. Canola grew at the second highest rate of 15% between 2006 and 2007, and is the lowest absolute area of the four biotech crops at 5.5 million hectares grown in Canada and the USA. RR® alfalfa, first grown in 2006, occupied 102,000 hectares equivalent to approximately 5% of the 1.3 million hectare seeded in the USA in 2007. Small hectarages of biotech virus-resistant squash and papaya continue to be grown in the USA and virus resistant papaya is also grown on approximately 3,550 hectares in China which also grows about 400 hectares of Bt poplar.

Figure 9. Global Area of Biotech Crops, 1996 to 2007: by Crop (Million Hectares)



Source: Clive James, 2007.

Table 19. Global Area of Biotech Crops, 2006 and 2007: by Crop (Million Hectares)

	2006	%	2007	%	+/-	%
Soybean	58.6	57	58.6	51	0.0	0
Maize	25.2	25	35.2	31	10.0	+40
Cotton	13.4	13	15.0	13	1.6	+12
Canola	4.8	5	5.5	5	0.7	+15
Alfalfa	<0.1	<1	<0.1	<1	--	--
Papaya	<0.1	<1	<0.1	<1	--	--
Others	<0.1	<1	<0.1	<1	--	--
Total	**102.0**	**100**	**114.3**	**100**	**+12.3**	**+12**

Source: Clive James, 2007.

Distribution of economic benefits for the four major biotech crops for the first 11 years of commercialization 1996 to 2006 were as follows: herbicide tolerant soybean 17.5 billion, Bt cotton US$9.6 billion, Bt maize US$3.6 billion, herbicide tolerant canola US$1.1 billion, herbicide tolerant maize 1.1 billion, herbicide tolerant cotton US$0.8 billion, and the balance of US$0.3 billion in virus resistant papaya and squash for a total of approximately US$34 billion (Brookes and Barfoot, 2008).

Distribution of economic benefits for the major biotech crops for 2006 only were as follows: herbicide tolerant soybean US$3.1 billion, Bt cotton US$2.2 billion, Bt maize US$1.1 billion, herbicide tolerant maize US$0.3 billion, herbicide tolerant canola US$0.2 billion, herbicide tolerant cotton <US$0.1 billion for a total of US$7 billion.

Biotech soybean

In 2007, the global hectarage of herbicide tolerant soybean remained exactly the same as 2006 with 58.6 million hectares. The "no growth" outcome results from a significant decreases of almost 4 million hectares in the USA, a small decrease in Canada offset by significant increase in Brazil of 3.1 million hectares, and modest increases in Argentina, Paraguay and Uruguay. The 58.6 million hectares of biotech soybean worldwide is equivalent to 64% of the global 91 million hectares of soybean. In Brazil in 2007, about 64% of the soybean crop was estimated to be RR® soybean, up from 55% in 2006. In the USA, herbicide tolerant soybean hectarage in 2007 occupied 24.2 million hectares of the 30.3 million hectare crop. In Argentina, continued growth is projected to result in 16.0 million hectares in 2007, up slightly from 15.8 million hectares in 2006; virtually all the Argentinean national soybean hectarage is planted with herbicide tolerant soybean. Paraguay reported 2.0 million hectares of herbicide tolerant soybean in 2006 and this area increased in 2007 to 2.6 million hectares, equivalent to 93% adoption of the 2.8 million hectare crop, up from 90% in 2006, when the national hectarage of soybean was 2.2 million hectares. Canada continued to plant about 60% of its national soybean hectarage with herbicide tolerant soybean in 2007. Uruguay's herbicide tolerant soybean continued to occupy 100% of the national soybean hectarage of 470,000 hectares in 2007. South Africa and Mexican biotech soybean hectarage decreased slightly to approximately 145,000 hectares and 4,000 hectares, respectively, in 2007, in line with decreased total plantings of soybean in the two countries. The increase in income benefits for farmers growing biotech soybean during the eleven year period 1996 to 2006 was US$17.5 billion and for 2007 alone, US$3.1 billion.

Biotech maize

In 2007, biotech maize increased by a massive 40% to 35.2 million hectares, a significant 10 million hectare increase mainly contributed by the 8 million hectare increase in the USA where soybean decreased by 3.8 million hectares. Biotech cotton increased by 12% and canola increased by 15% (Table 19). The annual growth rate of 40% for biotech maize in 2007 is the highest of the consistently high rates in the last four years-viz 19% in 2006, 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 24%, almost a quarter, of the global maize area of 148 million hectares globally in 2007. Most of the increase in biotech maize in 2007 occurred in six countries, USA with an increase of 8.1 million hectares, Argentina 920,000 hectares, South Africa 0.4 million hectares, Canada 320,000 hectares, Uruguay 50,000 hectares and the Philippines 50,000 hectares. Modest increases were reported in Honduras and small absolute increases, but large proportional increases, in all the eight EU countries that grew Bt maize in 2007, with Poland and Romania growing Bt maize for the first time in 2007.

Preliminary projections of yield gains from drought tolerant maize in the USA, expected to be available about 2011, are 8 to 10% in the non-irrigated areas from North Dakota to Texas. By 2015, current yields of 5.5 metric tons in the dry regions of the USA may increase to 7.5 metric tons 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 consumed 24% of maize in the USA in 2007, up from 19% in 2006, is expected to increase to 41% by 2015. The increase in income benefits for farmers growing biotech maize during the 11 years (1996 to 2006) was US$4.7 billion and US$1.4 billion for 2006 alone.

Biotech cotton

The area planted to biotech cotton globally in 2007 was up by 1.6 million hectares, equivalent to a 12% growth over 2006, reaching 15 million hectares globally and equivalent to 43% of the global area of 35 million hectares in 2007. Most of the growth was in India (2.4 million hectares), Brazil (380,000 hectare increase) and China (311,000 hectare increase) offset by a significant decrease of 1.3 million hectares in the USA and a 130,000 hectare decrease in Australia because of the very severe drought. Bt cotton was grown in Brazil for the second 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 4.0 million hectares are a record high in percentage adoption (93%). RR® Flex cotton was introduced in the USA and Australia for the first time in 2006 by Monsanto and continues to enjoy strong growth in 2007. It is marketed as a single gene and also as a stacked product with insect resistance in Bollgard® II. In China, total cotton plantings were up by approximately 5% from 5.3 million hectares in 2006 to 5.8 million hectares in 2007 and this paralleled increases in Bt cotton from 3.5 million hectares in 2006 to 3.8 million hectares in 2007 with the adoption rate up slightly at 69% compared with 66% in 2006. It is estimated that in 2007, 7.1 million small resource-poor farmers planted and 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 2007, the biotech cotton area in India again exceeded the Bt cotton in China. In 2007, biotech hybrid cotton in India, the largest cotton growing country in the world, occupied 6.2 million hectares of approved Bt cotton increasing by an impressive 63% gain between 2006 and 2007. The advantages of Bt cotton hybrid in India are significant and a substantial increase is projected again for 2008 due to significant gains in production, economic, environmental, health and social benefits. The increase in income benefits for farmers growing biotech cotton during the eleven year period 1996 to 2006 was US$10.4 billion and US$2.2 billion for 2006 alone.

A recent paper from the World Bank (WPS3197), (Anderson *et al.,* 2006), 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 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 2007 is estimated to have increased by a modest 0.7 million hectares, from 4.8 million hectares in 2006 to an estimated 5.5 million hectares in 2007. There were modest increases in both Canada, and in the USA for the net increase of 0.7 million hectares globally (Table 19). 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, 11% in 2006, 11% in 2007 and only 2% of the crop is now conventional. 87% of the canola in Canada was biotech in 2007, the highest percentage ever. Only two countries currently grow biotech canola, Canada and the USA, but the global acreage and prevalence could increase significantly in the near term in response to the likely increased use of canola for biodiesel. One percent of the canola crop in Canada was used for biodiesel in 2007 and this is expected to increase as high as 2% in 2008 when new biodiesel plants come on stream The increase in income benefits for farmers growing biotech canola during the eleven year period 1996 to 2006 was US$1.1 billion and US$0.2 billion for 2006 alone.

Biotech alfalfa

Herbicide tolerant RR® alfalfa, was approved for commercialization in the USA 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. Herbicide tolerance is expected to be the first of several traits to be incorporated into this important forage crop. A court injunction in 2007 suspended further plantings of RR® alfalfa until a new dossier of information is submitted to the regulators for consideration. Before the injunction came into force another 22,000 hectares were planted bringing the total of RR® alfalfa in the USA in 2007 to 102,000 hectares. There are approximately 9 million hectares of alfalfa grown for dry hay in the USA annually, worth US$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

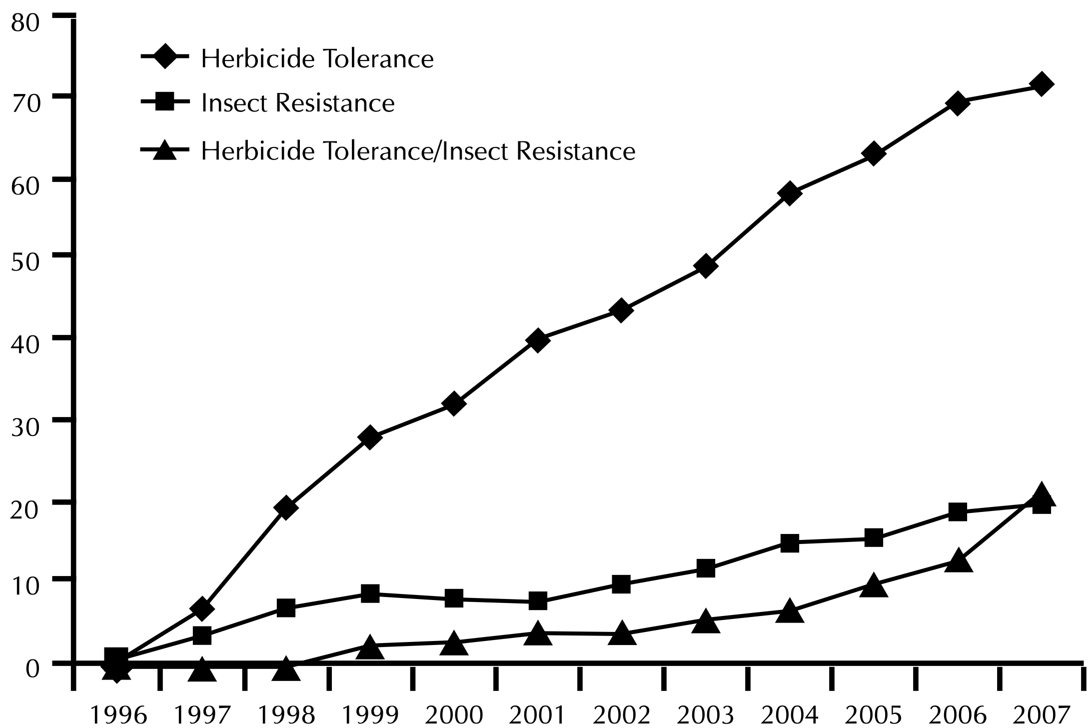
Small areas of biotech virus resistant squash (2,000 hectares) and PRSV resistant papaya in Hawaii (2,000 hectares with a 62% adoption) were continued to be grown in the USA in 2007. In China there are approximately 3,500 hectares of PRSV resistant papaya and 400 hectares of Bt poplars.

Distribution of Biotech Crops, by Trait

During the twelve year period 1996 to 2007, herbicide tolerance has consistently been the dominant trait with insect resistance, second (Figure 10). In 2007, herbicide tolerance, deployed in soybean, maize, canola, cotton, and alfalfa occupied 72.2 million hectares or 63% of the 114.3 million hectares (Table 20). RR® Flex cotton was introduced in a significant launch in the US and Australia for the first time in 2006 and continues to grow in 2007. There were 20.3 million hectares planted to Bt crops, including cotton and maize. It is noteworthy that Poland and Romania both EU member countries grew Bt maize for the first time in 2007 bringing the total number of EU countries planting Bt maize to eight with a collective total of 110,000 hectares in 2007. Biotech crops with Bt genes occupied 18% of the global biotech area in 2007, with stacked traits for herbicide tolerance and insect resistance deployed in both cotton (Bt/HT) and maize (Bt/Bt, Bt/HT, and Bt/Bt/HT) and occupying 19% of the global biotech area (Table 20). It is significant that the stacked traits in maize and cotton increased by a substantial 66% in 2007, the highest of all trait categories. The increase of the stacked traits in maize, over 100% increase from 9.0 million hectares in 2006 to over 19 million hectares in 2007 was noteworthy. This significant increase in stacked traits in maize 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 USA with 87.1 million “trait hectares” in 2007, compared with only 57.7

Figure 10. Global Area of Biotech Crops, 1996 to 2007: by Trait (Million Hectares)



Source: Clive James, 2007.

Table 20. Global Area of Biotech Crops, 2006 and 2007: by Trait (Million Hectares)

Trait	2006	%	2007	%	+/-	%
Herbicide tolerance	69.9	68	72.2	63	+2.3	+3
Stacked traits	13.1	13	21.8	19	+8.7	+66
Insect resistance (Bt)	19.0	19	20.3	18	+1.3	+7
Virus resistance/Other	<0.1	<1	<0.1	<1	<0.1	<1
Total	**102.0**	**100**	**114.3**	**100**	**+12.3**	**+12**

Source: Clive James, 2007.

million hectares planted. The other nine countries deploying stacked traits are Canada (0.3 million hectares), Philippines, Australia, Mexico, South Africa, Honduras, Chile, Colombia, and Argentina with less than 0.1 million 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 and more than doubled to over 60,000 hectares in 2007. 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 on a single biotic stress. On a global basis the 117.7 million "trait hectares" planted in 2006 increased by 22% to 143.7 million hectares in 2007.

In the USA in 2007, almost two-thirds (63%) of the biotech maize hectarage featured a double or triple construct of Bt and herbicide tolerant traits whereas over 93% of biotech cotton in the US featured the stacked traits for insect resistance and herbicide tolerance. In Canada, 25% of the biotech maize hectarage had stacked traits for insect resistance and herbicide tolerance in 2007. Similarly in Australia in 2007, 83% 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 USA in 2005, continued to grow in adoption in 2007. The European corn borer and the corn rootworm can both be major economic pests that cost US farmers up to US$1 billion dollars, each, per year, in losses and insecticide control costs.

Distribution of economic benefits at the farm level by trait, for the first eleven years of commercialization of biotech crops 1996 to 2006 was as follows: herbicide tolerant soybean US$17.5 billion, Bt cotton US$9.6 billion, insect resistant maize US$3.6 billion, herbicide tolerant canola US$1.1 billion, herbicide tolerant maize US$1.1 billion, and herbicide tolerant cotton US$814 million, for a total of approximately US$34 billion.

Dominant Biotech Crops in 2007

Herbicide tolerant soybean continued to be the dominant biotech crop grown commercially in nine countries in 2007; listed in order of hectarage, the nine countries were, USA, Argentina, Brazil, Paraguay, Canada, Uruguay, South Africa, Mexico and Chile. Globally, herbicide tolerant soybean occupied 58.6 million hectares, representing 51% of the global biotech crop area of 114.3 million hectares for all crops (Table 21). The second most dominant biotech crop was maize with stacked traits, which occupied 18.8 million hectares, and equivalent to 17% of the global biotech area and planted in seven countries, the USA, Canada, South Africa, the Philippines, Honduras, Argentina, and Chile. The stacked maize category includes three combinations of traits: a double stack with insect resistance (Bt) and herbicide tolerance (HT), Bt/HT; a double stack with two traits for insect resistance Bt/Bt; and a triple stack with two types of insect resistance, plus herbicide tolerance Bt/Bt/HT. It is noteworthy that maize with stacked traits, occupied a total of 18.8 million hectares compared with

Table 21. Dominant Biotech Crops in 2007 (Million Hectares)

Crop	2006	2007	% Biotech in 2007
Herbicide tolerant Soybean	58.6	58.6	51
Stacked traits Maize	9.0	18.8	17
Bt Cotton	8.0	10.8	9
Bt Maize	11.1	9.3	8
Herbicide tolerant Maize	5.0	7.0	6
Herbicide tolerant Canola	4.8	5.5	5
Stacked traits Cotton	4.1	3.2	3
Herbicide tolerant Cotton	1.4	1.1	1
Herbicide tolerant Alfalfa	<0.1	<0.1	<1
Others	<0.1	<0.1	<1
Total	**102.0**	**114.3**	**100%**

Source: Clive James, 2007.

only 9.0 million hectares in 2006, a year-to-year substantial increase of over 100% – the highest for any biotech crop, which reflects the large increase of maize with stacked traits in the USA in 2007. The third most dominant crop was Bt cotton, which occupied 10.8 million hectares, equivalent to 9% of the global biotech area and planted in nine countries, listed in order of hectarage; India, China, Brazil, Argentina, USA, Colombia, Mexico, Australia, and South Africa. The fourth most dominant crop was Bt maize which occupied 9.3 million hectares, equivalent to 8% of global biotech area and was planted in 17 countries – USA, Argentina, South Africa, Canada, Uruguay, the Philippines, Spain, Chile, France, Colombia, Czech Republic, Portugal, Germany, Honduras, Slovakia, Romania, and Poland. The fifth most dominant crop was herbicide tolerant maize occupying 7.0 million hectares, about 40% more area in 2007 than 2006 and planted in seven countries – the USA, South Africa, Argentina, Canada, the Philippines, Honduras, and Chile. The sixth most dominant crop was herbicide tolerant canola, occupying 5.5 million hectares, 15% more area in 2007 than 2006 and planted in Canada, the USA and Chile. The four other crops listed in Table 21 occupied from 4% to <1% of global biotech crop area and include, in descending order of area: cotton with stacked traits (3%) grown on 3.2 million hectares in the USA, Australia, South Africa, Mexico and Colombia; herbicide tolerant cotton grown in the USA, Argentina, Australia, Mexico, South Africa and Colombia on 1.1 million hectares, equivalent to 1% of the global crop biotech hectarage; herbicide tolerant alfalfa grown on less than 0.1 million hectares in the USA in 2007. The “Others” category, with a total of less than 1000 hectares, includes virus resistant papaya and squash in the USA, Bt poplars and biotech papaya, sweet pepper and tomato in China.

Global Adoption of Biotech Soybean, Maize, Cotton and Canola

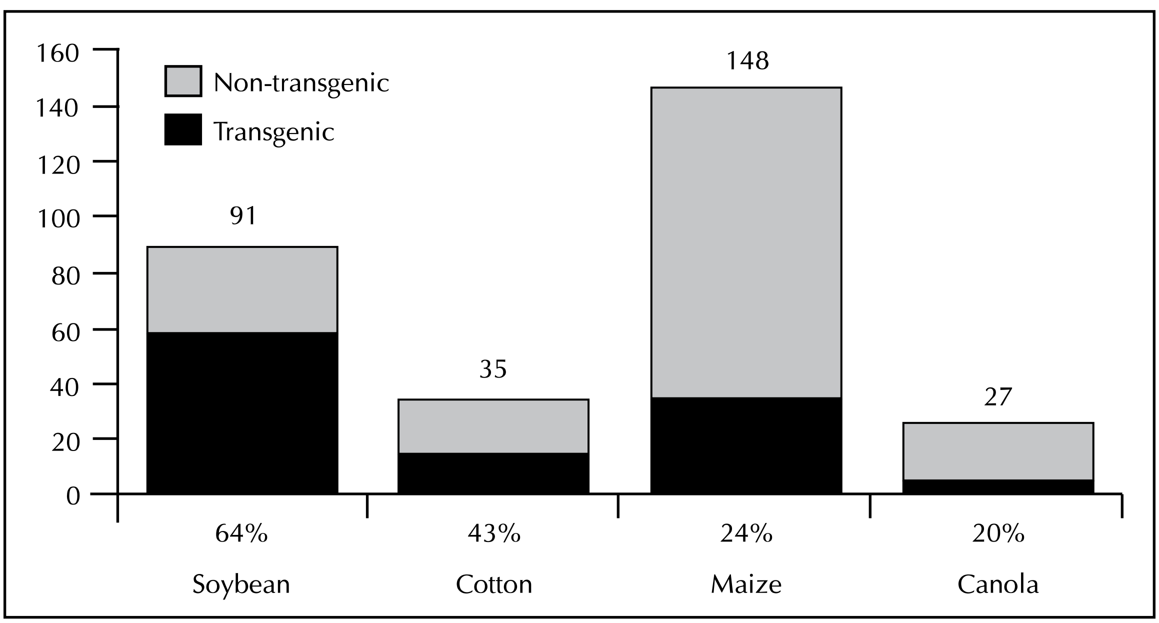
Another way to provide a global perspective of the status of biotech crops is to characterize the global adoption rates as a percentage of the respective global areas of the four principal crops –soybean, cotton, maize and canola – in which biotechnology is utilized (Table 22 and Figure 11). The data indicate that in 2007, 64% of the 91 million hectares of soybean planted globally were biotech – the same as in 2006. Of the 35 million hectares of global cotton, 43% or 15.0 million hectares were

Table 22. Biotech Crop Area as % of Global Area of Principal Crops, 2007 (Million Hectares)

Crop	Global Area*	Biotech Crop Area	Biotech Area as % of Global Area
Soybean	91	58.6	64
Cotton	35	15.0	43
Maize	148	35.2	24
Canola	27	5.5	20
Total	**301**	**114.3**	**38**

Source: Clive James, 2007. *FAO 2005 hectarage

Figure 11. Global Adoption Rates (%) for Principal Biotech Crops, 2007 (Million Hectares)



Source: Clive James, 2007.

biotech in 2007 compared with 38% or 13.4 million hectares planted to biotech cotton in 2006 – a significant increase from 38% to 43% of global cotton in one year mainly due to the significant 2.4 million hectare increase in Bt cotton in India. Of the 148 million hectares of maize planted in 2007, 24% or 35.2 million hectares, compared with only 17% or 25.2 million hectares planted to biotech maize in 2006 – an impressive 10 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 38%, equivalent to 114.3 million hectares, were biotech in 2007 – up from 34% in 2006. Similarly, the area planted to biotech canola in 2007, expressed on a percentage basis, was 20% or 5.5 million hectares compared with 18%, or 4.8 million hectares of the 27 million hectares of canola planted globally in 2006.

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 2007, the global market value of biotech crops, estimated by Cropnosis, was US$6.9 billion representing 16% of the US$42.2 billion global crop protection market in 2007, and 20% of the ~US$34 billion 2007 global commercial seed market. The US$6.9 billion biotech crop market comprised of US$3.2 billion for biotech maize (equivalent to 47% of global biotech crop market, up from 39% in 2006), US$2.6 billion for biotech soybean (37%, down from 44% in 2006), US$0.9 billion for biotech cotton (13%), and US$0.2 billion for biotech canola (3%). Of the US$6.9 billion biotech crop market, US$5.2 billion (76%) was in the industrial countries and US$1.6 billion (24%) was in the developing countries. 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 US$42.4 billion. The global value of the biotech crop market is projected at approximately US$7.5 billion for 2008.

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 2 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

Table 23. The Global Value of the Biotech Crop Market, 1996 to 2007

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
2007	6,872
Total	**42,344**

Source: Cropnosis, 2007 (Personal Communication).

of all events 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 2 is as comprehensive as documented in currently available databases from various countries.

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*. 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.

* *http://www.agbios.com*

While 23 countries planted commercialized biotech crops in 2007, an additional 29 countries, totaling 52, 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 615 approvals have been granted for 124 events** for 23 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 52 countries that have granted approvals for biotech crops, Japan tops the list followed by USA, Canada, South Korea, Australia, Mexico, the Philippines, New Zealand, the European Union and China. Maize has the most events approved (40) followed by cotton (18), canola (15), and soybean (8). The event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 24 approvals (EU=27 counted as 1 approval only), followed by insect resistant maize (MON810) and herbicide tolerant maize (NK603) both with 18 approvals, and insect resistant cotton (MON531/757/1076) with 16 approvals worldwide.

Concluding Comments

In 2007, the second year of the second decade of commercialization of biotech crops, 2006-2015, the global area of biotech crops continued to soar at double-digit rates to 114.3 million hectares (equivalent to 143.7 million "trait hectares"), with a gain of 12 million hectares, the second highest increase in global biotech crop area in the last five years. Growth measured in "trait hectares" between 2006 (117.7 million) and 2007 (143.7 million) was 22%, reflecting the actual growth between 2006 and 2007, which was almost double the apparent growth of only 12%, when conservatively measured in hectares. In 2007, the USA, followed by Argentina, Brazil, Canada, India and China continued to be the principal adopters of biotech crops globally, with the USA retaining its top world ranking with 57.7 million hectares (50% of global biotech area) spurred by a growing market for ethanol with the biotech maize area increasing by a substantial 40% – this was partially offset by smaller decreases in biotech soybean and cotton. Notably, 63% of biotech maize, 78% of biotech cotton and 37% of all biotech crops in the USA in 2007 were stacked products containing two or three traits that delivered multiple benefits. Stacked products are a very important feature and future trend which meets the multiple needs of farmers and consumers and are now increasingly deployed by ten countries – USA, Canada, the Philippines, Australia, Mexico, South Africa, Honduras, Chile, Colombia, and Argentina, with more countries expected to adopt stacked traits in the future.

** *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).*

Biotech crops achieved a very important milestone in 2007 with humanitarian implications – the number of small and resource-poor farmers benefiting from biotech crops in developing countries exceeded 10 million for the first time. Of the global total of 12 million beneficiary biotech farmers in 2007, (up from 10.3 million in 2006), over 90% or 11 million (up significantly from 9.3 million in 2006) were small and resource-poor farmers from developing countries; the balance of 1 million were large farmers from both industrial countries such as Canada and developing countries such as Argentina. Of the 11 million small farmers, most were Bt cotton farmers, 7.1 million in China (Bt cotton), 3.8 million in India (Bt cotton), and the balance of 100,000 in the Philippines (biotech maize), South Africa (biotech cotton, maize and soybeans) and the other eight developing countries which grew biotech crops in 2007. This initial modest contribution of increased small farmer income from biotech crops towards the Millennium Development Goals of reducing poverty by 50% by 2015 is a very encouraging and important development, which has enormous potential in the second decade of commercialization, 2006 to 2015.

During the period 1996 to 2007, the proportion of the global area of biotech crops grown by developing countries has increased consistently every single year. In 2007, 43% of the global biotech crop area, (up from 40% in 2006), and equivalent to 49.4 million hectares, was grown in developing countries where growth between 2006 and 2007 was substantially higher (78.5 million hectares or 21% growth) than industrial countries (3.8 million hectares or 6% growth). It is noteworthy that the five principal developing countries committed to biotech crops, span all three continents of the South; they are India and China in Asia, Argentina and Brazil in Latin America and South Africa on the African continent – collectively they represent 2.6 billion people or 40% of the global population, with a combined population of 1.3 billion who are completely dependent on agriculture, including millions of small and resource-poor farmers who represent the majority of the poor in the world. The increasing collective impact of the five principal developing countries is an important continuing trend with implications for the future adoption and acceptance of biotech crops worldwide.

It is noteworthy that more than half (55% or 3.6 billion people) of the global population of 6.5 billion live in the 23 countries where biotech crops were grown in 2007 and generated significant and multiple benefits worth US$7 billion globally. Also, more than half (52% or 776 million hectares) of the 1.5 billion hectares of cropland in the world is in the 23 countries where approved biotech crops were grown in 2007. The accumulated hectarage from 1996 to 2007 exceeded two thirds of a billion hectares for the first time at 690 million hectares (1.7 billion acres), with an unprecedented 67-fold increase between 1996 and 2007, making it the fastest adopted crop technology in recent history. The 114.3 million hectares of biotech crops in 2007 represent 8% of the 1.5 billion hectares of cropland in the world.

The positive experience of the first 12 (dozen) years of commercialization of biotech crops, 1996 to 2007, 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 690 million hectares (1.7 billion acres), equivalent to almost half of the total land area of the USA or China, were planted globally in 27 countries in the 12-year period 1996 to 2007. The 67-fold increase in global commercialized biotech crops in the same 12-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 55 million individual decisions by farmers in 23 countries over a 12-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. Notably, 2007 marks the first year when the accumulated number of farmer decisions to adopt biotech crops has exceeded 50 million. The number of farmers benefiting from biotech crops continued to grow in 2007 to reach 12 million, up from 10.3 million in 2006. Notably, over 90%, equivalent to 11 million (compared with 9.3 million in 2006) benefiting from biotech crops were small and resource-poor farmers mostly planting Bt cotton, whose increased incomes have contributed to the alleviation of their poverty. The 11 million small farmers included: 7.1 million resource-poor farmers in all the cotton growing provinces of China; 3.8 million, and rapidly growing, small farmers in India; 100,000 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 eight developing countries where biotech crops were planted in 2007.

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.

The most recent survey of the global impact of biotech crops for the first eleven years of commercialization of biotech crops, 1996 to 2006, (Brookes and Barfoot, 2008) estimates that the global net economic benefits to crop biotech farmers in 2006 was US$7 billion, and US$34 billion for the accumulated benefits during the period 1996 to 2006; these estimates include the benefits associated with the double cropping of biotech soybean in Argentina. The accumulative reduction in pesticides for the period 1996 to 2006 was estimated at 289,300 metric tons of active ingredient, which is equivalent to a 15.5% 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 a reduction of greenhouse gases and mitigate 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 2006 this was an estimated saving of 1.2 billion kg of carbon dioxide (CO_2), equivalent to reducing the number of cars on the roads by 0.5 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 2006 to 13.6 billion kg of CO_2, or removing 6.5 million cars off the road. Thus, in 2006 the combined permanent and additional savings through sequestration was equivalent to a saving of 14.7 billion kg of CO_2 or removing 6.5 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.

The six principal countries that have gained US$0.5 billion or more from biotech crops, during the period 1996 to 2006 are, in descending order of magnitude, the USA (US$15.9 billion), Argentina (US$6.6), China (US$5.8 billion), Brazil (US$1.9 billion), India (US$1.5 billion), Canada (US$1.2 billion), and others (US$1.1 billion) for a total of US$34 billion. Distribution of economic benefits amongst the four major biotech crops for the period 1996 to 2006 was as follows: soybean US$17.5 billion, cotton US$10.6 billion, maize US$4.8 billion, and canola US$1.1 billion for a total of US$34 billion. Distribution of economic benefits at the farm level by trait, for the decade 1996 to 2005 is as follows: herbicide tolerant soybean US$17.5 billion, Bt cotton US$9.8 billion, insect resistant maize US$3.3 billion, herbicide tolerant canola US$1.1 billion, and herbicide tolerant maize US$1.1 billion, herbicide tolerant cotton US$814 million and the balance for other crops for a total of approximately US$34 billion. The aggregate economic benefits from herbicide tolerance across all four crops was US$20.5 billion equivalent to 60% of the total of US$34 billion, with the balance of US$13.5 billion, equivalent to 40% due to insect resistance in cotton and maize.

Dr. Jikun Huang, from the Center of Chinese Academy of Sciences, has projected potential gains for China of $5 billion in 2010, US$1 billion from Bt cotton and US$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 US$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.

It is evident that much progress has been made in the first decade of commercialization of biotech crops but progress to-date is just the "tip of the iceberg", compared with potential progress in the second decade of commercialization, 2006-2015. It is a fortunate coincidence that the last year of the second decade of commercialization of biotech crops, 2015 is also the year of the Millennium Development Goals (MDG). This offers the unique opportunity for the global biotechnology community, from the North and the South, the public and the private sectors, to define in 2008 the contributions that biotech crops will make to the Millennium Development Goals in 2015 – this will give the global biotech crop community seven years to work towards implementing an action plan that will deliver on the goals for 2015. Five goals, described in the following paragraphs, deserve consideration because there is a high probability that crop biotechnology can deliver on these MDG promises by 2015.

1. ***Increasing global crop productivity to improve food, feed and fiber security in sustainable crop production systems that also conserve biodiversity***
   A significant contribution has already been made in the first decade of commercialization through deployment of biotech crops more tolerant to the biotic stresses caused by pests, weeds and diseases. This sustainable increase in productivity on the same area of cropland allows biodiversity to be conserved because it will help preclude the need for deforestation and slash and burn agriculture. Increases in productivity of maize for feed, the oil seed crops soybean and canola, and the fiber crop cotton have been significant with gains valued at US$34 billion in the period 1996 to 2006. Initial progress has been made with food crops with white maize in South Africa, ingredients of biotech maize, soybean and canola used commonly in processed foods, biotech papaya and squash consumed in the USA, and papaya in China. Progress with control of abiotic stresses is expected in the near term with drought tolerance available within five years and salt tolerance thereafter. A new family of input and output traits will not only increase yield but provide more nutritious food, such as omega-3 oil and golden rice enriched with pro-vitamin A, expected to be approved by 2012. The most important event in the next five years is the expected approval of biotech rice, the most important food crop in the world, already temporarily released in Iran in 2005. Extensive multi-locational field trials of biotech rice have been completed in China and the product is being considered for commercial release. Field trials are already underway in India and many countries in Asia have research programs, which would be expedited to deliver biotech rice products following approval by China. Biotech rice has enormous potential to coincidentally contribute to food security and alleviation of poverty.

2. ***Contributing to the Alleviation of Poverty and Hunger***
   Fifty percent of the world's poorest people are small and resource-poor farmers, and another 20% are the rural landless dependent on agriculture for their livelihoods. Thus, increasing income of small and resource-poor farmers contributes directly to the poverty alleviation of a large majority of the world's poorest people. Biotech cotton has already made a significant

contribution to the income of poor farmers in the first decade, 1996 to 2005, and this can be enhanced significantly in the second decade. Biotech maize is already delivering benefits to a modest number of small farmers and holds enormous potential by 2015. Crops such as biotech eggplant, being developed in India, the Philippines, and Bangladesh are expected to be approved in the near term and used almost exclusively by millions of small farmers. Focusing on a pro-poor agenda for orphan crops such as cassava, sweet potato, sorghum and vegetables will allow a diversified and balanced crop biotech program to be developed that is specifically targeted at alleviation of poverty and hunger.

3. ***Reducing the Environmental Footprint of Agriculture***
   Conventional agriculture has impacted significantly on the environment and biotechnology can be used to reduce the environmental footprint of agriculture. Progress in the first decade includes a significant reduction in pesticides, saving on fossil fuels and decreasing CO_2 emissions through no/less ploughing, and conserving soil and moisture by optimizing the practice of no till through application of herbicide tolerance. Increasing efficiency of water usage will have a major impact on conservation and availability of water globally. Seventy percent of fresh water is currently used by agriculture globally, and this is obviously not sustainable in the future as the population increases by almost 50% to 9.2 billion by 2050; in developing countries the current agricultural usage of fresh water is even higher at 86%. Other biotech crop applications that will become available towards the end of the second decade 2006-2015 are crops with increased nitrogen efficiency, which has implications for global warming and the pollution of aquifers and deltas, such as the Mekong, with nitrogen related pollutants. The first biotech maize varieties with drought tolerance are expected to be commercialized by around 2011 and the trait has already been incorporated in several other crops. Drought tolerance is expected to have a major impact on cropping systems worldwide, particularly in developing countries where drought is more prevalent and severe than industrial countries.

4. ***Mitigating Climate Change and Reducing Greenhouse Gases (GHG)***
   Droughts, floods, and temperature changes are predicted to become more prevalent and more severe, and hence there will be a need to expedite improvement of crops that are well adapted to changing climatic conditions. Several biotech crop tools, including diagnostics, genomics, molecular marker-assisted selection (MAS) and biotech crops can be used for 'speeding the breeding' and mitigating the effects of climate change. Biotech crops are already contributing to reducing CO_2 emissions by precluding the need for ploughing a significant portion of cropped land, conserving soil and moisture, reducing pesticide spraying as well as sequestering CO_2.

5. ***Contributing to the Cost-effective Production of Biofuels***
   Biotechnology can be used to cost effectively optimize the productivity of biomass/hectare

of first generation food/feed and fiber crops and also second generation energy crops. This can be achieved by developing crops tolerant to abiotic stresses (drought/salinity) and biotic stresses (pests, weeds, diseases) and also to raise the ceiling of potential yield per hectare through modifying plant metabolism. There is also an opportunity to utilize biotechnology to develop more effective enzymes for the downstream processing of biofuels.

The Future

The future for biotech crops looks encouraging. The number of biotech crop countries, crops and traits and hectarage are projected to double between 2006 and 2015, the second decade of commercialization; in the developing countries, Burkina Faso and Egypt, and possibly Vietnam are potential candidates for adopting biotech crops in the next one or two years. The lifting of the four-year ban on biotech canola in late November 2007 in the states of Victoria and New South Wales was a very important development for the future of biotech crops in Australia, where drought tolerant wheat is already being field-tested. By 2015 the number of farmers adopting biotech crops could increase up to ten fold to 100 million, or more, assuming that only biotech rice will be approved in the near term. Genes conferring a degree of drought tolerance, expected to become available around 2011 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 vital 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. Other products, including pharmaceutical products, oral vaccines, and specialty products will also be featured. The use of biotechnology to increase efficiency of first generation food/feed crops and second-generation energy crops for biofuels is likely to have significant 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. The key role of crop biotechnology is to cost-effectively optimize the yield of biomass/biofuel per hectare, which in turn will provide more affordable fuel. However by far, the most important potential contribution of biotech crops will be their contribution to the humanitarian Millennium Development Goals (MDG) of reducing poverty and hunger by 50% by 2015. 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.

The most important message in the recently published 2008 World Bank Development Report "Agriculture for Development" is that ***"Agriculture is a vital development tool for achieving the Millennium Development Goals that calls for halving by 2015 the share of people suffering from extreme poverty and hunger"*** (World Bank, 2008). The Report offers an important reminder that three out of every four people in developing countries live in rural areas and most of them depend directly or indirectly on agriculture for their livelihoods. It recognizes that overcoming abject poverty cannot be achieved in Sub Saharan Africa without a revolution in agricultural productivity for the millions of suffering subsistence farmer in Africa, most of them women. However, it also draws attention to the fact that Asia's fast growing economies, where most of the wealth of the developing world is being created, are also home to 600 million rural people (compared with 770 million total population of Sub Saharan Africa) living in extreme poverty, and that rural poverty in Asia will remain life-threatening for millions of rural poor for decades to come. It is a stark fact that poverty today is a rural phenomenon where 50% of the poorest people in the world are resource-poor farmers and another 20%, the rural landless, who are completely dependent on agriculture for their livelihoods. Thus, the majority, 70%, of the world's poorest people are small and resource-poor farmers and the rural landless labor who live and toil on the land. The challenge is to transform this concentration of poverty in agriculture into an opportunity for alleviating poverty by sharing with resource-poor farmers the knowledge and experience of those from developing countries who have successfully employed biotech crops to increase crop productivity, and in turn income. The World Bank Report specifically recognizes that the revolution in biotechnology and information offer unique opportunities to use agriculture to promote development, but cautions that there is a risk that fast-moving biotech crops can easily be missed by developing countries if the political will and international assistance support is not forthcoming, particularly for the more controversial application of biotech/GM crops which is the focus of this ISAAA Review. It is encouraging to witness the growing "political will" and conviction of visionary politicians and lead farmers for biotech/GM crops in several of the lead developing countries highlighted in this Review. The challenge for the international community and the lead biotech crop developing countries of India, China, Argentina, Brazil, and South Africa, which have already benefited from biotech crops, is to openly share their experience and knowledge with the legion of developing countries that have yet to have first-hand experience with biotech crops. To implement this will require urgent but modest financial support from the philanthropic foundations, the bilateral and multilateral AID organizations and from all the multinationals in the private sector that are benefiting from the US$7 billion biotech crop industry today. Failure to provide this critical support at this time will risk many developing countries missing out on a one-time window of opportunity and become permanently disadvantaged and non-competitive in crop productivity, with all its dire implications for the hope of alleviating poverty. There is no substitution for sharing the collective experience of a "national team of practitioners" who have been involved in a successful national crop biotech program such as Bt cotton in India or China or biotech maize in South Africa or the Philippines. The national team sharing the experience should include all the key resource personnel, including politicians, policy makers, agronomists, biotechnologists, economists and farmers who have been directly engaged with all aspects of biotech crops. Both the pros and the cons must be frankly shared so that there is no need for newcomers to the technology to reinvent the wheel. One key question that must be asked of the team sharing the experience is "how would you implement a crop biotech program differently, the second time around " i.e. what have been the lessons and learning of the first generation of biotech crop adopters that can be shared with second generation adopters so that the latter can gain from the experience.

The most important constraint to biotech crops in most developing countries, that deserves highlighting, is the lack of appropriate cost-effective and responsible regulation systems that incorporate all the lessons of a dozen years of regulation. Current regulatory systems in most developing countries are usually inappropriate, unnecessarily cumbersome and in many cases it is impossible to implement the system to approve products which can cost up to US$1 million or more to deregulate – this is beyond the means of most developing countries. The current regulatory systems were designed more than ten years ago to meet the initial needs of industrial countries dealing with a new technology and with access to significant resources for regulation which developing countries simply do not have – the challenge for developing countries is "how to do a lot with little." With the accumulated knowledge of the last dozen years it is now possible to design appropriate regulatory systems that are responsible, rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries – this should be assigned top priority. Today unnecessary and unjustified stringent standards designed to meet the needs of resource-rich industrial countries are denying the developing countries timely access to products such as golden rice, whilst millions die unnecessarily in the interim. This is a moral dilemma, where the demands of regulatory systems have become "the end and not the means", overriding common sense, and where "the regulatory surgery may be successful but the patient died."

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 *SEAsia*Center and his staff, for always providing excellent and expeditious services for formatting and proofreading the manuscript. Particular thanks to Rhodora Aldemita for coordinating and verifying the entire document and compiling Appendix 2, with assistance from Margarita Escaler, and to Bhagirath Choudhary for providing significant input. Thanks also to Mariechel Navarro, Clement Dionglay, Von Mark Cruz, Panfilo De Guzman, 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.

ABSPII. 2007. Agricultural Biotechnology Support Project II (ABSPII). http://www.absp2.cornell.edu/projects/project.cfm?productid=2.

AgBioview. 2007. GM Canola in Australia. May 28, 2007.

Anderson, K., E. Valenzuela, and L.A. Jackson. 2006. Recent and Prospective Adoption of Genetically Modified Cotton: A Global CGE Analysis of Economic Impacts. World Bank Policy Research Working Paper 3917. pp. 1-27.

Apted, S., D. McDonald, and H. Rodgers. 2005. Transgenic Crops: Welfare Implications for Australia. Australia Bureau of Agriculture and Research Economics (ABARE).

Avellaneda, J. 2006. Voices of Plant Biotechnology. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Beauville, J. 2006. Voices of Plant Biotechnology. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Bearden, R. 2006. Voices of Plant Biotechnology. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Bennett, R., Y. Ismael, U. Kambhampati and S. Morse. 2004. Economic impact of genetically modified cotton in India. AgBioForum, 7(3): 96-100.

Bennett, R., Y. Ismael, U. Kambhampati and S. Morse. 2006. Farm-level economic performance of genetically modified cotton in Maharastra, India. Review of Agricultural Economics, 28(1): 59-71.

Brazilian Government. 2007. http://www.presidencia.gov.br.

Brookes, G. and P. Barfoot. 2007. Personal Communication.

Brookes, G. and P. Barfoot. 2008. GM Crops: Global Socio-economic and Environmental Impacts 1996-2006. P.G. Economics 2008. In Press.

Bureau of Indian Standards. 2007. Annual Report. http://www.bis.org.in/AnnualReport2005-06.pdf.

Buzdugan, L. 2006. The experience of farmer Lucina Buzdungan with RR Soybean in Romania. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Carneiro, P. 2007. Personal Communication.

Canola Council of Canada. 2007. Impact of Transgenic Canola on Growers Industry and Environment. http://www.canol-council.org/manual/gmo/gmo_main.htm.

Chidambaram, P. 2007. Finance Minister of India at the opening of the Seventh Edition of Bangalore's Annual Biotechnology Event, Bio-2007 on 7-9 June 2007 at Bangalore. In Indian Express, June 8, 2007. http://www.indianexpress.com/story/33014.htm.

Cotton Advisory Board (CAB). 2007. Minutes of the meetings for the cotton year 2006-07 and cotton projections for 2007-08 season, Office of the Textile Commissioner, Ministry of Textile, Government of India held on 9 August 2007 at Mumbai, India and the National Cotton Scenario 2006-07, the Cotton Corporation of

India (CCI), Government of India. http://www.cotcorp.gov.in/current_cotton.asp

CTNBio Brazil, 2007. http://www.ctnbio.gov.br/index.php/content/views/366.2html.

Department of Biotechnology's (DBT) Energy Biosciences Strategy for India. 2007. http://www.dbtindia.nic.in/Energy_bioscience/EBS.htm.

Demont, M., K. Dillens, E. Mathijs and E. Tollens. 2007. GM crops in Europe: How much value and for whom? EuroChoices, 6(3): 46-53. December 2007. http://www.agr.kuleuven.ac.be/aee/clo/euwab.htm.

Fitzgerald, P. 2007. AgriFood Awareness Australia Limited.

Frisvold, G.B., J.M. Reeves, and R. Tronstad. 2006. Bt cotton adoption in the United States and China: International trade and welfare effects. AgBioForum, 9(2): 69-78.

Galvão Gomes, A. 2007. Economic and Environmental Benefits of Biotechnology in Brazil. Personal Communication.

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

Gonzales, L.A. 2005. Harnessing the Benefits of Biotechnology: The Case of Bt Corn in the Philippines. SIKAP/STRIVE Foundation, Los Baños, Laguna, Philippines.

Gonzales, L.A. 2007. Four Seasons of Post-Commercialization: Monitoring and Evaluating the Socio-Economic Impact of Bt Corn in the Philippines. SIKAP/STRIVE Foundation, Los Baños, Laguna, Philippines.

Gouse, M., C.A. Pray, J. Kirsten and D. Schimmelpfennig. 2005. A GM subsistence crop in Africa: The case of Bt white maize in South Africa. Int. J. Biotechnology, vol.7, nos. 1/2/3.

Grenouillet, C. 2006. Intérêt du maïs Bt Yieldgard pour limiter le risque de développement de fusarioses des épis et la présence de mycotines dans les grains, AFPP 8th Confé rence sur les maladies pes plantes, Tours, France, December 5-6, 2006.

Government of India. 2007. Monthly Report. October 2007. http://www.txcindia.com/html/mdo2007_1.pdf.

ICAR. 2002. Report on 2001 IPM Trial Cost Benefit Analysis. Indian Council for Agricultural Research (ICAR), New Delhi, India.

ICAR. 2006. Front Line Demonstrations on Cotton 2005-06, Mini Mission II, Technology Mission on Cotton. Indian Council for Agricultural Research (ICAR), New Delhi, India.

IDEA, CELERES, 2007. Contributed by Galvão Gomes, A. 2007. Personal Communication.

IGMORIS NIC INDIA. 2007. http://igmosris.nic.in/field_trials.asp.

IMRB International. 2007. Economic Benefits of Bt cotton Cultivation in India. IMRB International Survey, 2006-2007.

INIA, Chile. 2007. http://www.inia.cl/noticias2/index.php?id=3&tx_ttnews%5btt_news%5d=209&tx_ttnews%5bbackPid%5d=1&cHash=2391adb610l.

Indicus Analytics. 2007. Socio-economic appraisal of Bt cotton cultivation in India. Indicus Analytics Study.

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

James, C. 2005. Global Status of Commercialized Biotech/GM Crops: 2006. ISAAA Brief No. 34. ISAAA: Ithaca, NY.

James, C. 2004. Global Status of Commercialized Biotech/GM Crops: 2004 ISAAA Brief No. 32. ISAAA: Ithaca, NY.

James, C. 2003. Global Status of Commercialized Biotech/GM Crops: 2003. ISAAA Brief No. 30. ISAAA: Ithaca, NY.

James, C. 2002. Global Review of Commercialized Transgenic Crops: 2001 Feature Bt cotton. ISAAA Brief No. 29. ISAAA: Ithaca, NY.

James, C. 2001. Global Review of Commercialized Transgenic Crops: 2001. ISAAA Brief No. 24. ISAAA: Ithaca, NY.

James, C. 2000. Global Review of Commercialized Transgenic Crops: 2000. ISAAA Brief No. 21. ISAAA: Ithaca, NY.

James, C. 1999. Global Review of Commercialized Transgenic Crops: 1999. ISAAA Brief No. 17. ISAAA: Ithaca, NY.

James, C. 1998. Global Review of Commercialized Transgenic Crops: 1998. ISAAA Brief No. 8. ISAAA: Ithaca, NY.

James, C. 1997. Global Review of Commercialized Transgenic Crops: 1997. ISAAA Brief No. 5. ISAAA: Ithaca, NY.

James, C. and A.F. Krattiger. 1996. Global Review of the Field Testing and Commercialization of Transgenic Plants 1986 to 2005. The First Decade of Crop Biotechnology, 1986 to 1995. ISAAA Brief No. 1. ISAAA: Ithaca, NY.

Javier, P.A., M.V. Agsaoay and J.L. dela Cruz. 2004. Influence of YieldGard on the effectiveness of *Trichogramma evanescens* (Hymenoptera:Trichogrammatidae), an egg parasitoid of Asian corn borer, *Ostrinia furnacalis* (Guenee). Project Terminal Report. National Crop Protection Center, University of the Philippines Los Baños. 40 pp.

Khichad, B. 2007. Experience of Mr. Balbir Khichad a Bt cotton farmer from Haryana. ISAAA.

Lok Sabha, Parliament of India. 2007. Ethanol blended petrol. Gazette notification No. 705 (E) dated 27.10.2004. The Gazette of India and Starred Question no. 332. http://164.100.24.208/lsq14/quest.asp?qref=5794.

Lopez, F. 2006. Voices of Plant Biotechnology. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Mclaren, A. 2007. Prime Minister of Australia. GM Crops. Sunday Herald, Sydney, Australia 7 September 2007.

Mdutshane, 2005. Experience of Chief Mdutshane with Bt maize in South Africa. Farmers Weekly, South Africa, 21 January 2005.

Mdletshe, P. 2004. Experience of Philiswe Mdletshe a small scale farmer with Bt cotton in South Africa. Agri News, South Africa, December 2004.

Miami Herald. 2007. Annual Meeting of African Development Bank in China. 26 May 2007.

Ministry of New and Renewable Energy, Government of India. 2007. Annual Report, 2006-07. http://mnes.nic.in/annualreport/2006_2007_English/HTML/ch6_pg6.htm.

Ministry of Petroleum and Natural Gas, Government of India. 2005. Biodiesel Purchase Policy. http://petroleum.nic.in/Bio-Diesel.pdf

Ministry of Rural Development, Government of India. 2007. Annual Report, 2006-07. http://rural.nic.in/annualrep0607/anualreport0607_eng.pdf.

Ministry of Textile, Government of India, 2007. Annual Report, 2006-2007.

Mlambo, V. 2007. Experience of Velapi Mlambo, a small scale farmer with Bt cotton in South Africa.

Morse, S., R. Bennett and Y. Ismael. 2004. Why Bt cotton pays for small scale producers in South Africa. Nature Biotechnology, 22(4): 379-80.

Musi, M. 2007. Experience of Molasi Musi, a small scale farmer with Bt maize in South Africa.

Naik, G. 2001. An analysis of socio-economic impact of Bt technology on Indian cotton farmers. Centre for Management in Agriculture, IIMA, India.

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

Pallister, J. 2006. Voices of Plant Biotechnology. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Patil, P.D. 2007. The President of India, Smt. Pratibha Devisingh Patil, at the National Academy of Agricultural Sciences at a special lecture on 'Agriculture Cannot Wait', 6 August 2007.

Pawar, S. 2007a. Indian Minister of Agriculture, at the September 2006 ILSI conference.

Pawar, S. 2007b. Union Minister of Agriculture and Consumer Affairs, Food and Public Distribution on the occasion of 78th Annual General Meeting of the ICAR Society, 17 May 2007.

Qaim, M. 2006. Adoption of Bt cotton and impact variability: Insights from India. Agricultural Economics Review, 28: 48-58.

Qingjun, N. 2007. Experience of Mr. Niu Qingjun a small Bt cotton farmer who grows approx 0.6 hectares of Bt cotton in China.

Ramgopal, N. 2006. Economics of Bt cotton vis-à-vis traditional cotton varieties: Study in Andhra Pradesh. Agro-Economic Research Center, Andhra University, Andhra Pradesh.

Ramadevi, P. 2007. Experience of Mrs. Aakkapalli Ramadevi a woman Bt cotton farmer from India who farms 3 acres of Bt cotton.

Ramon, G. and L. Malabed. 2007. A brief on the socio-economic impacts of living modified organisms (LMOs) in the Philippines. Submitted to the Secretariat of the Convention on Biological Diversity, 27 November 2007.

Rasquilha, J.M. 2006. Voices of Plant Biotechnology. Council for Biotechnology Information. http://whybiotech.com/html/pdf/Voices.pdf.

Sankula, S. 2006. Quantification of the Impacts on US Agriculture of Biotechnology-Derived Crops Planted in 2005. National Center for Food and Agricultural Policy, Washington, DC. November 2006. http://www.ncfap.org/whatwedo/pdf/2005biotechimpacts-finalversion.pdf.

Stein, A.J., H.P.S. Sachdev and M. Qaim. 2006. Potential impact and cost-effectiveness of Golden Rice. Nature Biotechnology, 24: 1200-01.

Singh, M. 2006. Prime Minister 2006. At the opening of the International Rice Congress in New Delhi, October 2006.

Sitole, R. 2004. Experience of Richard Sitole with Bt maize in South Africa. Presentation at traditional leaders conference, East London. South Africa Daily Dispatch, 28 October 2004.

Sunday Independent Business Report. 2005. on ARC, Makathini Flats on South Africa. 26 July 2005.

The Economist. 2007. Biotech Crop Plantings in Romania. November 17-23 edition. p. 63.

Textile Commissioner Office, Government of India. 2007. Monthly Report, October 2007. http://www.txcindia.com/html/mdo2007_1.pdf.

Trigo, E.J. and E.J. Cap. 2006. Ten Years of Genetically Modified Crops in Argentine Agriculture. Argentine Council for Information and Development of Biotechnology (ArgenBio), Buenos Aires, Argentina. December 2006.

University of Andra Pradesh, India. 2005. Study on Bt cotton in Andra Pradesh and India.

USDA/FAS. 2007. Cotton: World Markets and Trade Monthly Circular, 1 September 2007. FAS, USDA. http://www.fas.usda.gov/cotton/circular/Current.asp.

Yorobe, J.M., Jr. and C.B. Quicoy. 2006. Economic impact of Bt corn in the Philippines. The Philippine Agricultural Scientist, 89(3): 258-67.

World Bank. 2008. The World Development Report, Agriculture for Development. World Bank, Washington, DC. 365 pp.

Zhu, M. 2007. Personal Communication on Status of Bt poplars in China.

Appendix 1

Selected Events in India in 2007

There were several key developments in India during 2007 that merit noting in this Brief; the events are summarized in the following 5 sections quoting the official text released by the respective organizations:

1. SUPREME COURT LIFTS BAN ON FIELD TRIALS ON GM CROPS

The Supreme Court of India order dated 22.9.2006 directing the GEAC to stop all approvals was amended in the hearing held on 8 May 2007 to the extent that the GEAC may accord approval for commercial release of Bt cotton hybrids expressing approved gene events BG-I event, BG-II event, Event-I and GFM event. Further, the Supreme Court has also permitted conduct of field trials of GM crops expressing new gene events subject to specific conditions; the case is ongoing.

Source: Supreme Court order dated 8.5.2006 in Writ Petition 260/2005 in IA 4/2006 filed by M/s Aruna Rodrigues vs UoI at http://www.envfor.nic.in/divisions/csurv/geac/writ_petition.pdf

Referring to the Supreme Court judgment on lifting the ban on the field trials of GM crops, the Union Minister of State for Environment and Forests, Mr Namo Narayan Meena, said the entire research activities of the country which have been at a standstill will get momentum, and that the Genetic Engineering Approval Committee (GEAC) will be able to work speedily. Mr Meena assured the members of the Consultative Committee of the Ministry of Environment and Forests (MOEF) that along with treating agricultural biotechnology as a priority area for investments, priority will be given to proper risk assessment and to appropriate measures to mitigate its adverse impacts.

Source: http://pib.nic.in/release/release.asp?relid=27636

2. APPROVAL OF LARGE SCALE FIELD TRIALS FOR BT BRINJAL (EGGPLANT), MLRT FOR RICE, MUSTARD, BRINJAL, OKRA, GROUNDNUT, TOMATO AND POTATO

The Genetic Engineering Approval Committee (GEAC), India's apex biotechnology regulatory body, approved large scale field trials of the fruit and shoot borer resistant (FSBR) brinjal (eggplant) developed by Mahyco on 30 August 2007. It is the first large scale field trials for a genetically modified (GM) food crop in India.

The 7 varieties of brinjal hybrids MHB-4Bt, MHB-9Bt, MHB-10Bt, MHB-80Bt, MHB-99Bt, MHB-11Bt and MHB-39Bt expressing cry-1Ac gene (EE1 event) which makes the crop resistant to the FSB approved for a minimum of two seasons (2007 and 2008) of large scale trials (LST) in various agro-climatic zones under the direct supervision of the Indian Institute of Vegetable Research (IIVR), Varanasi, which is a premier public sector research institute of the Indian Council of Agricultural Research (ICAR) under the Ministry of Agriculture. The fruit and shoot borer (FSB) insect is a major constraint in brinjal production, which causes significant yield loss and reduces the number of marketable fruits. Farmers often resort to intensive use of pesticides to control the FSB. The GEAC also accords approval for experimental seed production of Bt brinjal hybrids with certain conditions. The FSB resistant varieties will be evaluated for their environmental safety and agronomic performance, soil impact assessment, food and feed safety assessment, toxicity, allergenicity, compositional and nutritional studies and efficacy in controlling FSB and their effect on beneficial insects in the fields of the Indian Institute of Vegetable Research. In order to ascertain direct benefits of new Bt brinjal hybrids to farmers, a three members sub-committee will closely look into the socio-economic aspects of Bt brinjal hybrids during the LST. The GEAC directed the IIVR and Mahyco to strictly comply with the Supreme

Court order dated 8 May 2007 for all field trials and seed production of different Bt brinjal hybrids. In order to share benefits of this technology with small resource poor farmers, Mahyco has already transferred this technology to public sector institutions in India, Bangladesh and the Philippines.

In addition to the approved four events of biotech cotton, the following six new events are at the different stages of regulatory approval for commercialization in India:

1) Five Bt cotton hybrids namely NHH-44, DBt-1, DBt-H1, DBt-H2, DBt-H5 and one Bt cotton variety, BN Bt, expressing the cry1Ac (Truncated and codon-modified) gene developed by the Central Institute for Cotton Research (CICR), Nagpur of the Indian Council of Agricultural Research (ICAR) of Ministry of Agriculture, India.
2) Permission to conduct multi location research trial (MLRT) of BG-II Roundup Ready flex Cotton hybrids containing stacked cry1Ac, cry2Ab (Event 15985) and CP4epsps (MON 88913) genes developed by M/s Maharashtra Hybrid Seeds Company Ltd., Mumbai.
3) Four Bt cotton hybrids JKCH 99 Bt, JK-Durga Bt, JK-Ishwar Bt and JK-Varun Bt containing stacked event expressing Cry1EC (Event 24) along with already commercialized Cry1Ac (Event 1) developed by M/s J.K. Agri Genetics Ltd., Hyderabad.
4) Eight cotton hybrids namely WS 102, WS103, WS 104, WS105, WS106, WS 107, WS109 and WS 110 containing cry1Ac and cry1F gene (WideStrike = Event 3006-210-23 and Event 281-24-236) developed by M/s Dow AgroSciences, Mumbai.
5) Five Bt cotton hybrids SCH1V1C1, SCH2V1C1, SCH3V1C1, SCH4V1C1 and SCHV1C1 expressing genes vip3Aa (COT102 event) and cry1Ab (COT67B event) developed by M/s Deltapine India Seed Pvt. Ltd., Hyderabad.
6) Three Bt cotton hybrids 5174 Bt, 3134 Bt and 5125 Bt expressing synthetic cry1C gene (Event 9124) developed by M/s Metahelix Life Science Pvt. Ltd., Bangalore.

Source: 78th Meeting of the Genetic Engineering Approval Committee held on 22.6.2007 available at http://www.envfor.nic.in/divisions/csurv/geac/geac-jun-78.pdf

The GEAC has also accorded permission to conduct Multi Location Research Trials (MLRT) for several new GM crops/events. To comply with the Supreme Court order, the GEAC stipulated that the MLRT should be undertaken by the Companies/Institutions either in their own premises, research farms, long-leased land or at the SAU/ICAR institutions. The following new GM crops have been accorded approval to undertake MLRT in 2007:

1) Conduct MLRT with marker free six transgenic Bt rice hybrids namely MRP 5305 Bt, MRP 5319 Bt, MRP 5401 Bt, MRP 5445 Bt, MRP 5629 Bt and MRP 5631 Bt containing cry1Ac gene developed by Mahyco.
2) Conduct MLRT with three Bt okra hybrids namely MHOK-10 Bt, MHOK-12 Bt and MHOK-421 Bt containing stacked cry1Ac, cry2Ab (Event 15985) and CP4epsps (Mon-88913) genes developed by Mahyco
3) Conduct MLRT with transgenic hybrid mustard DMH-1 and DMH-11 expressing barnase and barstar genes developed by Delhi University, Delhi.
4) Conduct MLRT of six hybrids of Bt brinjal containing cry1Ac gene (EE 1 event) by University of Agricultural Sciences, Dharwad, Karnataka.

5) Conduct Multi location research trials (MLRT) of four transgenic Bt brinjal namely Co2-Bt, MDU1-Bt, KKM1-Bt and PLR1-Bt containing cry1Ac gene (EE1 event) developed by Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu.
6) Conduct confined Multi Location Research Trial (MLRT) on 2 Bt cabbage hybrids namely SCB-3 Bt and SCB-7 Bt expressing cry1Ac gene developed by M/s. Sungro Seeds Research Ltd., New Delhi
7) Conduct contained limited field research trial (strip trial) with transgenic tomato (cv. Pusa. Ruby) expressing antisense ACC synthase gene developed by National Research Centre on Plant Biotechnology (NRCPB) of the Indian Agricultural Research Institute (IARI), New Delhi.
8) Permission for repeating the contained field research trial (strip trial) of groundnut plants vars JL-24 expressing chitinase gene from rice (Rchit) developed by ICRISAT, Hyderabad, Andhra Pradesh.
9) Extension of the period for conducting contained limited field research trial (strip trial) on RB-transgesnic potato lines (SP-951) developed by the Central Potato Research Institute (CPRI), Shimla of the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture.

Source: 78, 79 and 80th GEAC meeting held on 22.06.2007, 08.08.2007 and 01.10.2007 available at
http://www.envfor.nic.in/divisions/csurv/geac/geac-jun-78.pdf
http://www.envfor.nic.in/divisions/csurv/geac/geac-aug-79.pdf
http://www.envfor.nic.in/divisions/csurv/geac/decision-sep-80.pdf

3. MINISTRY OF ENVIRONMENT AND FORESTS EXEMPTS RULE ON APPROVAL FOR GM FOOD STUFFS

India's Ministry of Environment and Forests (MOEF) through the Gazette notification dated 11 Sept 2007 granted an exemption to Rule 11 titled "Permission and approval of food stuffs" of the manufacture, use, import, export and storage of hazardous microorganisms/genetically engineered organisms from the Cells Rules 1989 (Rules 1989) of the Environment Protection Act 1986. This exemption will allow producers not to seek approval from the Genetic Engineering Approval Committee (GEAC) to produce, sell, import or use food stuffs, ingredients in food stuffs and additives including processing aids containing or consisting of genetically engineered organisms or cells where the end product is not a living modified organism (LMO). However, the food stuffs derived from the GM organisms, as other food products will be regulated as per the Prevention of Food Adulteration Act and Rules 1954 and the recently enacted Food Safety and Standard Act, 2006 which is being implemented by the Ministry of Health and Family Welfare. The GEAC will continue to regulate and govern products consisting of living modified organisms (LMOs).

Source: The Gazette of India Extraordinary Part II Sec. 3(ii) S.O.No.1519 (E) New Delhi, published on 11 September, 2007

4. GOVERNMENTT OF INDIA BEGINS IMPLEMENTING REGULATIONS ON PROTECTING PLANT VARIETIES AND FARMERS' RIGHTS

India's Ministry of Agriculture has issued a new set of regulations aiming to protect plant varieties and farmers' rights. This is part of an effort to expedite the implementation of the Protection of Plant Varieties and Farmers' Rights Act 2001 and effective functioning of the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA). The new regulations came into force on December 7, 2006 and the PPV&FRA issued guidelines for submission of application for registration of plant varieties. All applications for plant varieties including new varieties and extant varieties and seed material for registration of varieties of 12 notified crop species namely rice, bread wheat, maize, sorghum, pearl millet, chick pea, pigeon pea, green gram, black gram, lintel, field pea and kidney bean being accepted for DUS testing and protection from 21 May, 2007.

Source: http://www.plantauthority.in/PDFile/Indgazette.pdf and http://www.plantauthority.in/publications.htm

5. ADOPTION OF NATIONAL BIOTECHNOLOGY DEVELOPMENT STRATEGY AND NATIONAL BIOTECHNOLOGY REGULATORY AUTHORITY (NBRA) TO BE FULLY FUNCTIONAL IN TWO YEARS.

Recognizing that biotechnology is a sunrise sector which requires focused attention, the Government of India approved the National Biotechnology Development Strategy. This was announced by the Union Minister for Science and Technology and Earth Sciences, Mr. Kapil Sibal. "The strategy, while enabling the full utilization of currently available opportunities in manufacturing and services, will lay a strong foundation for discovery and innovation, effectively utilizing novel technology platforms with potential to contribute to long term benefits in agriculture, animal productivity, human health, environmental security and sustainable industrial growth," said Sibal.

The key elements of the strategy are to set up a National Biotechnology Regulatory Authority (NBRA) which would act as an independent, autonomous, and professionally led body to provide a single window mechanism for biosafety clearance of genetically modified products and processes and will be administered by the Department of Biotechnology, of the Ministry of Science and Technology of India. A Biotechnology Industry Partnership Program (BIPP) for advanced technology will be launched to build world class human capital and cluster development; initiate grand challenges of national relevance in the areas of agriculture, health, energy and environment and promote new translational initiatives for the wide use of technologies, and leverage international partnerships to achieve global best practices in the S&T efforts for joint IP generation. Initiatives for the harmonization of regulatory processes, smooth trans-boundary movement of biological materials, and access of global markets for biotech products and processes are also included in the priorities.

Source: National Biotechnology Development Strategy, available at: http://www.dbtindia.nic.in/biotechstrategy/biotech_strategy.htm

Appendix 2

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 December 2007. Regulatory approval processes for biotech products vary from country to country and therefore, countries should be consulted for specific details.

Appendix 2. Global Status of Regulatory Approvals

Compiled by M. Escaler, ISAAA 2006; RR Aldemita, ISAAA 2007

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.*	IR	DBT 418	DeKalb Genetics Corporation	1998				
Maize	*Zea mays L.*	HT + IR	TC1507	Mycogen (Dow AgroSciences); Pioneer (Dupont)	2005	✓	2005		
Maize	*Zea mays L.*	IR + HT	MON-00603-6 x MON-00810-6	Monsanto Company	2007	✓	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
Alfalfa	*Medicago sativa*	HT	MonØØ1Ø1-8 x Mon -ØØ163-7 (J101 x J163)	Monsanto Co. & Forage Genetics International				2007	
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	✓			
Carnation	*Dianthus caryophyllus*	FC + HT	Moonlite (123.2.38)	Florigene Pty Ltd.	2007	✓			
Carnation	*Dianthus caryophyllus*	FC + HT	Moonshade (123.2.2)	Florigene Pty Ltd.	2007	✓			
Carnation	*Dianthus caryophyllus*	FC + HT	Moonshadow 11363	Florigene Pty Ltd.	2007	✓			
Carnation	*Dianthus caryophyllus*	FC + HT	Moonvista (123.8.8)	Florigene Pty Ltd.	2007	✓			
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	

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

Sources:
http://www.agbios.com
http://www.fas.usda.gov/itp/biotech/countries.html
http://www.ogtr.gov.au
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
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	
Maize	*Zea mays L.*	Lys	REN-ØØØ38-3 (LY038)	Monsanto Company			2007		
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	
Sugarbeet	*Beta vulgaris*	HT	GTSB77	Novartis Seeds; Monsanto Company			2002		
Sugarbeet	*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 + IR	31807 x 31808	Calgene Inc.				1998	
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

CANADA

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
Maize	*Zea mays L.*	IR	SYN-IR6Ø4-5 (MIR604)	Syngenta Seeds Inc	2007	✓		2007	2007
Papaya	*Carica papaya*	VR	55-1/63-1	Cornell University				2003	
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, ATBT04-36, SPBT02-5, SPBT02-7	Monsanto Company	1997	✓		1996	1997
Potato	*Solanum tuberosum L.*	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	1995	✓		1995	1995
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.*	HT	MON89788	Monsanto Company	2007	✓		2007	2007
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	
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2005	✓		2005	2005
Sugarbeet	*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	
Papaya	*Carica papaya*	VR	55-1/63-1	South China Agricultural University		✓		2006	
Petunia	*Petunia*	FC	CHS gene	Beijing University	1997	✓			
Poplar	*Populus nigra L.*	IR	Bt gene	Research Insitute of Foresty, Chinese Academy of Forestry	2003	✓			
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	not available	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		2006
Maize	*Zea mays L.*	IR	TC1507	Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont)	2006			2006	2006
Maize	*Zea mays L.*	HT	NK 603	Monsanto Company			2004		
Soybean	*Glycine max L.*	HR	Mon-Ø4Ø32-6	Monsanto Company					2007

EUROPEAN UNION (27 Member States)

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	2005			1997	1996
Argentine canola	*Brassica napus*	HT	T45	Bayer Crop Science				1998	1998
Argentine canola	*Brassica napus*	HT	MS8/RF3	Bayer Crop Science/ Plant Genetic Systems	2007		2007	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	Moonlite (123.2.38) (Flo 40644-4)	Florigene Pty Ltd.	2007				
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.*	IR + HT	DAS-Ø15Ø7-1 x MON-ØØ6Ø3-6	DOW AgroSciences LLC	2007		2007		
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
Maize	*Zea mays L.*	IR	Mon 863 x Mon 810	Monsato Company					2005
Maize	*Zea mays L.*	HT + IR	Mon 863 x NK603	Monsanto				2005	2005
Maize	*Zea mays L.*	HT + IR	DAS 59122	Dow-AgroSciences / Pioneer Hybrid	2007		2007	2007	2007
Soybean	*Glycine max L.*	HT	GTS 40-3-2	Monsanto Company				1996	1996
Sugarbeet	*Beta vulgaris*	HT	KM 00071-4 (H7-1)	KWS SAAT AG / Monsanto			2007	2007	2007
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	MON89249-2 (GT200)	Monsanto Company	2006			2001	2001
Argentine Canola	*Brassica napus*	HT +F	MS1, RF1 PGS1	Bayer CropScience	1996			1996	1996
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 + F	PHY-36	Bayer CropScience	1997			1997	1997
Argentine Canola	*Brassica napus*	HT	OXY 235	Bayer CropScience	1998			1999	1999
Argentine Canola	*Brassica napus*	HT	ACS - BN007-1	Bayer CropScience	2007	✓		2007	2007
Carnation	*Dianthus caryophyllus L.*	HT	FLO-40689-6	Suntory Limited	2007	✓			
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	SYN - IR67B-1	Syngenta Seeds Inc	2007	✓			
Cotton	*Gossypium hirsutum L.*	IR	SYN-IR102-7	Syngenta Seeds Inc	2007	✓			
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.*	HT + IR	LLCotton25 x 15985	Bayer CropScience	2007			2006	2007
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.*	IR +HT	DAS-59122-7 x NK603	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.	2006			2005	2006
Maize	*Zea mayz L.*	IR + HT	SYN - EV176-9	Syngenta Seeds Inc.	2007	✓	2007	1999	
Maize	*Zea mays L.*	HT	B16 (DLL25)	Dekalb Genetics Corporation	1999	✓		1997	2001
Maize	*Zea mays L.*	HT	T14	Bayer CropScience	2006			2001	2003
Maize	*Zea mays L.*	HT	T25	Bayer CropScience	2004	✓		1999	1999
Maize	*Zea mays L.*	HT	GA21	Monsanto Company	1998	✓	2003		
Maize	*Zea mays L.*	HT/ HT	DP-098140-6	DuPont Inc.	2007	✓	2004	2001	2001
Maize	*Zea mays L.*	HT	NK603	Monsanto Company	2001	✓	2004	2001	1996
Maize	*Zea mays L.*	HT + IR	176	Syngenta Seeds	1996		2004	2001	1996
Maize	*Zea mays L.*	HT + IR	Bt11	Syngenta Seeds	1996		2003	2001	
Maize	*Zea mays L.*	HT + IR	DBT418	Dekalb Genetics Corporation	1999			1999	2002
Maize	*Zea mays L.*	HT + IR	TC1507	Mycogen (c/o Dow AgroSciences); Pioneer (c/o Dupont)	2002	✓		2002	1997
Maize	*Zea mays L.*	IR	MON810	Monsanto Company	1996	✓		1997	2006
Maize	*Zea mays L.*	HT + IR	DAS-59122-7	Dow AgroSciences LLC/Pioneer	2006	✓	2007	2006	2006
Maize	*Zea mays L.*	HT + IR	MON88017	Monsanto Company	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	

JAPAN

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
Maize	*Zea mays L.*	IR	MON863	Monsanto Company	2004	✓		2002	2003
Maize	*Zea mays L.*	IR	DAS-Ø6275-8 (DAS-06275-8)	Dow AgroSciences LLC				2007	
Maize	*Zea mays L.*	IR	SYN-IR6Ø4-5 (MIR604)	Syngenta Seeds Inc	2007	✓		2007	
Maize	*Zea mayz L.*	IR	SYN IR162-4	Syngenta Seeds Inc.	2007	✓		2007	
Maize	*Zea mays L.*	HT + IR	SYN-IR6Ø4-5 x MON-00021-9	Syngenta Seeds Inc	2007	✓		2007	
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	SYN-BTØ11-1 x MON-ØØØ21-9	Syngenta Seeds Inc.	2007	✓		2007	
Maize	*Zea mays L.*	HT + IR	TC1507 x DAS59122-7 x NK603	Dow AgroSciences LLC	2006	✓		2005	2006
Maize	*Zea mays L.*	HT + IR	MON89034	Monsanto Company				2007	
Maize	*Zea mays L.*	LYS	LY038	Monsanto Company	2007	✓		2007	
Maize	*Zea mays L.*	Lys + IR	MON-ØØ81Ø-6 x LY038	Monsanto Company	2007	✓		2007	2007
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	
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	
Poplar	*Populus alba*	High Cell	AaXEG2	Incorporated Administrative Agency Forest Tree Breeding Center, Japan	2007	✓			
Rice	*Oryza sativa L.*	CPP	7CRP# 242-95-7	National Institute of Agrobiological Sciences (NIAS)	2007	✓			
Rice	*Oryza sativa L.*	CPP	7 Crp#10	National Institute of Agrobiological Sciences (NIAS)	2007	✓			
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	2003
Soybean	*Glycine max L.*	HT	MON89788	Monsanto Company				2007	
Soybean	*Glycine max L.*	Oil content	DD-026005-3	Du Pont	2007	✓		2007	
Soybean	*Glycine max L.*	Oil content	G94-1, G94-19, G168	DuPont Canada Agricultural Products	1999			2001	1996
Soybean	*Glycine max L.*	OC + HT	DP 305423-1	Du Pont	2007	✓			
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2007	✓		2003	2007
Sugarbeet	*Beta vulgaris*	HT	GTSB77	Monsanto Company				2003	
Sugarbeet	*Beta vulgaris*	HT	T120-7	Bayer CropScience				2001	2003
Tomato	*Lycopersicon esculentum*	DR	FLAVR SAVR	Calgene Inc.	1996			1997	1999

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	MS8 x RF3	Aventis Crop Science &Agrevo			2004		
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	1997	✓		1997	1997
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	ACS-GHØØ1-3 (LLCotton25)	Bayer CropScience (Aventis CropScience(AgrEvo))			2006		
Cotton	*Gossypium hirsutum L.*	HR + IR	DAS-21Ø23-5 x DAS-24236-5 x MON88913	Dow AgroSciences LLC &Pioneer Hi-Bred International Inc.			2006		
Cotton	*Gossypium hirsutum L.*	HR + IR	MON-15985-7 x MON-Ø1445-2	Monsanto			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	

MEXICO

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
Maize	*Zea mays L.*	IR	MON863	Monsanto Company				2003	
Maize	*Zea mays L.*	IR	MON88017	Monsanto Company			2006		
Maize	*Zea mays L.*	IR	SYN-IR6Ø4-5 (MIR604)	Syngenta Seeds Inc			2007		
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			2006		
Maize	*Zea mays L.*	IR-HT	MON863/MON810/NK603	Monsanto Company				2004	
Maize	*Zea mays L.*	IR+ HT	SYN-BTØ11-1 (BT11 (X4334CBR, X4734CBR))	Syngenta Seeds Inc.				2007	
Maize	*Zea mays L.*	IR +HT	DAS-59122-7 x NK603)	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.			2006		
Maize	*Zea mays L.*	IR + HT	DAS-59122-7 x TC1507 x NK603	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.			2007		
Maize	*Zea mays L.*	HT	DAS-59122-7 (DAS-59122-7)	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.			2004		
Maize	*Zea mays L.*	HT + IR	DAS-Ø15Ø7-1 x MON-ØØ6Ø3-6	DOW AgroSciences LLC			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	
Maize	*Zea mays L.*	HT	ACS-ZMØØ2-1 / ACS-ZMØØ3-2 (T14, T25)	Bayer CropScience (Aventis CropScience(AgrEvo))			2007		
Maize	*Zea mays L.*	HT + IR	TC1507 x DAS-59122-7)	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.				2006	
Maize	*Zea mays L.*	LYS	LY038	Monsanto Company				2007	
Tomato	*Lycopersicon esculentum*	DR	1345-4	DNA Plant Technology Corporation				1998	
Tomato	*Lycopersicon esculentum*	DR	FLAVR SAVR	Calgene Inc.	1995			1995	1995
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	
Rice	*Oryza sativa*	HT	LLRICE06, LLRICE62	Aventis Crop Science			2007		
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	1998	✓		1998	1998
Soybean	*Glycine max L.*	HT	ACS-GMØØ6-4 (A5547-127)	Bayer Crop Science			2003		
Sugarbeet	*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
Alfalfa	*Medicago sativa*	HT	J101 x J163	Monsanto Co. & Forage Genetics International				2007	
Argentine Canola	*Brassica 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	

NEW ZEALAND

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
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	
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company				2005	
Sugarbeet	*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-00863-5 x MON-00810-6 x MON-00603-6	Monsanto Company				2005	2004
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.*	IR +HT	DAS-59122-7 x NK603)	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.			2006		
Maize	*Zea mays L.*	HT + IR	SYN-BTØ11-1 x MON-ØØØ21-9	Syngenta Seeds Inc			2007		
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
Maize	*Zea mays L.*	IR	MIR1604	Syngenta Seeds Inc	2007			2007	2007
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	BT16	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
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company				2005	2005
Sugarbeet	*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	
Sugarbeet	*Beta vulgaris*	HT	GTSB77	Novartis Seeds; Monsanto Company				2001	
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company				2006	

SINGAPORE

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
Cotton	*Gossypium hirsutum L.*	HT	MON 88913	Monsanto company				2007	
Maize	*Zea mays L.*	HT	NK603	Monsanto Company				2006	2006
Maize	*Zea mays L.*	IR	MON863	Monsanto Company				2006	2006
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company			2007		

SOUTH AFRICA

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
Argentine Canola	*Brassica napus*	HT +F	Topas 19/2, HCN92	Bayer Crops Science/Aventis Crop Science			2001		
Argentine Canola	*Brassica napus*	HT	MS1, RF1	Bayer Crops Science/Aventis Crop Science			2001		
Argentine Canola	*Brassica napus*	HT	MS1,RF2	Bayer Crops Science/Aventis Crop Science			2001		
Argentine Canola	*Brassica napus*	HT	MS8RF3	Bayer Crops Science/Aventis Crop Science			2001		
Cotton	*Gossypium hirsutum L.*	HT	MON1445/1698	Monsanto Company	2000	✓			
Cotton	*Gossypium hirsutum L.*	IR	MON531	Monsanto Company	1997	✓		1997	1997
Cotton	*Gossypium hirsutum L.*	IR	MON15985	Monsanto Company	2005	✓		2005	2005
Cotton	*Gossypium hirsutum L.*	HT + IR	MON88913 x MON15985	Monsanto Company	2007	✓	2007		
Cotton	*Gossypium hirsutum L.*	HR	MON88913	Monsanto Company	2007	✓	2007		
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	2007	✓	2004		
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	

SOUTH KOREA

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
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	DAS-21Ø23-5 x DAS-24236-5 x MON-Ø1445-2	Dow AgroSciences LLC				2006	
Cotton	*Gossypium hirsutum L.*	HT + IR	DAS-21Ø23-5 x DAS-24236-5 x MON88913	Dow AgroSciences LLC & Pioneer Hi-Bred International Inc.				2006	
Cotton	*Gossypium hirsutum L.*	HT + IR	15985 X LLCotton25	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	
Maise	*Zea mays L.*	IR	SYN-IR6Ø4-5 (MIR604)	Syngenta Seeds Inc				2007	
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	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.				2006	
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	Dow AgroSciences LLC/Pioneer Hi-Bred International Inc.				2006	
Maize	*Zea mays L.*	HT + IR	Bt11 X GA21	Syngenta Seeds				approved	
Maize	*Zea mays L.*	HT + IR	MON88017 X MON810	Monsanto Company	--			2006	
Maize	*Zea mays L.*	HT + IR	SYN-BTØ11-1 x MON-ØØØ21-9	Syngenta Seeds Inc				2006	
Potato	*Solanum tuberosum L.*	IR	SPBT02-05	Monsanto Company	--			2004	
Potato	*Solanum tuberosum L.*	IR	RBBT06	Monsanto Company	--			2004	
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	
Sugarbeet	*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		
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.*	HT + IR	MON 89034	Monsanto Company		✓		2007	
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.*	IR	SYN-IR6Ø4-5 (MIR604)	Syngenta Seeds Inc	2007			2007	

USA

Crop	Latin Name	Trait	Event	Developer	Environment	* Planting	Food/Feed	Food	Feed
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		
Plum	*Prunus domestica*	VR	ARS-PLMC5-6 (C5)	USDA-Agricultural Research Service	2007				
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 Crop Science	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	MON89788	Monsanto Company	2007	✓	2007		
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		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2005	✓	2004		
Sugarbeet	*Beta vulgaris*	HT	T120-7	Bayer CropScience	1998	✓	1998		
Sugarbeet	*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		

Appendix 3

Useful Tables and Charts on the International Seed Trade

Reproduced with the Permission of the International Seed Federation (ISF)

Table 1. Seed Exports (FOB) of Selected Countries, 2006 (with over 100 Million $ Market)

Country	Agricultural Seeds	Horticultural Seeds	Total
USA	581	288	869
Netherlands	182	641	823
France	590	200	790
Germany	360	33	393
Denmark	216	40	256
Canada	180	71	251
Chile	114	60	174
Mexico	153	7	160
Italy	89	58	147
Hungary	137	8	145
Belgium	120	4	124
Others	829	416	1245
Total	**3551**	**1826**	**5377**

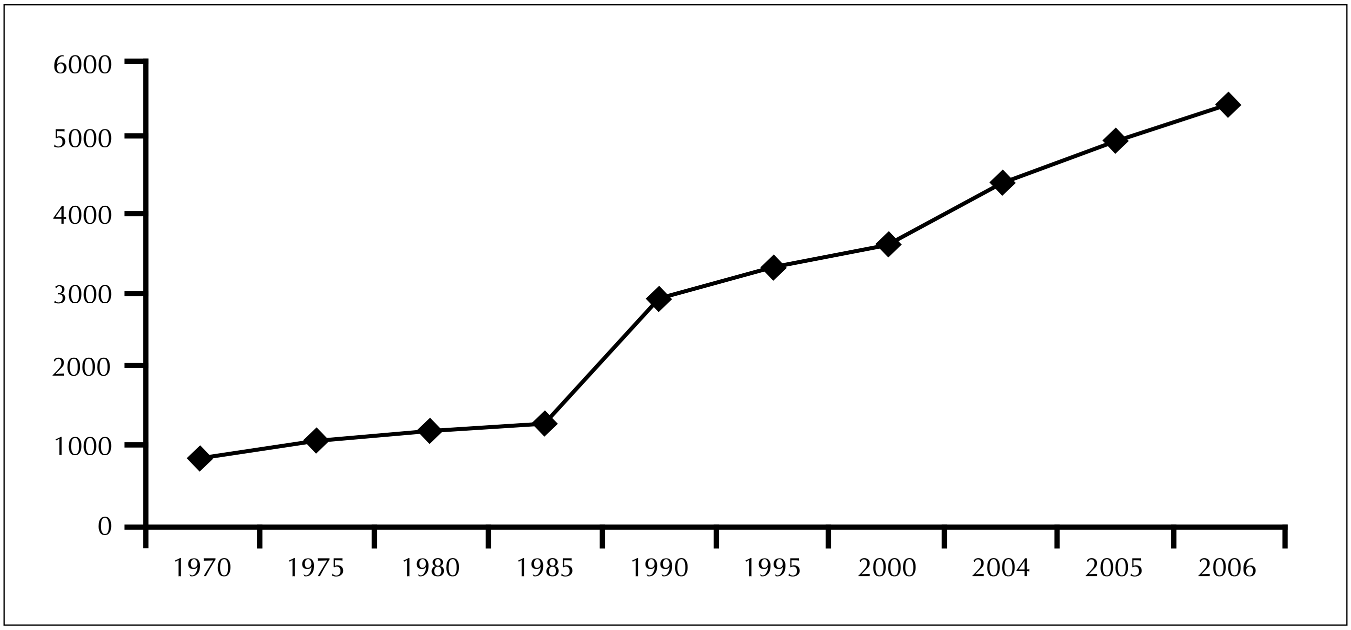
Source: International Seed Federation

Table 2. Seed Imports (FOB) of Selected Countries, 2006 (with over 100 Million $ Market)

Country	Agricultural Seeds	Horticultural Seeds	Total
USA	412	189	601
Mexico	236	142	378
France	275	78	353
Netherlands	138	180	318
Germany	251	50	301
Spain	139	147	286
Italy	161	111	272
Canada	163	54	217
Belgium	172	28	200
United Kingdom	130	43	176
Japan	78	59	137
Poland	98	38	136
Russian Fed.	93	28	121
China	56	50	106
Others	1152	557	1709
Total	**3354**	**1754**	**5311**

Source: International Seed Federation

Figure 1. Evolution of International Seed Trade (Million US$)



US$ 50.00

978-1-892456-42-7