ISAAA
INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

ISAAA Briefs

BRIEF 43

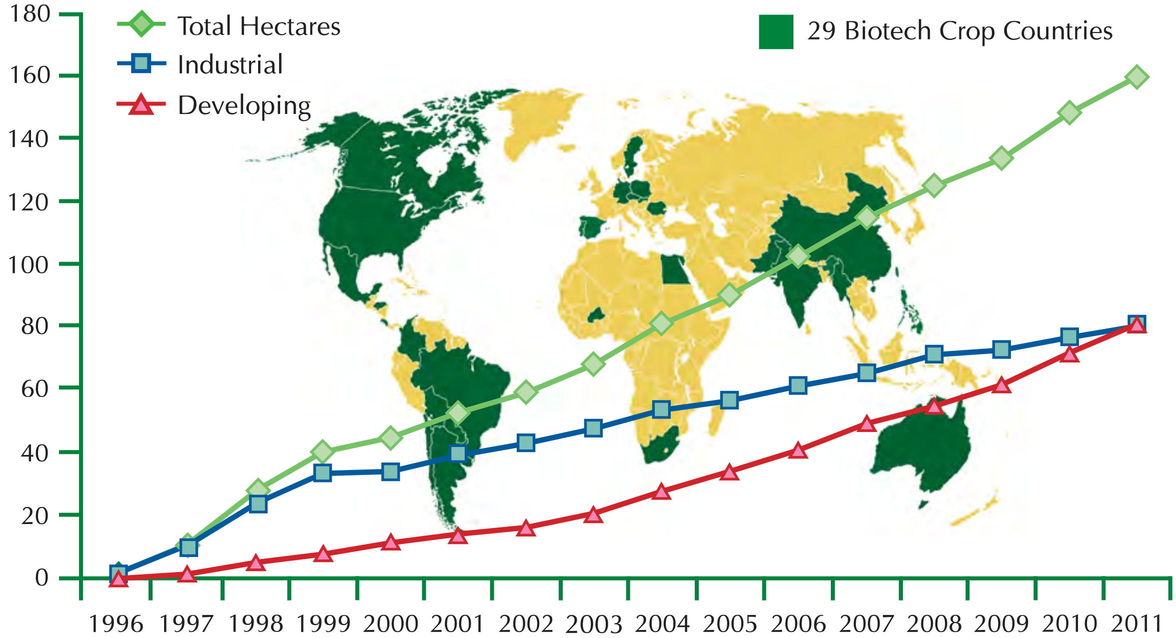
Global Status of Commercialized Biotech/GM Crops: 2011

By

Clive James
Chair, ISAAA Board of Directors

Dedicated by the author to the 1 billion poor and hungry people, and their survival

GLOBAL AREA OF BIOTECH CROPS
Million Hectares (1996-2011)



A record 16.7 million farmers, in 29 countries, planted 160 million hectares (395 million acres) in 2011, a sustained increase of 8% or 12 million hectares (30 million acres) over 2010.

Source: Clive James, 2011.

No. 43 - 2011

AUTHOR'S NOTE:

Global totals of millions of hectares planted with biotech crops have been rounded off to the nearest million and similarly, subtotals to the nearest 100,000 hectares, using both < and > characters; hence in some cases this leads to insignificant approximations, and there may be minor variances in some figures, totals, and percentage estimates that do not always add up exactly to 100% because of rounding off. 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 2011 information for Argentina, Brazil, Australia, South Africa, and Uruguay is hectares usually planted in the last quarter of 2011 and harvested in the first quarter of 2012 with some countries like the Philippines having more than one season per year. Thus, for countries of the Southern hemisphere, such as Brazil, Argentina and South Africa the estimates are projections, and thus are always subject to change due to weather, which may increase or decrease actual planted hectares before the end of the planting season when this Brief has to go to press. For Brazil, the winter maize crop (safrinha) planted in the last week of December 2011 and more intensively through January and February 2012 is classified as a 2011 crop in this Brief consistent with a policy which uses the first date of planting to determine the crop year. Details of the references listed in the Executive Summary are found in the full Brief 43.

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ISAAA

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Highlights of "Global Status of Commercialized Biotech/GM Crops: 2011"

By Clive James, Founder and Chair of ISAAA

Dedicated by the author to the 1 billion poor and hungry people, and their survival

Biotech Crop hectares continue to climb after 15 consecutive years of strong growth, as global population soars to 7 billion

Due to significant benefits, strong growth continued in 2011 with a double-digit increase of 12 million hectares, at an annual growth rate of 8%, reaching 160 million hectares, up from 148 million hectares in 2010.

A 94-fold increase from 1.7 million hectares in 1996 to 160 million hectares in 2011, makes biotech crops the fastest adopted crop technology in recent history.

The most compelling testimony to biotech crops is that, in the period 1996 to 2011, millions of farmers in 29 countries worldwide, made more than 100 million independent decisions to plant and replant an accumulated hectarage of 1.25 billion hectares – one principal reason underpins the trust and confidence of risk-averse farmers in the technology – biotech crops deliver sustainable and substantial, socioeconomic and environmental benefits.

Of the 29 countries planting biotech crops in 2011, 19 were developing and 10 were industrial countries. The top 10 countries each grew more than one million hectares and they provide a broad-based, worldwide foundation for diversified growth in the future.

In 2011, a record 16.7 million farmers, up 1.3 million or 8% from 2010, grew biotech crops – notably over 90%, or 15 million, were small resource-poor farmers in developing countries; farmers are the masters of risk aversion and in 2011, a record 7 million small farmers in China and another 7 million in India, elected to plant 14.5 million hectares of Bt cotton.

Developing countries grew ~50% of global biotech crops in 2011 and are expected to exceed industrial country hectarage in 2012. In 2011, growth rate for biotech crops was twice as fast, and twice as large, in developing countries, at 11% or 8.2 million hectares, versus 5% or 3.8 million hectares in industrial countries.

Stacked traits are an important feature – 12 countries planted biotech crops with two or more traits in 2011, and encouragingly 9 of the 12 were developing countries – 42.2 million hectares, or more than a quarter, of the 160 million hectares were stacked in 2011, up from 32.3 million hectares or 22% of the 148 million hectares in 2010.

The five lead developing countries in biotech crops are India and China in Asia, Brazil and Argentina in Latin America, and South Africa on the continent of Africa, which together represent 40% of the global population, which could reach 10.1 billion by 2100.

Brazil, for the third consecutive year, was the engine of growth globally, increasing its hectarage of biotech crops more than any other country – a record 4.9 million hectares, up 20% from 2010. A fast-track system approved 6 new products in 2011, including a homegrown biotech virus resistant bean, developed in the public sector by EMBRAPA (Brazilian Agricultural Research Cooperation).

The US continued to be the lead producer of biotech crops globally with 69.0 million hectares, with an average adoption rate of ~90% across all biotech crops. Planting of RR®alfalfa resumed with up to 200,000 hectares, plus 475,000 hectares of RR®sugarbeet. Virus resistant papaya from the US was approved for consumption as a fresh fruit/food in Japan, effective December 2011.

India celebrated the 10th anniversary of Bt cotton, with plantings exceeding 10 million hectares for the first time, reaching 10.6 million hectares, and occupying 88% of the record 12.1 million hectare cotton crop. The principal beneficiaries were 7 million small farmers growing, on average, 1.5 hectares of cotton. India enhanced farm income from Bt cotton by US$9.4 billion in the period 2002 to 2010 and US$2.5 billion in 2010 alone.

In China, 7 million small farmers (average of 0.5 hectare) grew a record 3.9 million hectares of Bt cotton at record adoption rate of 71.5%. The expected commercial approval of Golden Rice in the Philippines in 2013/14 will be of significance to China.

Mexico grew 161,500 hectares of biotech cotton, at an adoption rate of 87%, up a record 178% from 58,000 hectares in 2010. The aim is self-sufficiency in cotton, and planting of biotech maize in the northern states, to partially offset 10 million tons of increasing and costly maize imports.

Africa made steady progress with regulation. South Africa, Burkina Faso and Egypt, together planted a record 2.5 million hectares; three more countries, Kenya, Nigeria, and Uganda conducted field trials.

Six EU countries planted a record 114,490 hectares of biotech Bt maize, up 26% from 2010, and an additional two countries planted the biotech potato "Amflora".

From 1996 to 2010, <u>biotech crops contributed to Food Security, Sustainability and Climate Change</u> by: increasing crop production valued at US$78.4 billion; providing a better environment, by saving 443 million kg a.i. of pesticides; in 2010 alone reducing CO_2 emissions by 19 billion kg, equivalent to taking ~9 million cars off the road; conserving biodiversity by saving 91 million hectares of land; and helped alleviate poverty by helping 15.0 million small farmers who are some of the poorest people in the world. Biotech crops are essential but are not a panacea and adherence to good farming practices such as rotations and resistance management, are a must for biotech crops as they are for conventional crops.

There is an urgent need for appropriate, science-based and cost/time-effective regulatory systems that are <u>responsible, rigorous but not onerous,</u> for small and poor developing countries and for the EU.

Global value of biotech seed alone was valued at ~US$13 billion in 2011, with the end product of commercial grain from biotech crops valued at ~US$160 billion per year.

<u>Future Prospects</u> up to the MDG year of 2015 and beyond, look encouraging: an increase of up to ~10 new countries; the first biotech-based drought tolerant maize planned for release in North America in 2013 and in Africa by ~2017; Golden Rice in the Philippines in 2013/2014; biotech maize in China with a potential of ~30 million hectares and thereafter, Bt rice. Biotech crops have the potential to make a substantial contribution to the 2015 MDG goal of cutting poverty in half, by optimizing crop productivity, which can be expedited by public-private sector partnerships, such as the drought tolerant maize for Africa supported by philanthropic entities such as the Bill and Melinda Gates Foundation.

ISAAA's focus on the troika of knowledge sharing, innovation and creative partnership is consistent with the Gates Foundation's proposal to the G20 in November 2011.

Global Status of Commercialized Biotech/GM Crops: 2011

By

Clive James
Chair, ISAAA Board of Directors

Introduction

This Brief focuses on the global biotech crop highlights in 2011, and is dedicated to the 1 billion poor and hungry people, and their survival.

2011 marks the 16th anniversary of the commercialization, 1996-2011, 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 15 years of commercialization, 1996 to 2010, 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 15 years of commercialization, 1996 to 2010, 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 2010, developing and industrial countries contributed to a record 87-fold increase in the global area of biotech crops from 1.7 million hectares in 1996 to 148 million hectares in 2010. Adoption rates for biotech crops during the period 1996 to 2010 were unprecedented and, by recent agricultural industry standards, they represent the highest adoption rates for improved crops, for example, 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 weeds, insect pests and diseases varies from year-to-year and country to country, and hence location 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 almost 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. Around 15 million farmers in 29 countries grew biotech crops in 2010 and derived multiple benefits that included significant agronomic, environmental, health, social and economic advantages. ISAAA's 2010 Global Review (James, 2010) predicted that the number of farmers planting biotech crops, as well as the global area of biotech crops, would continue to grow in 2011. Global population was approximately 6.5 billion in 2006 and is expected to reach approximately up to 9.3 billion by 2050, when around 90% of the global population will reside in Asia, Africa, and Latin America. The latest projection by the UN Population (United Nations, 2011 World Population Prospects: The 2010 Revision) is that the population will continue to increase until the end of this century when it will plateau at 10.1 billion. In 2010, ~1 billion people in the developing countries suffered from hunger, malnutrition and poverty. Biotech crops represent promising technologies that can make a vital contribution, but are not a panacea, to global food, feed and fiber security. Biotech crops can also make a critically important contribution to the alleviation of poverty, the most formidable challenge facing global society which has made the commitment to the Millennium Development Goals (MDG) to cut poverty, hunger and malnutrition by half by 2015; this is also the year that marks 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 **contribute to global food, feed, and fiber security,** with benefits for producers, consumers and society at large alike; **contribute to more affordable food** as a result of coincidentally increasing productivity significantly and reducing production costs substantially;

self-sufficiency which is optimizing productivity and production on a nations own arable land, whereas food security is "food for all" without specific reference to source – self-sufficiency and food security are not mutually exclusive, currently there is an increased emphasis on self-sufficiency by both national programs and donors;

conserving biodiversity – as a land-saving technology capable of higher productivity on the current ~1.5 billion hectares of arable land, biotech crops can help preclude deforestation and protect 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; special attention should be assigned to more efficient use of water in crop production and development of drought tolerant biotech crops;

mitigating some of the challenges associated with climate change (increased frequency and severity of droughts, floods, epidemics, changes in temperature, rising sea levels exacerbating salinity and changes in temperature) and reducing greenhouse gases by using biotech applications for "speeding the breeding" in crop improvement programs to expedite the development of well adapted germplasm for rapidly changing climatic conditions and optimize the sequestration 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; and

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 who represent 70% of the world's poor; thus, **provide significant and important multiple and mutual benefits to producers, consumers and global society.**

A 2011 comprehensive study at the UN University, Tokyo (Adenle, 2011) concluded that: ***"there is an urgent need for the advancement of agricultural technology (e.g. crop biotechnology or genetic modification (GM) technology), particularly, to address food security problem, to fight against hunger and poverty crisis and to ensure sustainable agricultural production in developing countries. Over the past decade, the adoption of GM technology on a commercial basis has increased steadily around the world with a significant impact in terms of socio-economic, environment and human health benefits. However, GM technology is still surrounded by controversial debates with several factors hindering the adoption of GM crops."*** The study reviewed current literature on commercial production of GM crops, and assessed the benefits and constraints associated with adoption of GM crops in developing countries in the last 15 years. The manuscript provides policy guidance to facilitate the development and adoption of GM technology in developing countries.

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, including molecular breeding and the incorporation of transgenic novel traits. The improved crop products, resulting from the synergy of combining the best of the old with the best of the new must then be incorporated as the **innovative 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 innovative plant breeding offers global society.

The author has published global reviews of biotech crops annually since 1996 as ISAAA Briefs, James 2010, James, 2009b; James, 2008; James, 2007; 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 2011 and the changes that have occurred between 2010 and 2011 are highlighted. The global adoption trends during the last 16 years from 1996 to 2011 are also illustrated as well as the contribution of biotech crops to the world's 1 billion poor people, of which resource-poor farmers are a significant proportion.

This ISAAA Annual Global Review of biotech crops (Brief 43, 2011) is the sixteenth in an annual series. It documents the global database on the adoption and distribution of biotech crops in 2011 and in the Appendix there are six sections: 1) a comprehensive inventory of biotech crop products that have received regulatory approvals for import for food, feed use and for release into the environment, including planting, in specific countries; 2) a table with global status of crop protection in 2010 and 2011, courtesy of Cropnosis; 3) useful tables and charts on the international seed trade – these have been reproduced with permission of the International Seed Federation (ISF); 4) a table detailing the deployment of Bt cotton hybrids and varieties in India in 2011; 5) Listing of events, Bt cotton varieties and hybrids in India in 2011; and 6) EMBRAPA Annual Budget and Projects Around the World.

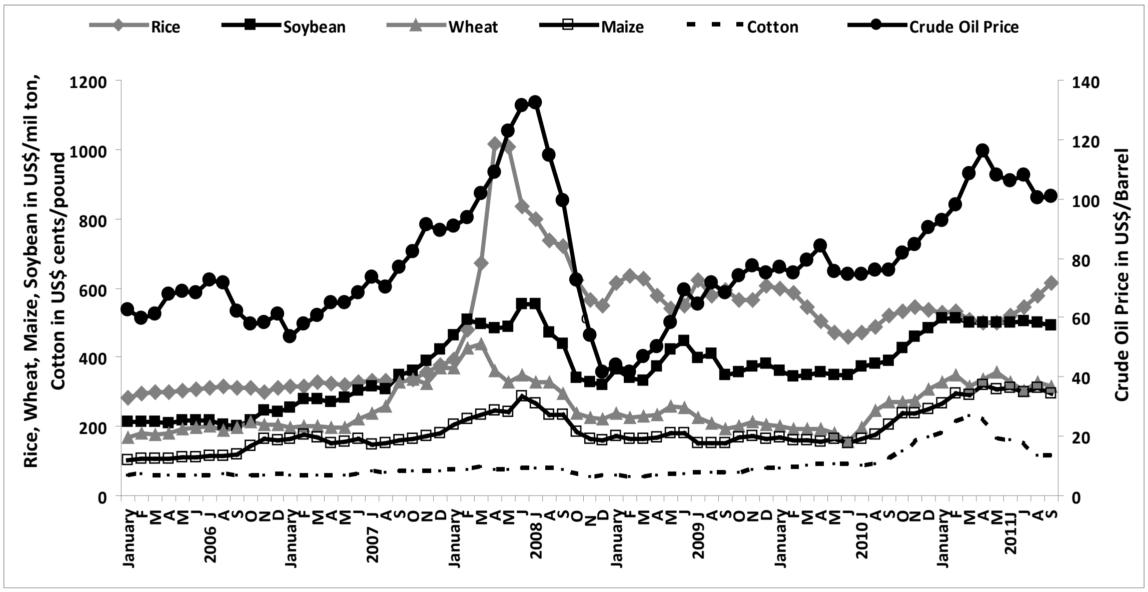
Note that the words rapeseed, canola, and Argentine canola are used synonymously, as well as transgenic, genetically modified crops, GM crops, and biotech crops, reflecting the usage of these words in different regions of the world, with biotech crops being used exclusively in this text because of its 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. All $ dollar values in this Brief are US dollars unless otherwise noted. Some of the listed references may not be cited in the text – for convenience they have been included because they are considered useful reading material and were used as preparatory documents for this Brief. Global totals of millions of hectares planted with biotech crops have been rounded off to the nearest million and similarly subtotals to the nearest 100,000 hectares, using both < and > characters; hence in some cases this leads to insignificant approximations, and there may be minor variances in some figures, totals, and percentage estimates that do not always add up exactly to 100% because of rounding off. 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 2011 information for Argentina, Brazil, Australia, South Africa, and Uruguay is hectares usually planted in the last quarter of 2011 and harvested in the first quarter of 2012, or later, with some countries like the Philippines planting crops in more than one season per year. Thus, for countries of the Southern hemisphere, such as Brazil and Argentina the estimates are projections, and thus are always subject to change due to weather, which may increase or decrease actual planted area before the end of the planting season when this Brief went to press. For Brazil, the winter maize crop (safrinha) planted at the end of December 2011 and more intensively through January and February 2012, is classified as a 2011 crop in this Brief, consistent with a policy which uses the first date of planting to determine the crop year. Country figures were sourced from The Economist, supplemented by data from World Bank, FAO and UNCTAD, when necessary.

Over the last 16 years, ISAAA has devoted considerable effort to consolidate all the available data on officially approved biotech crop adoption globally; it is important to note that 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. The range of crops are those defined as food, feed and fiber crops in the FAO database. 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 specific estimates. The "proprietary" ISAAA database on biotech crops is unique from two points of view; first, it provides a global perspective; second, it has used the same basic methodology, improved continuously for the last 15 years and hence provides continuity from the genesis of the commercialization of biotech crops in 1996, to the present. The database has gained acceptance internationally as a reliable benchmark of the global status of biotech food, feed and fiber crops and is widely cited in the scientific literature and the international press.

Global Area of Biotech Crops in 2011

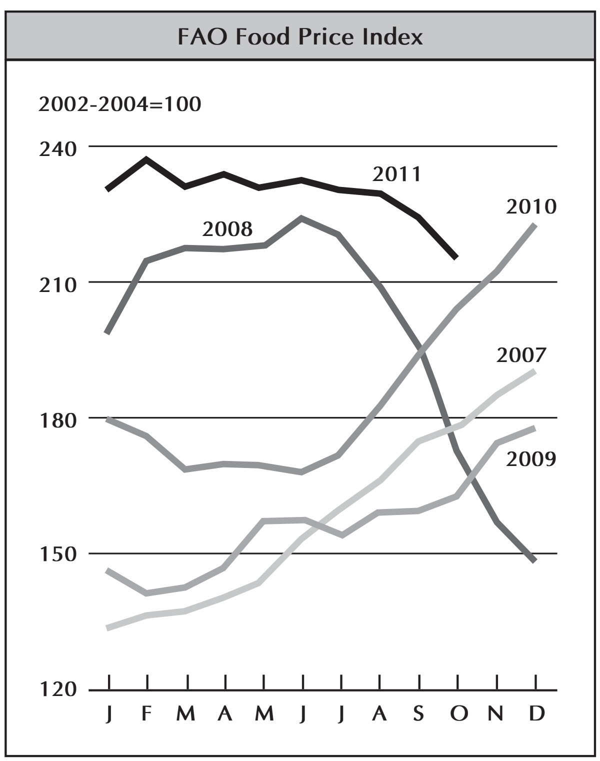
Subsequent to the peak prices of 2008, the price of oil has generally trended upwards in 2010 and 2011 (Figure 1), and in parallel there were increases, in the price of food, feed, and fiber commodities, rice, wheat, maize, soybean and cotton, with the latter reaching record prices in 2011, before correcting. The FAO Food Index (Figure 2) FAO was significantly higher in 2011

Figure 1. International Prices of Crop Commodities and a Barrel of Crude Oil, 2006 to 2011



Source: International Monetary Fund, 2011.

Figure 2. FAO Food Price Index, 2007 to 2011



Source: FAO, 2011.

than during the 2008 peak. The buoyant food, feed and fiber prices have provided incentives for farmers worldwide, resulting in increased hectarages of the principal crops and more investments in improved technologies, including biotech crops.

In 2011, the 16th year of commercialization, the global area of biotech crops continued to climb at a sustained growth rate of 8% or 12 million hectares reaching 160 million hectares or approximately 395 million acres (Table 1). The accumulated hectarage during the first sixteen years, 1996 to 2011, reached, over 1.25 billion hectares equivalent to 3.1 billion accumulated acres. Biotech crops have set a precedent in that the hectarage has grown impressively every single year for the past 16 years, since commercialization first began in 1996 with a remarkable 94-fold increase between 1996 and 2011. The number of farmers growing biotech crops in 2011 increased again by 1.3 million reaching 16.7 million (up from 15.4 million in 2010) of which over 90% or 15 million were small and resource-poor farmers from developing countries, representing some of the poorest people in the world.

Table 1. Global Area of Biotech Crops, the First 15 Years, 1996 to 2011

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
2008	125.0	308.8
2009	134.0	335.0
2010	148.0	365.0
2011	160.0	395.0
Total	**1,257.0**	**3,111.0**

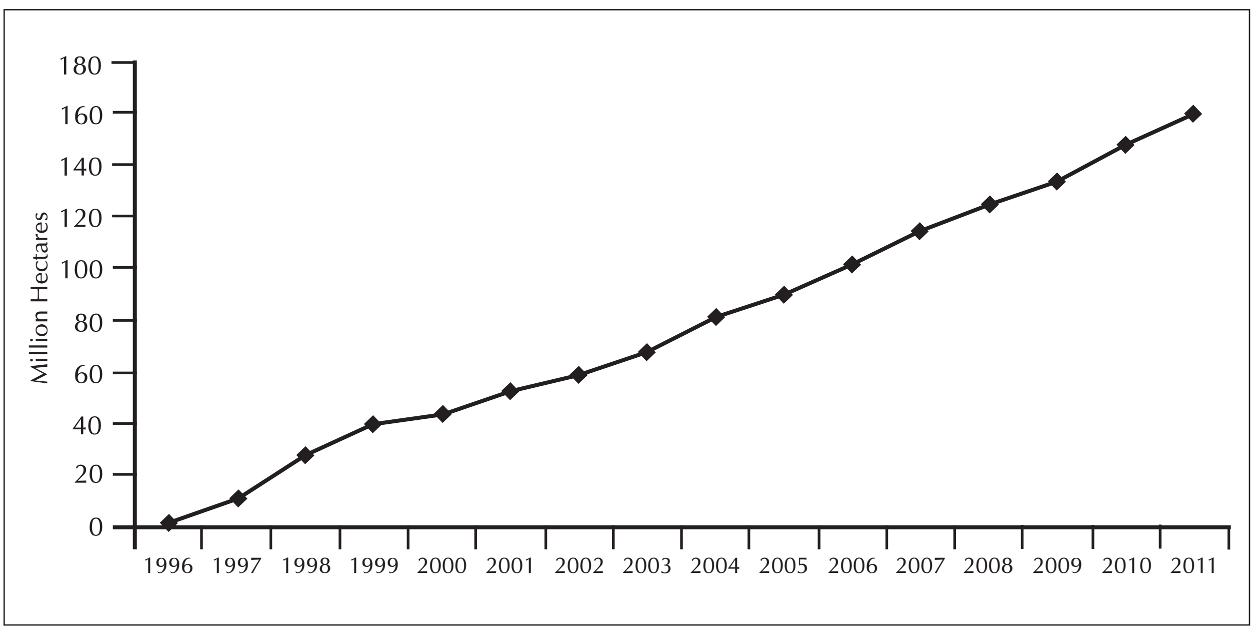
Increase of 8%, 12 million hectares (30 million acres) between 2010 and 2011.
Source: Clive James, 2011.

Thus, in 2011, a record 160 million hectares of biotech crops were planted by 16.7 million farmers in 29 countries, compared with 148 million hectares grown by 15.4 million farmers in 29 countries in 2010. Of the total number of 29 countries planting biotech crops in 2011, 19 were developing countries and 10 industrial countries. It is notable that 12 million hectares more were planted in 2011 by 16.7 million farmers in the 16th year of commercialization at a growth rate of 8% equivalent to 160 million hectares. The broad increases across countries in 2011 are robust and provide a solid foundation for future growth. The highest increase in any country, in absolute hectarage growth, was Brazil with 4.9 million hectares followed by the USA at 2.2 million hectares and Canada at 1.6 million hectares. It is notable that eight EU countries grew a record hectarage of 114,507 hectares compared with 91,438 hectares in 2010, a significant 25% increase of biotech crops in 2011.

To put the 2011 global area of biotech crops into context, 160 million hectares of biotech crops is equivalent to approximately 17% of the total land area of China (956 million hectares) or the USA (937 million hectares) and more than six times the land area of the United Kingdom (24.4 million hectares). The increase in area between 2010 and 2011 of 8% is equivalent to 12 million hectares or 30 million acres.

During the sixteen years of commercialization 1996 to 2011, the global area of biotech crops increased 94-fold, from 1.7 million hectares in 1996 to 160 million hectares in 2011 (Figure 3). This

Figure 3. Global Area of Biotech Crops, 1996 to 2011 (Million Hectares)



Source: Compiled by Clive James, 2011.

rate of adoption is the highest rate of crop technology adoption for any crop technology and reflects the continuing and 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 more than quadrupled, increasing from 6 in 1996 to 12 countries in 1999, 17 in 2004, 21 countries in 2005, 25 in 2009, and 29 in 2010 and 2011. A new wave of adoption of biotech crops is fueled by several factors which are contributing to a broad-based global growth in biotech crops. These factors include: 29 countries (19 developing and 10 industrial) already planting biotech crops in 2011, with a strong indication that several new countries will join in the near term; notable and significant continuing progress in Africa with the three African countries (South Africa, Burkina Faso and Egypt) collectively planting 2.5 million hectares in 2011 – Africa is the continent with the greatest challenge; significant increases in hectarage of "new" biotech crops such as biotech maize in Brazil opens up significant additional potential hectarage for biotech crops; newly approved biotech crop products, such as the IR/HT soybean approved for Brazil and the US in 2012/2013; resumption of RR®alfalfa planting in the US – alfalfa is the fourth largest crop in the US (8 million hectares) after maize, soybean and wheat; approval of the virus resistant bean in Brazil; continuing growth in stacked traits in cotton and maize, increasingly deployed by 12 countries worldwide; and new second generation events with quality traits such as Golden Rice enriched with vitamin A, and soybean with healthier omega-3 oil.

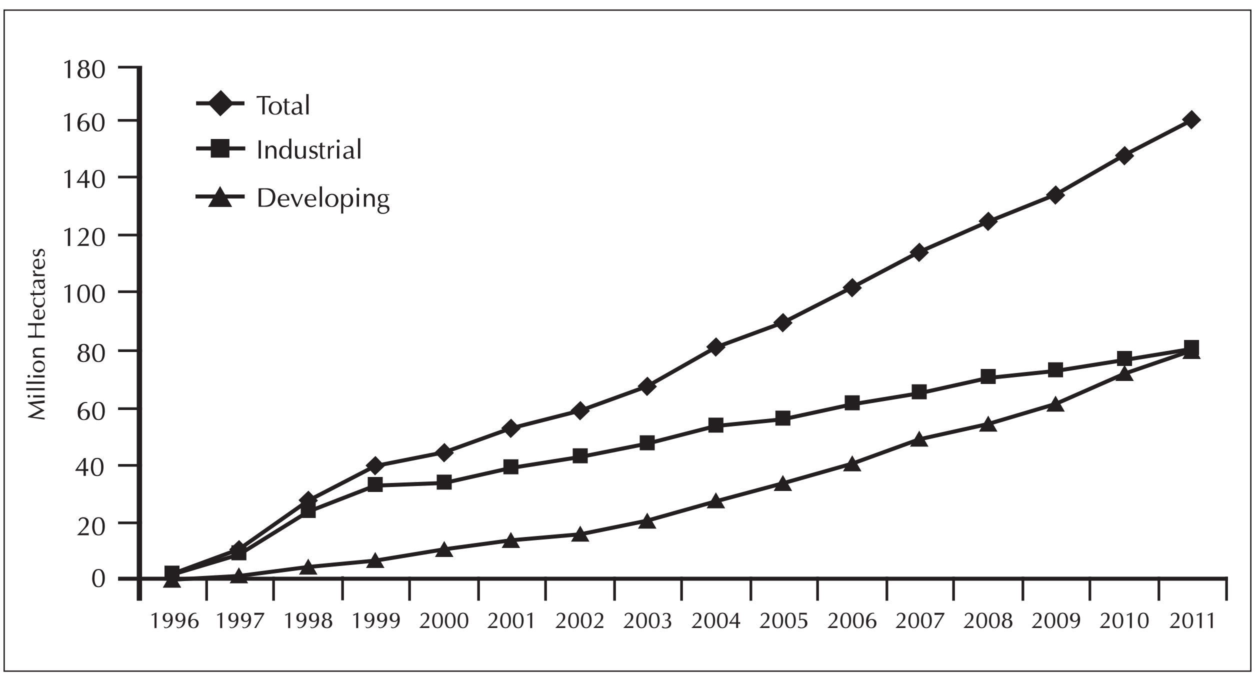
This new wave of adoption is providing a seamless interface with the first wave of adoption, resulting in continued and broad-based strong and stable growth in global hectarage of biotech crops. In 2011, the accumulated hectarage (planted since 1996) surged to 1.25 billion hectares. In 2011, developing countries continued to out-number industrial countries by 19 and 10, and for the first time, developing countries grew 50% of the global biotech crop hectarage. This trend of higher adoption by developing countries is expected to continue in the future with ~40 countries, expected to adopt biotech crops by 2015, the end of the second decade of commercialization. By coincidence, 2015 also happens to be the Millennium Development Goal year, when global society has pledged to cut poverty and hunger in half – a vital humanitarian goal that biotech crops can contribute to, in an appropriate and significant way in developing countries. The MDG provides global society and the scientific community with a one-time opportunity to urgently set explicit humanitarian goals, more specifically the imperative priority of food security and reducing hunger and poverty by 50% by 2015, to which biotech crops can make a significant contribution.

In summary, during the first sixteen years of commercialization 1996 to 2011, an accumulated total of 1.25 billion hectares, equivalent to over 3 billion acres of biotech crops, have been successfully grown as a result of ~100 million independent decisions by farmers to plant biotech crops (Table 1). Farmers have signaled their strong vote of confidence in crop biotechnology by consistently increasing their plantings of biotech crops by high growth rates every single year since biotech crops were first commercialized in 1996, with the number of biotech countries more than quadrupling from 6 to 29 in the same 16-year period.

Distribution of Biotech Crops in Industrial and Developing Countries

Figure 4 shows the relative hectarage of biotech crops in industrial and developing countries during the period 1996 to 2011. It illustrates that in 2011 for the first time, developing countries each planted 50% of the 160 million of global biotech crops. Figure 4 illustrates that prior to 2011, the proportion of biotech crops grown in developing countries had increased consistently every single year from 14% in 1997 to 16% in 1998, 18% in 1999, 24% in 2000, 26% in 2001, 27% in 2002, 30% in 2003, 34% in 2004, 38% in 2005, 40% in 2006, 43% in 2007, 44% in 2008, 46% in 2009, 48% in 2010, and 50% in 2011. Thus, in 2011, almost half of the global biotech crop area of 160 million hectares, equivalent to 79.8 million hectares, or 50%, was grown in 19 developing countries where growth continued to be strong, compared with the 10 industrial countries growing 80.2 million hectares of biotech crops also equivalent to 50% (Table 2). The increase in hectarage between 2010 and 2011 for developing countries was 8.2 million hectares or 11% versus 3.8 million hectares

Figure 4. Global Area of Biotech Crops, 1996 to 2011: Industrial and Developing Countries (Million Hectares)



Source: Clive James, 2011.

Table 2. Global Area of Biotech Crops, 2010 and 2011: Industrial and Developing Countries (Million Hectares)

	2010	%	2011	%	+/-	%
Industrial countries	76.3	52	80.2	50	3.8	+5
Developing countries	71.7	48	79.8	50	8.2	+11
Total	**148.0**	**100**	**160.0**	**100**	**12.0**	**+8**

Source: Clive James, 2011.

or 5% in industrial countries – thus, growth was more than twice as fast in developing countries compared with industrial countries, whether measured in absolute hectares or in percentage growth. The strong trend for higher growth in developing countries versus industrial countries is highly likely to continue in the near, mid and long-term, as more countries from the South adopt biotech crops and crops like rice, 90% of which is grown in developing countries, are deployed as new biotech crops.

Of the US$78.4 billion additional gain in farmer income generated by biotech crops in the first 15 years of commercialization (1996 to 2010), it is noteworthy that half, US$39.2 billion was generated in industrial countries and the other half of US$39.2 billion in developing countries. However, in 2010, developing countries had a slightly larger share, 55% equivalent to US$7.7 billion of the total US$14 billion gain, with industrial countries at 45% or US$6.3 billion (Brookes and Barfoot, 2012, Forthcoming). The slightly larger share for developing countries in 2010 reflects the higher growth rates in developing countries in more recent years, which is expected to continue in the future.

Distribution of Biotech Crops, by Country

The top ten countries each of which grew over 1 million hectares in 2011 are listed by hectarage in Table 3 and Figure 5, led by the USA which grew 69.0 million hectares (43% of global total), Brazil with 30.3 million hectares (19%), Argentina with 23.7 million hectares (15%), India with 10.6 million hectares (7%), Canada with 10.4 million hectares (7%), China with 3.9 million hectares (2%), Paraguay with 2.8 million hectares (2%), Pakistan 2.6 (2%), South Africa 2.3 million hectares (1%) and Uruguay with 1.3 million hectares or 1% of global biotech hectarage. An additional 19 countries grew a total of approximately 3.0 million hectares in 2011 (Table 3 and Figure 5). It should be noted that of the top ten countries, each growing 1.0 million hectares or more of biotech crops, the majority (8 out of 10) are developing countries, Brazil, Argentina, India, China, Paraguay, Pakistan, South Africa, and Uruguay compared with only two industrial countries, USA

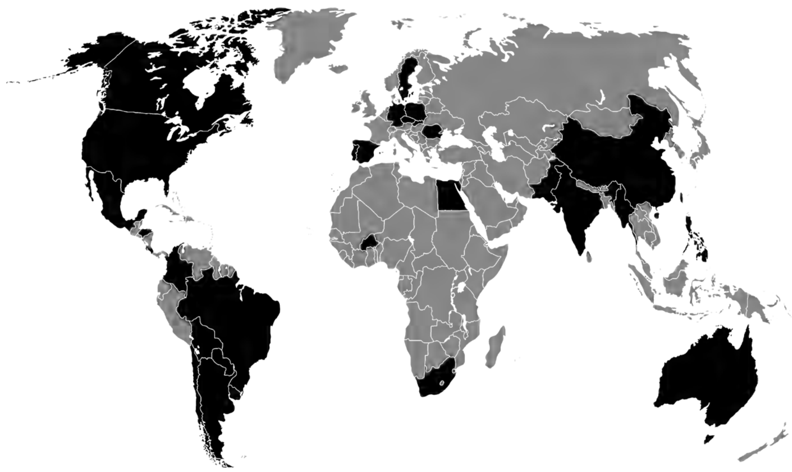
Table 3. Global Area of Biotech Crops in 2010 and 2011: by Country (Million Hectares**)

	Country	2010	%	2011	%	+/-	%
1	USA*	66.8	45	69.0	43	+2.2	+3
2	Brazil*	25.4	17	30.3	19	+4.9	+19
3	Argentina*	22.9	16	23.7	15	+0.9	+4
4	India*	9.4	6	10.6	7	+1.2	+13
5	Canada*	8.8	6	10.4	7	+1.6	+18
6	China*	3.5	2	3.9	2	+0.4	+11
7	Paraguay*	2.6	2	2.8	2	+0.2	+8
8	Pakistan*	2.4	2	2.6	2	+0.2	+8
9	South Africa*	2.2	2	2.3	1	+0.1	+5
10	Uruguay*	1.1	1	1.3	1	+0.1	+9
11	Bolivia*	0.9	1	0.9	1	<0.1	– –
12	Australia*	0.7	<1	0.7	<1	<0.1	– –
13	Philippines*	0.5	<1	0.6	<1	+0.1	+20
14	Myanmar*	0.3	<1	0.3	<1	<0.1	– –
15	Burkina Faso*	0.3	<1	0.3	<1	<0.1	– –
16	Mexico*	0.1	<1	0.2	<1	0.1	+100
17	Spain*	0.1	<1	0.1	<1	<0.1	– –
18	Colombia	<0.1	<1	<0.1	<1	<0.1	– –
19	Chile	<0.1	<1	<0.1	<1	<0.1	– –
20	Honduras	<0.1	<1	<0.1	<1	<0.1	– –
21	Portugal	<0.1	<1	<0.1	<1	<0.1	– –
22	Czech Republic	<0.1	<1	<0.1	<1	<0.1	
23	Poland	<0.1	<1	<0.1	<1	<0.1	– –
24	Egypt	<0.1	<1	<0.1	<1	<0.1	– –
25	Slovakia	<0.1	<1	<0.1	<1	<0.1	– –
26	Romania	<0.1	<1	<0.1	<1	<0.1	– –
27	Sweden	<0.1	<1	<0.1	<1	<0.1	
28	Costa Rica	<0.1	<1	<0.1	<1	<0.1	– –
29	Germany	<0.1	<1	<0.1	<1	<0.1	– –
	Total	**148.0**	**100**	**160.0**	**100**	**+12.0**	**+8**

***Biotech mega-countries growing 50,000 hectares, or more.**
****Rounded-off to the nearest hundred thousand.**

Source: Clive James, 2011.

Figure 5. Global Area (Million Hectares) of Biotech Crops, 1996 to 2011, by Country, and Mega-Countries, and for the Top Ten Countries

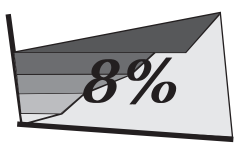


Biotech Mega-Countries

50,000 hectares, or more

1.	USA	69.0 million
2.	*Brazil**	30.3 million
3.	*Argentina**	23.7 million
4.	*India**	10.6 million
5.	Canada	10.4 million
6.	*China**	3.9 million
7.	*Paraguay**	2.8 million
8.	*Pakistan**	2.6 million
9.	*South Africa**	2.3 million
10.	*Uruguay**	1.3 million
11.	*Bolivia**	0.9 million
12.	Australia	0.7 million
13.	*Philippines**	0.6 million
14.	*Myanmar**	0.3 million
15.	*Burkina Faso**	0.3 million
16.	*Mexico**	0.2 million
17.	Spain	0.1 million

Increase over 2010



29 countries which have adopted biotech crops

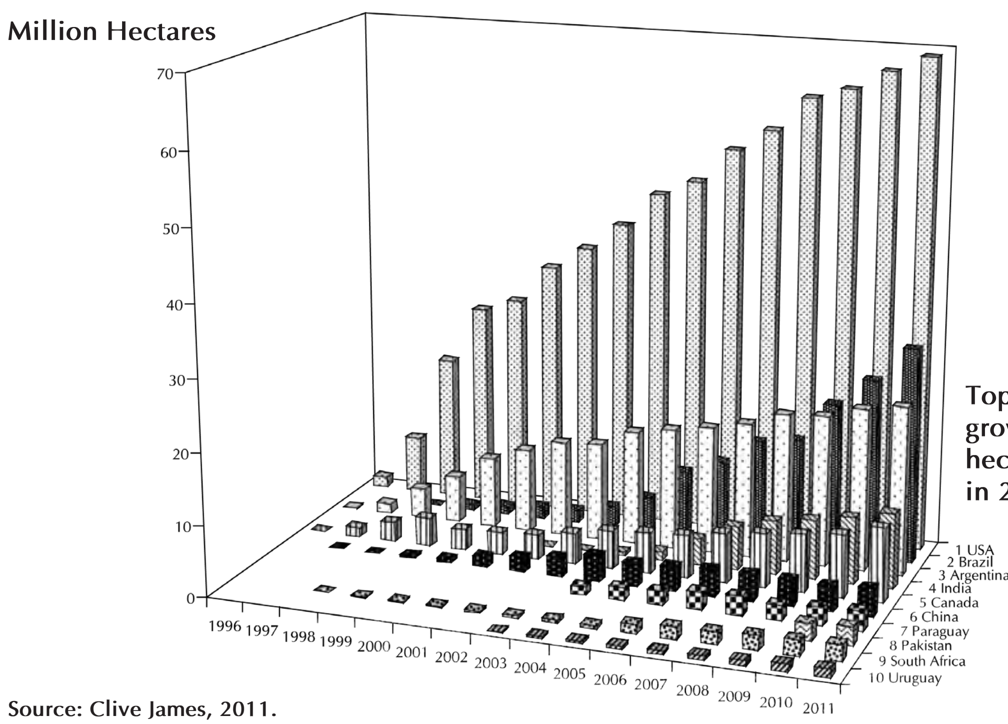
In 2011, global area of biotech crops was 160 million hectares, representing an increase of 8% over 2010, equivalent to 12 million hectares.

Less than 50,000 hectares

*Colombia**
*Chile**
*Honduras**
Portugal
Czech Republic
Poland
*Egypt**
Slovakia
Romania
Sweden
*Costa Rica**
Germany

** Developing countries*

Source: Clive James, 2011.



Top 10 countries growing 1 million hectares, or more in 2011

Source: Clive James, 2011.

and Canada. The number of biotech mega-countries (countries which grew 50,000 hectares, or more, of biotech crops) was 17, the same as 2010. Two of the three African countries (South Africa and Burkina Faso) are already mega-countries, with Burkina Faso qualifying in only the second year of commercialization. Notably, 13 of the 17 mega-countries are developing countries from Latin America, Asia and Africa. The high proportion of biotech mega-countries in 2011, 17 out of 29, equivalent to almost 60%, reflects the significant broadening, deepening and stabilizing in biotech crop adoption that has occurred within the group of more progressive mega-countries adopting more than 50,000 hectares of biotech crops, on all six continents in the last 16 years.

It is noteworthy, that of the 10 countries that witnessed growth of between 5 and 100% in 2011, nine were developing countries and only one, Canada was an industrial country. In absolute hectares, the largest year-over-year growth, by far, was Brazil at 4.9 million hectares, followed by the USA at 2.2 million hectares, Canada at 1.6 million hectares, and India at 1.2 million hectares. The top three in global share of the 160 million hectares were USA at 43%, Brazil at 19% and Argentina at 15%.

In the first twelve years of commercialization of biotech crops, 1996 to 2007, South Africa was the only country on the continent of Africa to commercialize biotech crops, and Africa is recognized as the continent that represents by far the biggest challenge in terms of adoption and acceptance. Accordingly, the decision in 2008 of Burkina Faso to grow Bt cotton and for Egypt to commercialize Bt maize for the first time was of strategic importance for the African continent. For the first time in 2008, there was a lead country commercializing biotech crops in each of the three major regions of the continent – South Africa in Southern and Eastern Africa, Burkina Faso in West Africa and Egypt in North Africa. This broader geographical coverage in Africa is of strategic importance because it allows more Africans to become practitioners of biotech crops and be able to benefit directly from "learning by doing", which has proven to be very important in China and India. Hectarage of biotech crops in all three African countries in 2011 totaled more than 2.5 million hectares for the first time, most of which was grown in South Africa.

It is noteworthy, that there are now 10 countries in Latin America which benefit from the extensive adoption of biotech crops; they are, listed in descending order of hectarage: Brazil, Argentina, Paraguay, Uruguay, Bolivia, Mexico, Colombia, Chile, Honduras and Costa Rica. It is also noteworthy, that Japan grew, for the third year, a commercial biotech flower, the "blue rose" in 2011. The rose was grown under partially covered conditions and not in "open field" conditions like the other food, feed and fiber biotech crops grown in other countries listed in this Brief. Australia and Colombia also grew biotech carnations.

In 2011, a record eight EU countries, Spain, Portugal, Czech Republic, Poland, Slovakia, Romania Sweden and Germany grew either Bt maize or the "Amflora" potato, approved by the EU. Spain grew more than 85% of all the Bt maize in the EU. The hectarage of Bt maize in the EU in 2011 was a record 114,490 hectares an increase of 26% over 2010.

Five countries reported significant increases in absolute area of biotech crops of 0.5 million hectares or more, between 2010 and 2011: they were Brazil with 4.9 million hectares, USA with a 2.2 million hectare increase, Canada with 1.6 million, India with 1.2 million and Argentina 0.9 million hectares.

The six principal countries that have gained the most economically (over US$1 billion) from biotech crops, during the first 15 years of commercialization of biotech crops, 1996 to 2010 are, in descending order of magnitude, the USA (US$35.3 billion), Argentina (US$12.2 billion), China (US$10.9 billion), India (US$9.4 billion), Brazil (US$4.6 billion), Canada (US$3.3 billion), and others (US$2.7 billion) for a total of US$78.4 billion. Developing countries and industrial countries as a group, both gained the same amount of US$39.2 billion (Brookes and Barfoot, 2012, Forthcoming).

In 2010 alone, economic benefits globally were US$14 billion of which US$7.7 billion was for developing and US$6.3 billion was for industrial countries. The six countries that gained the most economically from biotech crops in 2010 were , in descending order of magnitude, the USA (US$5.5 billion), India (US$2.5 billion), China (US$1.8 billion), Argentina US$1.8 billion, Brazil (US$1.2 billion), and Canada (US$0.6 billion), and others (US$0.6 billion) for a total of US$14 billion in 2010 (Brookes and Barfoot, 2012, Forthcoming).

Country Chapters

USA

In 2011, the USA continued to be the largest producer of biotech crops in the world with a global market share of 43%. In 2011, the USA planted a record hectarage of 69.0 million hectares of biotech maize, soybean, cotton, canola, sugarbeets, alfalfa, papaya and squash, up from the 66.8 million hectares in 2010, and equivalent to a year-on-year growth rate of 3%. The increase in biotech crop hectarage of 2.2 million hectares between 2010 and 2011 was the second largest, after Brazil, for any country in the world. The USA also leads the way in the deployment of stacked traits in maize and cotton which offer farmers multiple and significant benefits. In 2011, the USA benefited from a fifth season of commercializing biotech RR®sugarbeets which again occupied about 475,000 hectares equivalent to a 95% adoption, in its fifth year of commercialization; this makes RR®sugarbeets the fastest ever adopted biotech crop globally. The adoption rates for the principal biotech crops in the USA, soybean maize and cotton are close to optimal at an average of ~90%. Further significant increases will be achieved through stacking of multiple traits in the same crop or the introduction of new biotech crops and/or traits. A US study on the economic benefits of Bt maize reported that area-wide suppression of the European Corn Borer pest in both Bt maize and non-Bt maize crops resulted in a gain for farmers of US$6.9 billion over the 14 year period 1996 to 2009. Importantly, the indirect benefit associated with non-Bt maize (US$4.3 billion) was 62 percent, greater than the direct benefit of US$2.6 billion from planting Bt maize. RR®alfalfa, first cleared for commercialization in 2005, and resumed in February 2011, has spurred strong farmer demand and up to 200,000 hectares were cultivated in 2011.

The USA is the leader of the six "founder biotech crop countries", having spear-headed the commercialization of biotech crops in 1996, the first year of global commercialization of biotech crops. The USA continued to be the lead biotech country in 2011 with continued growth, particularly in terms of biotech maize in which stacked traits continued to be an important feature. USDA estimates (USDA NASS, 2011) indicate that the percentage adoption of two (maize and cotton) of the three principal biotech crops continued to increase despite the fact that the high adoption level of biotech crops was close to optimal – biotech maize at 88% adoption was up from 86% in 2010, soybean was 94% compared with 93% in 2010, whereas upland cotton at 90% was down from 93% in 2010, although cotton plantings had increased to 5.4 million hectares, up 25% from 2010. The total hectarage planted to biotech maize, soybean, cotton, canola, sugarbeets, alfalfa, papaya and squash was 69.0 million hectares or 3.1% increase from the 66.8 million hectares in 2010. With the exception of Brazil, the 2.2 million hectare increase in the USA in 2011 was the second largest increase in absolute terms, for any country, despite the fact that percent adoption of all biotech crops in the USA are now close to optimal levels at about an average of ~90%, in the three principal major biotech crops of soybean, maize and cotton but also in other biotech crops – 95% for biotech sugarbeets and almost 80% for canola.

Total plantings of maize in the USA in 2011 were 37.4 million hectares, up 5% from 2010 (NASS USDA Crop, 2011) and only down slightly from the record 37.9 million hectares in 2007. Biotech maize continued to be attractive in the USA in 2011 because of increasing global demand for feed, ethanol and strong export sales. Total plantings of soybean at 30.5 million hectares in 2011, was down 3% from 31.6 million hectares in 2010, due to farmers favoring maize over soybean.

Total plantings of upland cotton at 5.4 million hectares in 2011, compared with only 4.3 million hectares for 2010, were up 25% and associated with historically record high prices of cotton in 2010. Thus, after consecutive annual decreases for several years, (up until 2009), upland cotton hectares increased in 2010 and again significantly in 2011. Canola hectarage in the USA was 462,000 hectares, down significantly from 596,000 hectares in 2010. Total hectarage of sugarbeets in 2011 was similar at ~500,000 hectares in 2010. Estimates of alfalfa seedings for 2011, will not be available from USDA until the first quarter of 2012, but they are not likely to be very different from 2010 seedings at approximately 1.3 million hectares – this includes alfalfa harvested as hay and alfalfa haylage and green chop. Alfalfa is planted as a forage crop and grazed or harvested and fed to animals, and seeded in the spring and the fall.

USA

Population: 308.8 million

GDP: US$14,093 billion

GDP per Capita: US$46,350

Agriculture as % GDP: 1%

Agricultural GDP: US$140.9 billion

% employed in agriculture: 2%

Arable Land (AL): 178 million hectares

Ratio of AL/Population*: 2.4

Major crops:
- Maize
- Soybean
- Cotton
- Sugarcane
- Sugarbeet
- Alfalfa
- Wheat
- Canola

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

Total area under biotech crops and (%) increase in 2011:
69 Million Hectares (+3%)

Farm income gain from biotech, 1996-2010: $35.3 billion

*Ratio: % global arable land / % global population

Source: The Economist, supplemented with Data from the World Bank, FAO and UNCTAD when necessary.

In 2011, the USA continued to grow more biotech crops (69.0 million hectares) than any other country in the world, equivalent to 43% of global biotech crop hectarage. In 2011, the gain was 2.2 million hectares of biotech crops, equivalent to a ~3% growth rate. This is consistent with steady increases in the percentage adoption for the major crops which is now close to optimal with biotech soybean at 94%, cotton at 90% adoption, maize at 88% adoption, canola at close to 80% and sugarbeet at 95%.

Adoption of biotech maize continued to climb with strong growth in the stacked traits, particularly in the triple stacks. The two-trait stacked 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 (one for above-ground pests, and the other for below-ground pests) and one for herbicide tolerance. In addition to the USA, the other eleven countries which deployed stacked traits in 2011 were in descending order of hectarage: Brazil, Argentina, Canada, South Africa, Australia, the Philippines, Mexico, Chile, Uruguay, Honduras, and Colombia. The change in hectares in US biotech crops was different for each crop. Biotech maize increased by ~2 million hectares and biotech cotton by ~1 million hectares; these increases were offset by a ~1 million decrease in soybean due to a decrease in total plantings.

Sugarbeets growers have always faced significant challenges in weed management. In 2006, a small hectarage of a ‘new’ and important biotech crop was planted for the first time in the USA. Roundup Ready (RR®) herbicide tolerant sugarbeets was first planted in 2006 to evaluate the new technology and to sell the sugar, pulp and molasses in the market place. In 2007, another small hectarage was planted but because of very limited biotech seed availability, only one sugarbeets company was able to transition to Roundup Ready (RR®). With greater amounts of seed production, it was estimated that in 2008, 59% of the 437,246 hectares of sugarbeets planted in the USA, equivalent to 257,975 hectares were RR®sugarbeets. Farmers welcomed the commercialization of sugarbeets and were very pleased with the biotech product, which provided superior weed control, and was more cost-effective and easier to cultivate than conventional sugarbeets. Farmers cited many advantages of RR®sugarbeets over conventional including: the number of required cultivations cut by half, with 30% savings in fuel; significant labor savings including elimination of supplementary hand weeding and labor time; less soil compaction; provides an incentive and facilitates adoption of minimum or no till; number of herbicide applications decreased as well as the convenience of reliance on fewer types of herbicides; less crop damage from herbicide applications; and generally more profitable and convenient to cultivate than conventional sugarbeets. In 2008, growers became convinced of the value of RR®sugarbeets and were keen to support the development of other traits, which they know to be important including disease, insect and nematode resistance, and drought and cold tolerance.

Herbicide tolerant RR®sugarbeets were quickly and widely adopted by growers in the USA and Canada in 2009. For the first time in 2009, adequate supplies of many seed varieties were finally available for farmers. An estimated 95% or ~485,000 hectares of sugarbeets planted in the USA in 2009 were devoted to varieties improved through biotechnology. In the US in 2010 and 2011, the hectarage of sugarbeets was the same at approximately 485,000 hectares, of which 95% were biotech. Canadian growers planted approximately 15,000 hectares of biotech varieties in 2009, representing nearly 96% of the nation's sugarbeets crop and in 2011 the adoption of biotech was at about the same level, 18,000 hectares, close to 100%. 2011 was the third year of commercial planting in Eastern Canada and the second year of commercial production in Western Canada. This very high adoption rate in the US of 95% in five years makes RR®sugarbeets the fastest ever adopted biotech crop since biotech crops were first commercialized in 1996, sixteen years ago. Given the unqualified success of RR®sugarbeets, the estimated hectares of RR®sugarbeets in the US and Canada in 2011 was approximately the same for 2010 and 2011 at 95% adoption for RR®sugarbeets equivalent to approximately 475,000 hectares in the US and similarly, Canada had a ~95% adoption equivalent to 15,000 hectares. During the last couple of years critics have tried to pursue legal avenues for stopping or restricting planting of RR®sugarbeets, but the scientific and farming logic of biotech sugarbeets has resisted all the attempts in the courts by the critics.

Independent scientific analysis shows that the sugar derived from RR®sugarbeets is identical, at the molecular level, to sugar from other comparably grown sugarbeets, and to the sugar from sugarcane. It is important to note that the sugar from RR®sugarbeets does not contain any DNA from the biotech transformation process, so the sugar is the same as the sugar produced from conventional sugarbeets and accordingly does not require labeling in the USA, and in foreign markets like Japan. Since the USA is one of the largest importers of sugar in the world, most of the sugar and by-products from sugarbeets production are consumed domestically. However, the sugar, pulp and molasses derived from the RR®sugarbeets have been approved in all the major export markets including Japan, Canada, Mexico and the European Union, as well as South Korea, Australia, New Zealand, Colombia, Russia, China, Singapore and the Philippines.

Adoption of RR®sugarbeets by processors, and the consumers understanding and acceptance that the "sugar is the same" pure and natural sweetener as it has always been, has important implications regarding acceptance of biotech sugarbeets in other countries including the EU, and more generally by developing countries which grow sugarcane for food and ethanol production, such as Brazil.

The very high level of satisfaction and demand by US and Canadian farmers for RR®sugarbeets probably has implications for sugarcane (80% of global sugar production is from cane) for which biotech traits are under development in several countries and approval for field trials was granted in Australia in October 2009. Sugarcane crops, improved through biotechnology, have not yet been commercialized. However, significant research is actively under way in Australia, Brazil, Colombia, Mauritius and South Africa, as well as the United States. Traits under study in cane include, sugar content and quality, herbicide tolerance, pest resistance, disease resistance, and drought, cold and salt tolerance.

Luther Markwart, executive vice president of the American Sugarbeets Association, said ***"Biotech sugarbeets seeds arrived just in time to save a struggling industry that is essential to our nation's food security. Sugar from sugarbeets currently provides about half of the nation's sugar consumption. Our industry leaders have spent over 10 years to develop, approve, adopt and transition our U.S. production to this important technology. Growers simply said if our industry is going to survive, we've got to have these kinds of tools. Roundup Ready beet seeds are saving producers money and making the crop much easier to manage. Weeds are our biggest problem. Typically, with conventional beets you have to use four to five applications of a combination of various herbicides. Now, farmers are using fewer chemicals and less fuel, and Roundup Ready doesn't stress the beets"*** (Murphy, 2008; Porter, 2009).

Herbicide tolerant RR®alfalfa was first 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 plantings in 2006/2007 that brought the total to approximately 100,000 hectares. A court order (not based on safety reasons) filed by critics, stopped planting in 2007, pending completion of an environmental impact statement (EIS) by USDA. Farmers who had planted the 100,000 hectares of RR®alfalfa were not required to uproot the RR®alfalfa already planted which has remained in the ground for up to 6 years, due to the perennial nature of alfalfa which is normally ploughed at up to six years. On 21 June 2010, the Supreme Court overturned the ban and on 16 December USDA announced that the EIS was completed and on 27 January it declared that planting of RR®alfalfa could be resumed as of 2 February 2011; the first planting since 2007. Farmer demand has been high and it is estimated that up to 200,000 hectares of RR®alfalfa have been seeded in 2011. Thus, the estimated hectarage of RR®alfalfa in the US in 2011 is 200,000 hectares plus what remains in the ground of the original plantings in 2005 to 2007. Since it is very difficult to establish how much of the earlier plantings remain in 2011, a conservative estimate of up to 200,000 hectares of RR®alfalfa is projected by ISAAA for 2011. Up to 20% of the 8 million hectares of RR®alfalfa is reseeded every year and some observers (The Daily Beast, 15 October 2011) project that from one-third to one-half of the 8 million hectares will be reseeded with RR®alfalfa in five years from now, around 2015; other observers suggest that RR®alfalfa will occupy almost all the 8 to 9 million hectares in 10 years from now – this view is supported by the fact that farmer demand for RR®alfalfa in 2011 has been very strong, because of the significant benefits it offers.

Benefits of RR®alfalfa 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 provide adequate isolation between conventional and biotech alfalfa and 500 meters for seed crops. RR®alfalfa plants were first produced in 1997 and field trials were initiated in 1999, followed with multiple location trials to determine the best performing varieties. Import approvals have already been secured for RR®alfalfa in major US export markets for alfalfa hay including Mexico, Canada, Japan, the Philippines and Australia – these countries represent greater than 90% of the US alfalfa hay export market. Japan is the major market for alfalfa hay exports, mainly from California and the west coast states. The USA is a major producer of alfalfa hay which occupies approximately 8 to 9 million hectares with an average yield of 7.59 metric tons per hectare of dry hay valued conservatively 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.

In addition to the four major biotech crops, soybean, maize, cotton and canola, and the RR®alfalfa and RR®sugarbeets, small hectarages of virus resistant squash (2,000 hectares) and virus resistant papaya (2,000 hectares) continued to be grown successfully in the USA in 2011. In a landmark decision, Japan approved the import of biotech papaya from the US, for consumption as fresh fruit/food. The biotech papaya is resistant to the papaya ring spot virus and commercialized in Hawaii, and was approved and been available in the US since 1997, fourteen years ago. The Japanese approval was granted and officially announced by Japan's Ministry of Agriculture, Forestry and Fisheries responsible for GM processed food quality labeling, Article 7 Clause 1 on GM fresh food quality labeling was amended on 31 August 2011 to include papaya as Japan's 8th GM imported food; the notification was effective 1 December 2011 (www.caa.go.jp/jas/hyoji/pdf/kijun_03.pdf). The list of approved biotech plant products in Japan now includes the following eight GM products: soybean, maize, potato, rape seed, cotton seed, alfalfa, sugarbeet and papaya.

On 29 July 2011 Dr. Aaron Gassmann, from Iowa State University, reported that western corn rootworm (WCR), had developed resistance to the single Bt protein Cry3Bb1 in four fields in Iowa (Gassman et al, 2011). More specifically resistance was found in Monsanto's YieldGard® VT Triple and Genuity® VT Triple PRO™ maize products. Monsanto reported that in 2011, both of these products continued to perform very well for growers, providing the expected level of rootworm control. The company reported that they are collaborating with Dr. Gassmann to ***"better understand his initial data and to determine if and how they impact our IPM recommendations to growers."*** The trait has been monitored since its launch in 2003 and a low incidence of rootworm has been detected in confined areas with high rootworm densities under particular environmental conditions. No measurable increase in the frequency of these occurrences has been detected over time. Collaboration between Dr. Gassmann and Monsanto aims to gain a better understanding of the issue with a view to developing recommendation for farmers. The development is a timely reminder that biotech crops, just like conventional crops, require to be carefully managed using good farming practices that include crop rotation, integrated pest management practices that require judicious deployment of refugia facilitated with new approaches such as “refuge in the bag” (RIB) and the deployment of maize with a dual mode of action for pest control, particularly in areas with high infestations. In summary, an effective strategy should feature prevention rather than cure, and always utilize multiple approaches to decrease the probability of the development of pest resistance which will always be a challenge in both conventional and biotech crops.

On 1 July 2011, USDA/APHIS declared that it did not have the authority to require an herbicide tolerant Kentucky bluegrass, to be classed as a biotech/GM crop and undergo the same evaluation procedures that govern other GM crops. The rational underpinning the USDA decision was that, unlike other typical GM crops which use plant pests (for example *Agrobacterium*) or their elements (the promoter cauliflower mosaic virus) for development, no plant pests were involved in the production of the Kentucky grass product. The grass, *Poa pratensis*, is in the initial stages of R&D at Scotts Miracle-Gro, a lawn-care company in the USA. The biotech grass would facilitate the process of keeping lawns weed-free. The USDA decision precludes the need for the company to conduct several years of testing involved in the development of a biotech crop, although the company indicated that it has no plans to market this particular biotech grass variety. Whereas, *Agrobacterium* is the current method of choice for developers of biotech crops, it is premature to assess the implications of this USDA decision, because other competing technologies are being evolved very fast and will challenge current definitions and regulatory procedures. They include: mini-chromosomes’ that can act as a plant cell but precludes the need for integration into the plant genome; the use of zinc-finger nucleases to insert genes; enzymes called ‘meganucleases’ to introduce multiple new traits into current biotech crops. Thus, there will be a continuous need to review the appropriateness of definitions, technology categories, and regulatory procedures to ensure that they are appropriate and meaningful for a very fast-moving science (Ledford, 2011).

Benefits from Biotech Crops in the USA

In the most recent global study on the benefits from biotech crops, Brookes and Barfoot (2012, Forthcoming) estimate that USA has enhanced farm income from biotech crops by US$35.3 billion in the first fifteen years of commercialization of biotech crops 1996 to 2010. This represents 45% of global benefits for the same period, and the benefits for 2010 alone are estimated at US$5.5 billion (representing 39% of global benefits in 2010). These are the largest gains for any biotech crop country.

Professor of agricultural economics Carl Zulauf of the Ohio State University agricultural economics published two reports on the effects of biotechnology on the yield increase of three major crops: corn, soybeans, and cotton, and the effect of biotechnology on yield variation. The first report concluded that statistical evidence on linear yield trends show that biotechnology could play a role in escalating production. He studied the yield trends for corn, soybean, and cotton which are three of the most widely planted biotech crops in the U.S., and compared the trends with 11 other crops which are not yet commercialized as biotech products. The results of his evaluation showed that the 14 crops exhibited higher estimated yield trend from 1996-2011, the years when biotech varieties were already commercialized in the U.S. compared with the yield data of 1940-1995 when only conventional breeding techniques were used. “This analysis finds that, while the yield trend increased for all three biotech crops after 1996, the yield trend increased for less than half of the crops for which biotech varieties are of limited importance,” Zulauf says. “This finding does not prove that biotechnology is the reason for the higher yield trend for corn, cotton and soybeans. It only reveals that the evidence on linear yield trends is not inconsistent with such a conclusion” (Zulauf and Hertzog, 2011a).

In another study, Prof. Zulauf studied biotechnology and variation in US yields to provide information concerning the commonly-expressed argument that biotechnology has reduced yield variability. The study revealed that in the 14 crops studied, the variation trend-line yield was lower during the biotech crop commercialization period of 1996-2011 compared to the earlier non-biotech period of 1940-1955. The difference in variability in the biotech and non-biotech crops is small. The authors believe that both biotech and traditional breeding methods have been equally successful at creating varieties that reduce yield variation. Since the decline in yield variability is permanent and not transitory, a more reliable supply reduces the size of stocks that need to be carried to assure an adequate supply and enhances the ability to expand non-food uses of crops (Zulauf and Hertzog, 2011b).

A 2010 University of Minnesota study (Hutchinson et al, 2010) on biotech maize, resistant to European corn borer (ECB) reported that ***“area-wide suppression dramatically reduced the estimated US$1 billion in annual losses caused by the European Corn Borer (ECB).”*** Importantly, the study reported that biotech Bt maize has even benefited conventional maize. Widespread planting of biotech Bt maize throughout the Upper Midwest of the USA since the 1996 has suppressed populations of the ECB, historically one of maize’s primary pests causing losses estimated at approximately US$1 billion per year. Corn borer moths cannot discern between Bt and non-Bt maize, so the pest lays eggs in both Bt and non Bt maize fields. As soon as the eggs hatch in Bt maize, borer larvae feed and die within 24 to 48 hours. As a result, corn borer numbers have also declined in neighboring non-Bt fields by 28 percent to 73 percent in Minnesota, Illinois and Wisconsin. The study also reports similar declines of the pest in Iowa and Nebraska. The results of the study are consistent with the findings of Wu et al. (2008) who also demonstrated a dramatic up to 90%, area-wide reduction of cotton bollworm in China in other host crops such as maize, soybeans and vegetables.

In the US study, the economic benefits of this area-wide pest suppression was estimated at US$6.9 billion over the 14 year period 1996 to 2009 for the 5-state region, comprising Minnesota, Illinois and Wisconsin, Iowa and Nebraska. Of the US$6.9 billion, it is noteworthy that non-Bt corn hectares accounted for US$4.3 billion (62 percent, or almost two-thirds, of the total benefit). The principal benefit of Bt maize is due to reduced yield losses, resulting from the deployment of Bt maize for which farmers have paid Bt maize technology fees. However, what is noteworthy is that as a result of area-wide pest suppression, farmers planting non-Bt hectares also experienced yield increases without the cost of Bt technology fees; in fact non-Bt hectares benefited from more than half (62%) of the total benefits of growing Bt maize in the 5 contiguous states.

Importantly, the study, noted that ***"previous cost-benefit analyses focused directly on Bt maize hectares but that this study was the first in the USA to include the value of area-wide pest suppression and the subsequent indirect benefits to farmers planting conventional non-Bt maize."*** The study did not consider benefits for other important Midwestern crops affected by European corn borer, such as sweet corn, potatoes and green beans, which the Wu study in China did. The authors noted ***"that additional environmental benefits from corn borer suppression are probably being realized, such as less insecticide use, but that these benefits have yet to be documented."***

It is noteworthy that the suppression of European corn borer was only demonstrable in Minnesota, Illinois and Wisconsin because state entomologists have monitored pest populations for more than 45 years. Pest suppression and related yield benefits may well be occurring to both adopters and non-adopters of Bt maize in other parts of the United States and the rest of the world, but those benefits cannot be documented due to lack of historical benchmark data on pest levels. In conclusion, the authors noted ***"that sustaining the economic and environmental benefits of Bt maize and other transgenic crops for adopters and non-adopters alike depends on the continued stewardship of these technologies. Thus, farmers, industry, and regulators need to remain committed to planting appropriate non-Bt maize refugia to minimize the risk that corn borers will develop resistance to Bt maize which has now been successfully planted on millions of hectares globally since 1996."*** In summary, this important study confirms that Bt maize delivers more benefits to society than originally realized and is consistent with similar indirect benefits in China from the deployment of Bt cotton.

An independent study published by the US National Research Council (2010) (an organization related to the National US Academy of Sciences) in April 2010 is entitled ***"The impact of genetically engineered (GE) crops on farm sustainability in the United States."*** The study concluded that ***"many US farmers are realizing substantial economic and environmental benefits, such as lower production cost benefits, fewer pest problems, reduced use of pesticides and better yields compared with conventional crops."*** Whereas the study documents the decreased use of pesticides, and that GE farmers are more likely to practice conservation tillage, it opines that the improvement in water quality might prove to be the largest single benefit associated with biotech crops. The study concluded that farmers have not been adversely affected by the proprietary terms involved in patent protected GE seed. The study also noted that biotech crops ***"tolerant to glyphosate could develop more weed problems as weeds evolve their own resistance to glyphosate and that herbicide crops could loose their effectiveness unless farmers also use other proven weed and insect management practices."*** The study claims to be ***"the first comprehensive assessment of how GE crops are affecting all US farmers including those who grow conventional or organic crops."***

A study by Piggott and Marra (2007) of 2005 data in North Carolina, USA assessed the additional per hectare benefits to a farmer and to the state of North Carolina resulting from a change in policy for Bollgard®II cotton that would eliminate the required refuge. The annual benefit at the farm level was US$56.37 per hectare and US$32,202,907 at the state level for North Carolina, when non-pecuniary benefits are not considered. When non-pecuniary benefits are considered, the benefits per hectare were US$66.44 at the farm level and US$37,986,449 at the state level, which is an increase of US$10.07 per hectare and US$5,783,542 at the state level. The increase in value to the technology developer was US$2,427,620.

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 US 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.

Political Will and Support

Senator Richard Lugar, one of the sponsors of the Global Security Act by the Senate, said that ***"the bill directs US assistance in developing local technological solutions to advance agricultural productivity in countries suffering from chronic hunger - it does not require that these solutions be genetically modified technology, but it does not preclude it where appropriate." He also added that the bill "would mandate that US assistance be used to promote genetically modified agricultural technologies, and that US food aid would be conditioned on recipient countries approving the use of GM products"*** (Lugar, 2010).

In a panel of featured notable leaders and CEOs at the World Economic Forum in Davos-Klosters, Switzerland in 29 January 2010 called "Rethinking How to Feed the World," Bill Gates was asked if he was for or against genetically modified food. Mr. Gates confirmed his support for the transgenic approach saying that, ***"What our foundation is doing is we're working with partners, for example, Du Pont Pioneer on some new maize things, with Archer Daniels Midland (ADM) on some cocoa growing things. Some of these are traditional breeding and some of them are transgenic. In parallel, we are also funding scientific expertise in Africa so when, three or four years from now, there are some crops with big benefits, drought resistance, that <u>the transgenic approach probably can do better than any other approach,</u> each country can decide what are the benefits to them and what are the risks, what's known about its safety, IP licensing and things that would make them hesitant, and then, you know, they'll on their own, be able to make that decision"*** (Gates, 2010).

Farmer Experience

Laura Foell, a United Soybean Board director and a farmer from Iowa, said, ***"As a parent and a farmer, I chose biotechnology because I wanted my kids eating safe, nutritious foods. After all, our vegetable garden for the family's meals is right next to our soybean fields, so it was important to reduce my farm's pesticide use. Biotechnology cut it by half"*** (Foell, 2010).

Illinois Soybean Association Chairman and Roseville Farmer **Ron Moore** in his speech at a biotechnology conference in Chicago in 2010 said that, ***"the advancements in biotechnology have drastically changed the agricultural industry in the past decade, especially the seed trade. Corn and soybeans can now be genetically engineered to be herbicide resistant, insect resistant and drought resistant. Drought tolerant is big,"*** he said. ***"You can grow in more arid areas. It allows us to bring new traits to market quicker"*** (Moore, 2010).

<u>BRAZIL</u>

In 2011, Brazil grew 30.3 million hectares of biotech crops, comprising soybean, maize and cotton with a record year-over-year increase of 4.9 million hectares compared with 2010; for the third consecutive year, this is the largest increase in any country in the world. The total planted area of the three crops in Brazil was 40.6 million hectares of which 30.3 million hectares, or 75% was biotech. Brazil is second only to the US in terms of biotech crop hectarage and in 2011, it further enhanced its status by consolidating its position and decreasing the gap between it and the US. Brazil grew 19% of the global biotech crop hectarage of 160 million hectarage of

biotech crops globally in 2011. Of the three biotech crops in Brazil, by far the largest hectarage is herbicide tolerant soybean which occupied 20.6 million hectares, up from 17.8 million hectares in 2010, equivalent to an impressive year-over-year growth of 16%. Biotech soybean occupied 83% of the 25 million hectares of the national soybean crop grown in Brazil in 2011. Biotech maize is the second most important crop in Brazil with a total of 9.1 million hectares for both summer (summer 4.48 million hectares and winter 4.63 million hectares) and winter, up by 1.8 million hectares or a substantial 25% from 2010. All three categories of events Bt, HT, and the stack of Bt/HT are deployed in both summer and winter maize. The third and last biotech crop in Brazil is cotton which was planted on 1.55 million hectares in 2011 of which 0.606 million hectares or 39% was biotech. Biotech cotton increased from 0.250 million hectares in 2010 to 0.606 million hectares in 2011, equivalent to an unprecedented 142% year-over-year increase. In 2011, Brazil approved a biotech bean that is resistant to the important disease caused by the golden bean mosaic virus; the approval is notable because it was developed entirely by EMBRAPA. The economic benefits to Brazil from biotech crops for the eight year period 2003 to 2010 is US$4.6 billion and US$1.2 billion for 2010 alone. Brazil is quickly emerging as the engine of growth, not only in Latin America, but in the world with increased activities in Africa.

BRAZIL

Population: 194.2 million

GDP: US$1,575 billion

GDP per Capita: US$8,210

Agriculture as % GDP: 7%

Agricultural GDP: US$110 billion

% employed in agriculture: 21%

Arable Land (AL): 59.6 million hectares

Ratio of AL/Population*: 1.3

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

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

Total area under biotech crops and (%) increase in 2011:
30.3 Million Hectares (+19%)

Farm income gain from biotech, 2003-2010: US$4.6 billion

*Ratio: % global arable land / % global population

The first crop estimate for 2011-2012 from CONAB (the Brazilian agency for crop surveys), project that following good returns for the last two seasons, Brazilian farmers are expected to plant a record

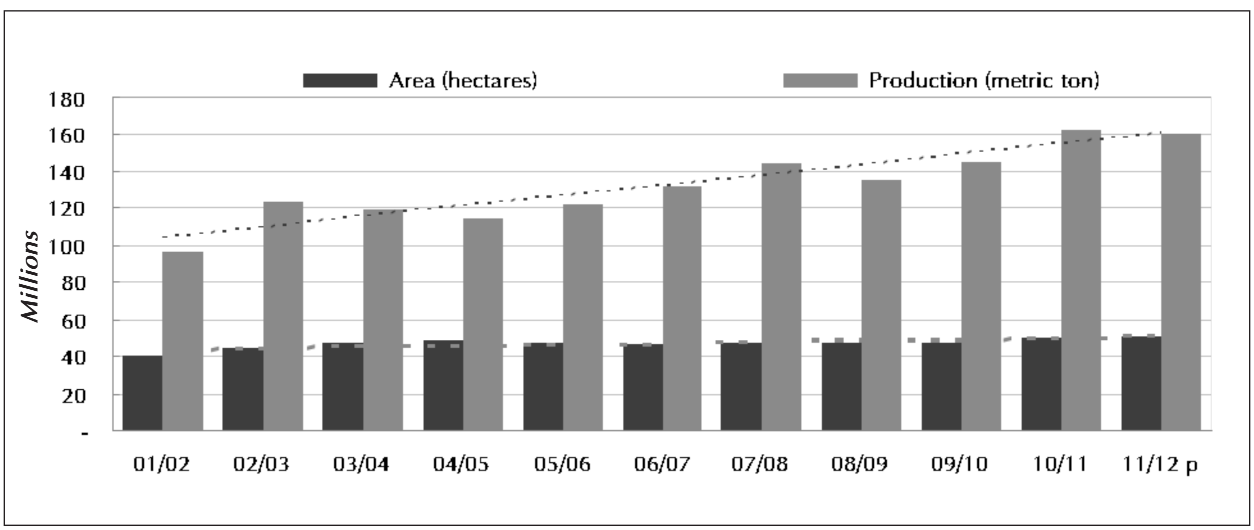
51.2 million hectares in the 2011/12 crop year, an increase of 2.7% in planted area over the last season.

In view of the expansion in planted areas and yield projections, and based on the trends over the last fifteen years, CONAB predicts that total grain production will reach 160.3 million tons, a marginal drop of 1.6%, compared to the record 2010/11 crop year (Figure 6). Between 2001/02 and 2010/11, harvested crop area in Brazil increased from 40.3 million hectares to 49.9 million hectares, an annual growth of 2.2%. In this period, the crops that occupied the biggest increase in hectarage increases were soybeans (+7.9 million ha), winter maize (+3.0 million ha) and cotton (+0.7 million ha). The crops that suffered a decrease in hectarage during the same period were summer maize (-1.5 million ha), rice (-0.4 million ha) and sorghum (-0.33 million ha).

In addition to the substantial economic benefits from crops in Brazil, the productivity gains from improved crops are important for sustainable production on crop land, and the conservation of natural resources, for future generations.

As a result of consistent gains in productivity, total grain production between 2001/02 and 2010/11 increased from 96.8 million tons to 160.3 million tons, an annual growth of 5.3%. These gains in productivity have made important contributions to Brazilian agriculture which has been one of the most dynamic sectors in the Brazilian economy, and one of the principal drivers of the thriving Brazilian economy, including significant export earnings. Agriculture and more specifically improved crop production has also protected the domestic economy from the global financial crises during the last couple of years.

Figure 6. Total Grain Production and Planted Area in Brazil



Source: CONAB | Elaboration: CÉLERES®.

For the 2011/12 crop year, the total hectarage predicted for grain crops is 51.2 million hectares, with soybeans occupying the largest acreage, with 25.0 million hectares, followed by summer maize, with 8.5 million hectares, winter maize with 5.9 million hectares, and beans, with 4.0 million hectares (Figure 7).

The outstanding performance of the Brazilian farming sector has contributed to the consolidation of the country's macroeconomic conditions, generating substantial exports and trade opportunities. Between 2002 and 2010, the total accumulated Brazilian foreign trade balance was US$286.4 billion. In the same period, the farming sector alone accumulated a trade balance of US$448.1 billion, confirming that the farming sector was a significant net exporter, whilst the other sectors of economy were net importers (Figure 8).

As a result of the booming economic growth in the last five years, plus the strengthening of the Real, the Brazilian economy has become more and more dependent on the farming sector to maintain Brazil's trade surplus. By the end of 2011, Brazil will have accumulated more than US$350 billion in international reserve funds, principally due to the farming sector's sterling performance, at a time when maintaining international reserve funds proved to be extremely important at a critical time when instability and uncertainty cast a shadow on the international economy, particularly on the stagnant economies of Europe and the United States.

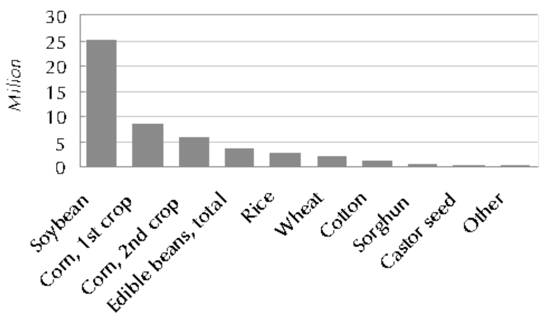
In a more detailed assessment of the agriculture trade balance in Brazil in 2010, it was evident that exports of soybeans (the grain, bran, and oil) have remained the major item in Brazilian exports. Of an agriculture balance of US$61.5 billion in 2010, soybeans and its sub-products accounted for US$16.5 billion, i.e., 27% of the total, followed by the meats sector, which amounted to US$12 billion (20% of the total) and sugar, totaling US$12,9 billion (19% of the total) (Figure 9).

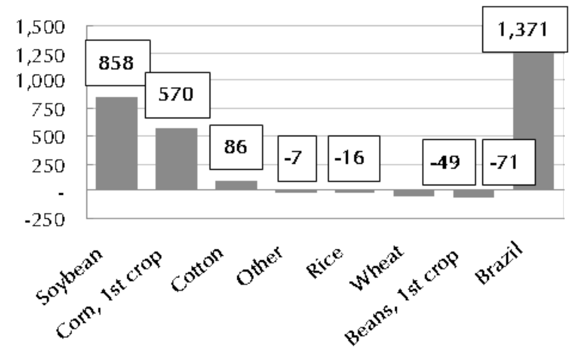
Of particular interest are increasing maize exports that are already responsible for nearly 3% of the trade balance, reaching US$1.7 billion in 2010. It is noteworthy that only a few years ago, Brazil still depended on Argentinean maize imports to offset its supply setting. The rapid transformation from being an importer to an exporter is only possible due to the substantial gains in productivity that the maize producers have been experiencing over the last years, and driven also by a high adoption rate of improved new biotech maize hybrids.

In a situation where the success of the Brazilian economy has been dependent on the farming sector's success and efficiency, the adoption of biotech crops is prerequisite and an essential technological tool to maintain and enhance the rate of crop productivity gains in crop production in Brazil in the remaining years of this decade.

Figure 7. Brazilian Grains Planted Area in 2011/12

Planted area in 2011/12 crop season (million ha)	Main changes from 2010/11 (thousand ha)

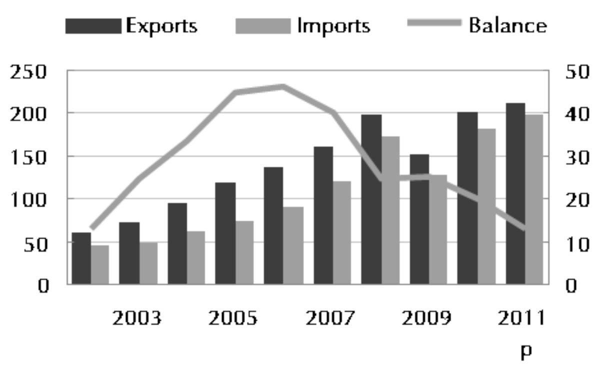


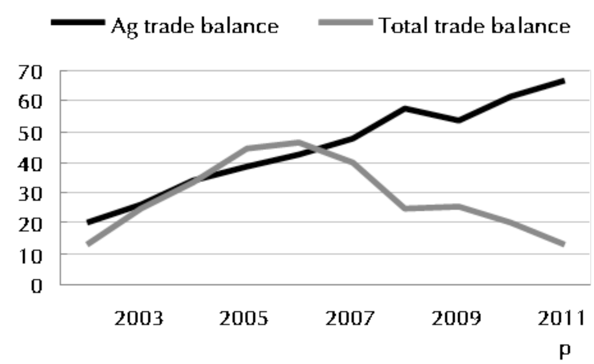


Source: CONAB | Elaboration: CÉLERES® | As of October, 2011.

Figure 8. Brazilian External Trade Analysis

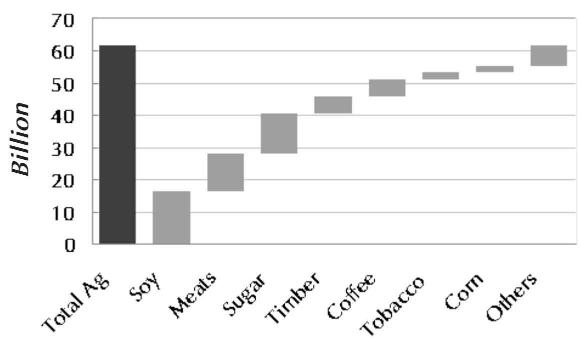
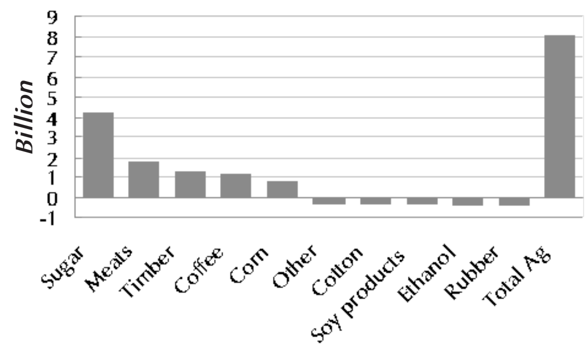
Brazilian total external trade, in US$ billion	Brazilian Ag trade balance x total trade balance, in US$ billion





Source: MDIC/SECEX/CONAB | Elaboration: CÉLERES® | As of October, 2011.

Figure 9. Brazilian Ag Trade Balance Analysis

Brazilian Ag trade balance, market share in 2010	Main changes between 2010 and 2009
	

Source: MDIC/SECEX/CONAB | Elaboration: CÉLERES® | As of October, 2011.

In 2011, Brazil grew 30.3 million hectares of biotech crops, comprising soybean, maize and cotton with a record year-over-year increase of 4.9 million hectares compared with 2010. The total planted area of the three crops in Brazil was 40.6 million hectares of which 30.3 million hectares, or 75% was biotech. Brazil is second only to the US in terms of biotech crop hectarage and in 2011 it further enhanced its position by consolidating its position and decreasing the gap between it and the US. Brazil grew 19% of the global biotech crop hectarage of 160 million hectarage of biotech crops globally in 2011. Of the biotech crops in Brazil by far, the largest hectarage is herbicide tolerant soybean which occupied 20.6 million hectares, up from 17.8 million hectares in 2010, equivalent to an impressive year-over-year growth of 16%. Biotech soybean occupied 83% of the 25 million hectares of the national soybean crop grown in Brazil in 2011 (Table 4). The highest adoption rate, by region, in the three regions was the South region with 90.5% (within which Rio Grande do Sul was the highest at 98.9% adoption) followed by the Southeast at 80.6% the NorthEast at 79.4% (Table 4).

Biotech maize is the second most important crop in Brazil with a total of 9.1 million hectares for both summer (summer 4.48 million hectares and winter 4.63 million hectares) and up by 1.8 million hectares or a substantial 25% from 2010 . All three categories of events: insect resistant (Bt), herbicide tolerant (HT), and the stack of Bt/HT are deployed in both summer and winter maize. For convenience, the summer and winter maize crops can be discussed separately and the respective details can be viewed in Tables 5 and 6. Of the 8.29 million hectares of summer maize 4.48 million hectares or 54% are biotech of which 32% is Bt, 17% as Bt/HT, and 5% as HT alone. The highest adoption, by region is in the Center West at 88.2%, South East at 72.15% and the South at 67.0%.

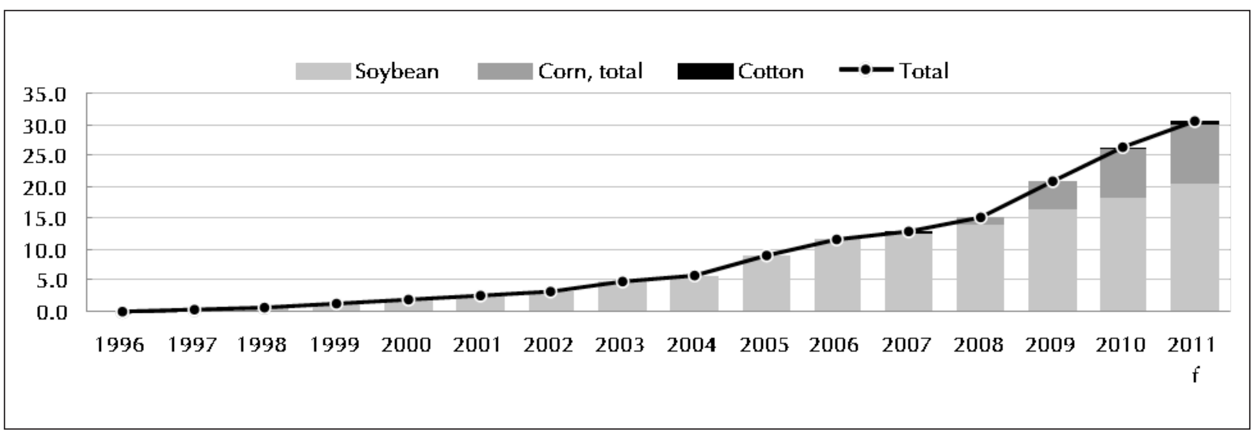
In contrast, winter maize (also referred to as "safrinha") occupies a smaller hectarage than summer maize at 5.75 million hectares. Of the 5.75 million hectares of winter maize 4.63 million hectares or 80% (compare summer maize at 54%) are biotech of which 40.6% is the stacked product Bt/HT, 28.6% is Bt and 11% as herbicide tolerance alone. The highest adoption, by region is in the South at 88.7%, followed by the South East at 82.0% and the Center West at 79.4%.

The third and last biotech crop in Brazil is cotton which was planted on 1.55 million hectares in 2011 of which 0.606 mill hectares or 39% was biotech (Table 7). Biotech cotton increased from 0.250 million hectares in 2010 to 0.606 million hectares in 2011, equivalent to an unprecedented 142% year-over-year increase. Of the 155 million hectares of cotton 0.606 million hectares or 39% were biotech of which 16.26% is the stacked product Bt/HT, 14.3% is Ht and 8.5% as Bt alone. The highest adoption, by region is in the North East at 40.6%, followed by the North/NorthEast 40.4% and the Center West at 38.6%.

Considering the current hectarage estimate for the 2011/12 crop year (CONAB) and the forecast of biotech crop adoption, 59.3% of the area cultivated with grains in Brazil will be planted with biotech crops. In 2011/12, 82.7% of the area grown with soybeans, 80.7% of the area harvested with maize (winter crop), 54.0% of the area with maize (summer crop) and 39.0% of cotton, will be planted with biotech traits (Figure 10).

The analysis of the traits in use in Brazil shows that herbicide tolerance (HT) is the most adopted trait, with 21.9 million hectares, followed by insect resistance (IR) with 4.4 million hectares and lastly, by the stacked genes technologies, with 4.1 million hectares. Considering the high rate of adoption for biotech maize it is important to note that Brazil is only in its fourth planting season

Figure 10. Biotech Crop Adoption in Brazil, by Crop (Million Hectares)



Source: CÉLERES®, 2011.

Table 4. Soybean Production and Biotech Soybean Adoption, 2011/12 Crop Season

	Area (ha)	Yield (t/ha)	Produc-tion (t)	Adoption rate (as % of total area)				Area with GM traits			
				IR	HT	IR/HT	Total	IR	HT	IR/HT	Total
NORTH	**0.7**	**3.1**	**2.2**	**0.0**	**62.3**	**0.0**	**62.3**	**0.0**	**0.4**	**0.00**	**0.4**
NORTHEAST	**2.1**	**3.1**	**6.4**	**0.0**	**78.8**	**0.6**	**79.4**	**0.0**	**1.6**	**0.01**	**1.6**
Maranhão	0.6	3.2	1.8	0.0	72.8	0.0	72.8	0.0	0.4	0.00	0.4
Piauí	0.4	2.9	1.1	0.0	69.4	0.0	69.4	0.0	0.3	0.00	0.3
Bahia	1.1	3.1	3.5	0.0	85.0	1.1	86.1	0.0	1.0	0.01	1.0
SOUTHEAST	**1.7**	**2.9**	**5.0**	**0.0**	**80.0**	**0.6**	**80.6**	**0.0**	**1.4**	**0.01**	**1.4**
Minas Gerais	1.1	3.0	3.4	0.0	80.0	0.5	80.5	0.0	0.9	0.01	0.9
São Paulo	0.6	2.6	1.7	0.0	80.0	0.6	80.6	0.0	0.5	0.00	0.5
SOUTH	**9.2**	**2.8**	**25.5**	**0.0**	**90.3**	**0.1**	**90.5**	**0.0**	**8.3**	**0.01**	**8.4**
Paraná	4.6	3.1	14.4	0.0	82.0	0.2	82.2	0.0	3.8	0.01	3.8
Santa Catarina	0.5	3.0	1.5	0.0	96.9	0.0	96.9	0.0	0.5	0.00	0.5
Rio Grande do Sul	4.2	2.3	9.6	0.0	98.8	0.1	98.9	0.0	4.1	0.01	4.1
CENTER WEST	**11.3**	**3.2**	**36.2**	**0.0**	**78.3**	**0.3**	**78.5**	**0.0**	**8.8**	**0.03**	**8.8**
Mato Grosso	6.7	3.3	22.1	0.0	76.0	0.3	76.3	0.0	5.1	0.02	5.1
Mato Grosso Sul	1.9	2.8	5.3	0.0	80.8	0.2	80.9	0.0	1.5	0.00	1.5
Goiás	2.7	3.2	8.6	0.0	82.0	0.3	82.3	0.0	2.2	0.01	2.2
Distrito Federal	0.1	3.3	0.2	0.0	82.0	0.0	82.0	0.0	0.0	0.00	0.0
N/NE	**2.8**	**3.1**	**8.6**	**0.0**	**74.6**	**0.4**	**75.0**	**0.0**	**2.1**	**0.01**	**2.1**
C-SOUTH	**22.2**	**3.0**	**66.8**	**0.0**	**83.4**	**0.2**	**83.6**	**0.0**	**18.5**	**0.05**	**18.6**
BRAZIL	**25.0**	**3.0**	**75.4**	**0.0**	**82.4**	**0.3**	**82.7**	**0.0**	**20.6**	**0.07**	**20.7**

Source: CÉLERES®, 2011.

Updated: August 2011

Table 5. Maize Production and Biotech Maize Adoption, 2011/12 Summer Crop Season

	Area (ha)	Yield (t/ha)	Produc-tion (t)	Adoption rate (as % of total area)				Area with GM traits			
				IR	HT	IR/HT	Total	IR	HT	IR/HT	Total
NORTH	**0.49**	**2.41**	**1.18**	**6.3**	**1.4**	**2.2**	**9.9**	**0.03**	**0.01**	**0.01**	**0.05**
NORTHEAST	**2.72**	**1.57**	**4.28**	**19.0**	**2.7**	**7.7**	**29.5**	**0.52**	**0.07**	**0.21**	**0.80**
Maranhão	0.38	1.71	0.66	42.0	5.8	17.4	65.2	0.16	0.02	0.07	0.25
Piauí	0.33	1.36	0.45	42.0	5.8	17.4	65.2	0.14	0.02	0.06	0.22
Bahia	0.42	3.64	1.51	42.0	5.8	17.4	65.2	0.17	0.02	0.07	0.27
SOUTHEAST	**1.75**	**5.86**	**10.26**	**47.5**	**5.9**	**18.6**	**72.1**	**0.83**	**0.10**	**0.33**	**1.26**
Minas Gerais	1.10	5.88	6.47	49.2	5.8	18.1	73.2	0.54	0.06	0.20	0.80
São Paulo	0.60	6.05	3.63	44.2	5.8	19.6	69.6	0.27	0.03	0.12	0.42
SOUTH	**2.70**	**6.04**	**16.31**	**36.0**	**6.3**	**24.7**	**67.0**	**0.97**	**0.17**	**0.67**	**1.81**
Paraná	0.95	7.98	7.58	36.0	6.3	27.9	70.2	0.34	0.06	0.26	0.67
Santa Catarina	0.60	6.03	3.62	36.0	6.3	24.0	66.3	0.22	0.04	0.14	0.40
Rio Grande do Sul	1.15	4.43	5.10	36.0	6.3	22.5	64.8	0.41	0.07	0.26	0.75
CENTER WEST	**0.63**	**6.81**	**4.32**	**47.1**	**7.6**	**33.5**	**88.2**	**0.30**	**0.05**	**0.21**	**0.56**
Mato Grosso	0.13	5.56	0.72	38.2	7.2	23.2	68.6	0.05	0.01	0.03	0.09
Mato Grosso Sul	0.09	7.47	0.64	50.5	7.2	31.0	88.6	0.04	0.01	0.03	0.08
Goiás	0.40	6.98	2.79	49.2	7.8	37.2	94.2	0.20	0.03	0.15	0.38
Distrito Federal	0.02	8.82	0.17	47.2	7.8	38.0	92.9	0.01	0.00	0.01	0.02
N/NE	**3.21**	**1.70**	**5.45**	**17.1**	**2.5**	**6.9**	**26.5**	**0.55**	**0.08**	**0.22**	**0.85**
C-SOUTH	**5.08**	**6.07**	**30.88**	**41.4**	**6.3**	**23.7**	**71.4**	**2.10**	**0.32**	**1.21**	**3.63**
BRAZIL	**8.29**	**4.38**	**36.34**	**32.0**	**4.9**	**17.2**	**54.0**	**2.65**	**0.40**	**1.43**	**4.48**

Source: CÉLERES®, 2011. Updated: August 2011

Table 6. Maize Production and Biotech Maize Adoption, 2011/12 Winter Crop Season

	Area (ha)	Yield (t/ha)	Produc-tion (t)	Adoption rate (as % of total area)				Area with GM traits			
				IR	HT	IR/HT	Total	IR	HT	IR/HT	Total
NORTH	**0.04**	**2.66**	**0.09**	**7.0**	**1.7**	**12.1**	**20.8**	**0.00**	**0.00**	**0.00**	**0.01**
NORTHEAST	**0.39**	**1.22**	**0.47**	**19.5**	**4.7**	**33.7**	**57.9**	**0.08**	**0.02**	**0.13**	**0.22**
Maranhão	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
Piauí	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
Bahia	0.39	1.22	0.47	19.5	4.7	33.7	57.9	0.08	0.02	0.13	0.22
SOUTHEAST	**0.33**	**2.94**	**0.91**	**25.6**	**15.2**	**41.2**	**82.0**	**0.08**	**0.05**	**0.13**	**0.27**
Minas Gerais	0.03	5.39	0.15	25.6	15.2	41.2	82.0	0.01	0.00	0.01	0.02
São Paulo	0.30	2.69	0.76	25.6	15.2	41.2	82.0	0.08	0.04	0.12	0.24
SOUTH	**1.69**	**4.14**	**6.85**	**33.0**	**11.7**	**44.0**	**88.7**	**0.56**	**0.20**	**0.74**	**1.50**
Paraná	1.69	4.14	6.85	33.0	11.7	44.0	88.7	0.56	0.20	0.74	1.50
Santa Catarina	0.00	0.00	0.00	0.0	0.0	0.0	0.	0.00	0.00	0.00	0.00
Rio Grande do Sul	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
CENTER WEST	**3.32**	**4.36**	**13.72**	**27.9**	**11.5**	**39.9**	**79.4**	**0.93**	**0.38**	**1.32**	**2.63**
Mato Grosso	2.10	4.74	9.66	27.9	11.5	39.9	79.4	0.59	0.24	0.84	1.67
Mato Grosso Sul	0.85	2.83	2.28	27.9	11.5	39.9	79.4	0.24	0.10	0.34	0.67
Goiás	0.36	5.14	1.75	27.9	11.5	39.9	79.4	0.10	0.04	0.14	0.29
Distrito Federal	0.01	5.74	0.04	27.9	11.5	39.9	79.4	0.00	0.00	0.00	0.01
N/NE	**0.42**	**1.34**	**0.57**	**18.5**	**4.4**	**31.9**	**54.8**	**0.08**	**0.02**	**0.13**	**0.23**
C-SOUTH	**5.33**	**4.20**	**21.49**	**29.4**	**11.8**	**41.3**	**82.5**	**1.57**	**0.63**	**2.20**	**4.40**
BRAZIL	**5.75**	**3.98**	**22.06**	**28.6**	**11.2**	**40.6**	**80.4%**	**1.65**	**0.65**	**2.34**	**4.63**

Source: CÉLERES®, 2011.

Updated: August 2011

Table 7. Cotton Production and Biotech Cotton Adoption, 2011/12 Crop Season

	Area (ha)	Yield (t/ha)	Production (t)	Adoption rate (as % of total area)				Area with GM traits			
				IR	HT	IR/HT	Total	IR	HT	IR/HT	Total
NORTH	**0.01**	**3.61**	**0.01**	**3.2**	**12.9**	**10.7**	**26.8**	**0.000**	**0.001**	**0.001**	**0.002**
NORTHEAST	**0.52**	**1.50**	**0.80**	**8.5**	**14.2**	**17.9**	**40.6**	**0.044**	**0.074**	**0.093**	**0.212**
Maranhão	0.02	1.49	0.03	7.7	12.9	17.9	38.5	0.002	0.003	0.004	0.008
Piauí	0.02	1.32	0.03	7.7	12.9	17.9	38.5	0.002	0.003	0.004	0.008
Bahia	0.47	1.56	0.74	8.6	14.4	17.9	40.8	0.040	0.067	0.084	0.192
SOUTHEAST	**0.06**	**1.43**	**0.09**	**8.6**	**14.4**	**10.7**	**33.6**	**0.005**	**0.009**	**0.006**	**0.020**
Minas Gerais	0.04	1.46	0.06	8.6	14.4	10.7	33.6	0.003	0.006	0.004	0.013
São Paulo	0.02	1.33	0.03	8.6	14.4	10.7	33.6	0.002	0.003	0.002	0.007
SOUTH	**0.00**	**0.79**	**0.00**	**8.0**	**13.5**	**4.7**	**26.2**	**0.000**	**0.000**	**0.000**	**0.000**
Paraná	0.00	0.79	0.00	8.0	13.5	4.7	26.2	0.000	0.000	0.000	0.000
Santa Catarina	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000
Rio Grande do Sul	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000
CENTER WEST	**0.96**	**1.40**	**1.52**	**8.6**	**14.4**	**15.7**	**38.6**	**0.082**	**0.138**	**0.151**	**0.371**
Mato Grosso	0.78	1.37	1.23	8.6	14.4	15.7	38.6	0.067	0.112	0.122	0.301
Mato Grosso Sul	0.07	1.46	0.11	8.6	14.4	15.7	38.6	0.006	0.010	0.011	0.027
Goiás	0.11	1.57	0.18	8.6	14.4	15.7	38.6	0.009	0.016	0.017	0.042
Distrito Federal	0.00	1.29	0.00	8.6	14.4	15.7	38.6	0.000	0.000	0.000	0.001
N/NE	**0.53**	**1.50**	**0.81**	**8.4**	**14.2**	**17.8**	**40.4**	**0.045**	**0.075**	**0.094**	**0.214**
C-SOUTH	**1.02**	**1.40**	**1.61**	**8.6**	**14.4**	**15.3**	**38.3**	**0.088**	**0.147**	**0.157**	**0.392**
BRAZIL	**1.55**	**1.43**	**2.43**	**8.5**	**14.3**	**16.**	**39.0**	**0.132**	**0.222**	**0.251**	**0.606**

Source: CÉLERES®, 2011.

Updated: August 2011

and that 2011 will only be the second year with an abundant supply of stacked traits for maize and cotton. Even so it is already evident that usage of the single trait technology is decreasing fast in favor of the stacked traits. For example, insect resistance (IR), decreased by almost 50% from 7.2 million hectares in 2010 to 4.4 million in 2011. Consistent with experience in other countries such as the United States and Canada, Brazilian farmers have indicated a clear preference for the stacked traits over the single traits (Figure 11).

The approval in August 2010 of the first biotech soybeans with stacked traits, which will be commercially available in 2012, is expected to further boost the deployment of stacked traits in Brazil and will have high impact because of the large hectarage of soybean (25 million hectares) versus, maize (14 million hectares) and cotton at 1.55 million hectares. In as much as the technology developers were able to develop biotech varieties and hybrids adapted to the different farming regions in Brazil, a continuous migration of and adoption of biotech crops was witnessed with adoption progressing from one end of the country to the other. Rio Grand do Sul was the early leader with biotech crops but in 2011, Mato Grosso will be the largest region for biotech crops, with 7.1 million hectares, followed by Paraná, with 5.9 million hectares, and Rio Grande do Sul, with 4.8 million hectares (Figure 12).

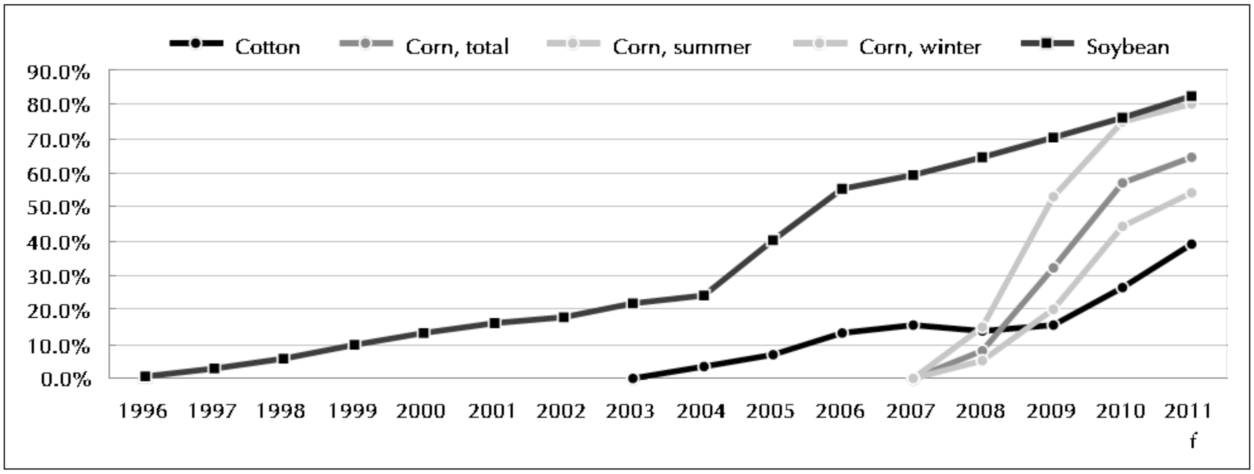
Subsequent to early judicial difficulties with biosafety in Brazil, consolidation of the federal biotech regulatory framework, and the effective functioning of CTNBio, (Brazilian National Technical Commission on Biosafety) Brazil has accelerated the approvals of biotech events – in 2010 alone Brazil approved a record number of 8 products, and 6 have already been approved as of end of September 2011. Thus, Brazil is making up for the lost time in the first five years. There are currently 32 biotech approved traits in the country for farm use, five traits for soybeans, seventeen for maize, nine for cotton and one for an edible virus resistant bean (Figure 14).

High adoption rates are an important feature of biotech crops in Brazil. Taking soybeans as an example, one of the important drivers of high adoption rates is the direct benefits realized by Brazilian farmers from using biotech soybeans rather than conventional. According to an analysis conducted from 2007/08 crop season onwards, the production cost for one hectare of biotech soybeans was consistently less expensive than production of conventional soybeans, irrespective of region (Figure 15).

In addition to the critical importance of direct benefits, Brazilian farmers also assign high value to the substantial indirect value related to the adoption of biotech soybeans, that impacts on efficiency gains, and the convenience and ease of weed management systems, possible only with herbicide tolerant soybeans.

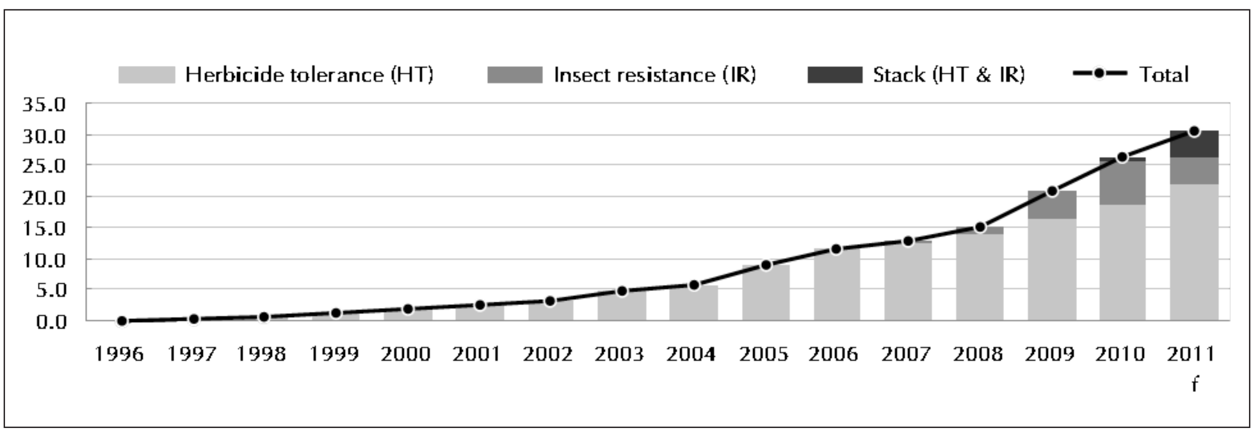
Due to the soil fertility characteristics in Brazil, fertilizer is by far the most important and costly of all inputs for soybean direct production costs. Mato Grosso, is Brazil's major soybean producer, and

Figure 11. Biotech Crop Adoption Rates in Brazil, by Crop (Percent of Total Hectarage)



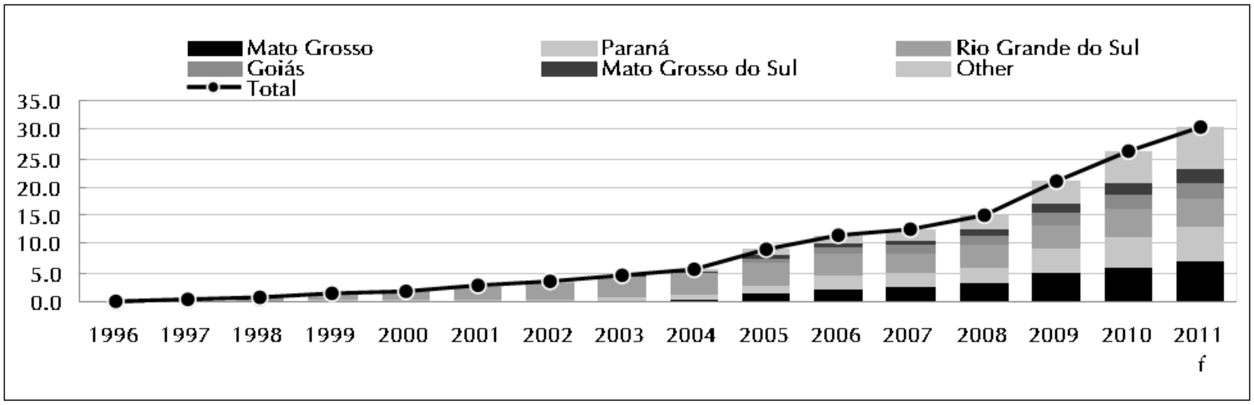
Source: CÉLERES®, 2011.

Figure 12. Biotech Crop Adoption in Brazil, by Trait (Million Hectares)



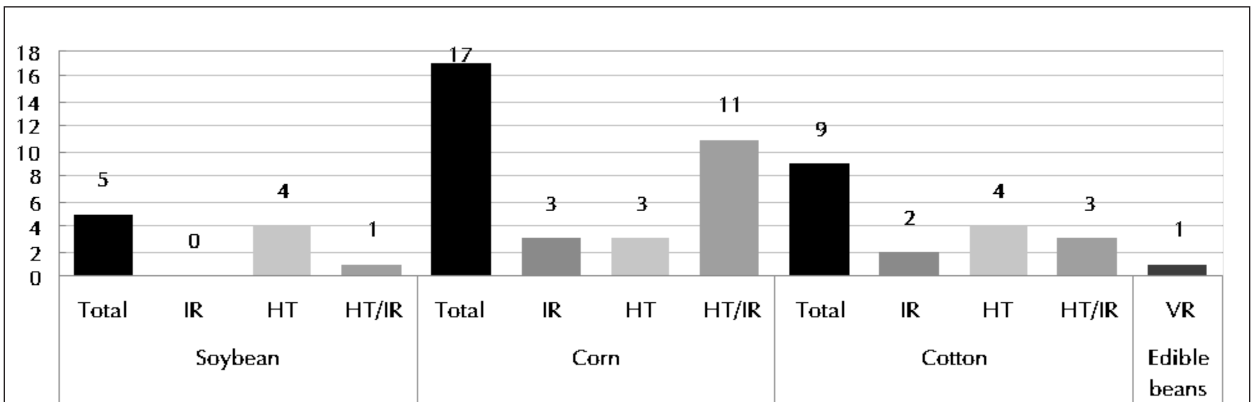
Source: CÉLERES®, 2011.

Figure 13. Biotech Crop Adoption in Brazil, by State (Million Hectares)



Source: CÉLERES®, 2011.

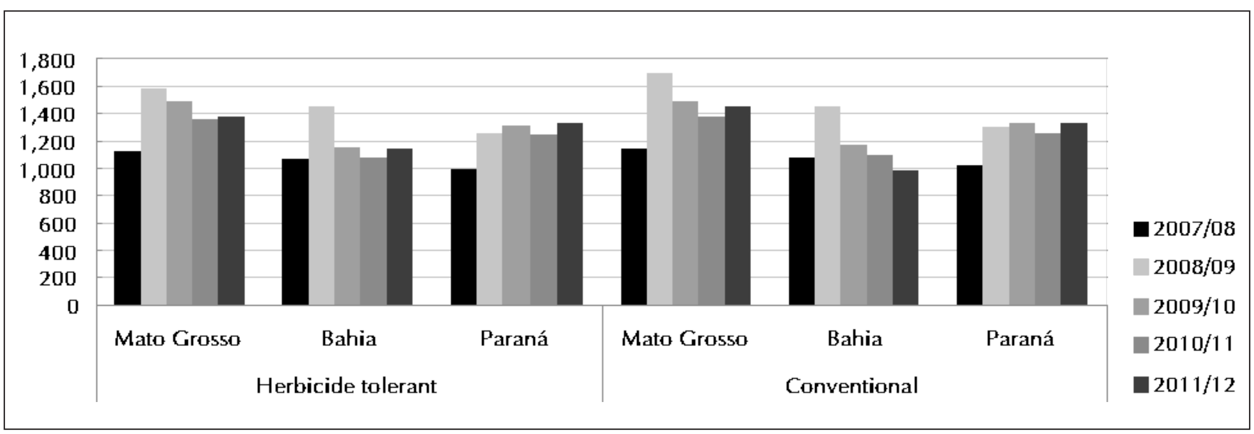
Figure 14. Number of Approved Biotech Traits in Brazil, by Crop



Note: IR: Insect resistance; HT: herbicide tolerance; IR/HT: stack; VR: virus resistance

Source: CTNBio | Elaboration: CÉLERES® | As of October 1st, 2011.

Figure 15. Direct Production Costs for Soybean in Different Regions in Brazil (R$/Hectare)

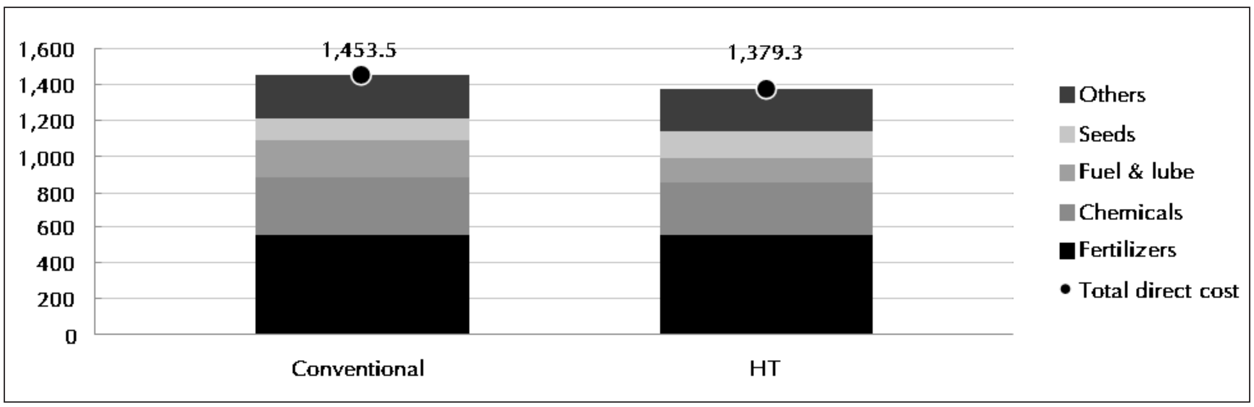


Source: CÉLERES®, 2011.

fertilizer is estimated to represent 40% of all direct costs for the 2011/12 crop season. In addition to the many advantages that herbicide tolerant soybeans offer, the cost of herbicides is only 20.9% compared with 40% for fertilizers (Figure 16).

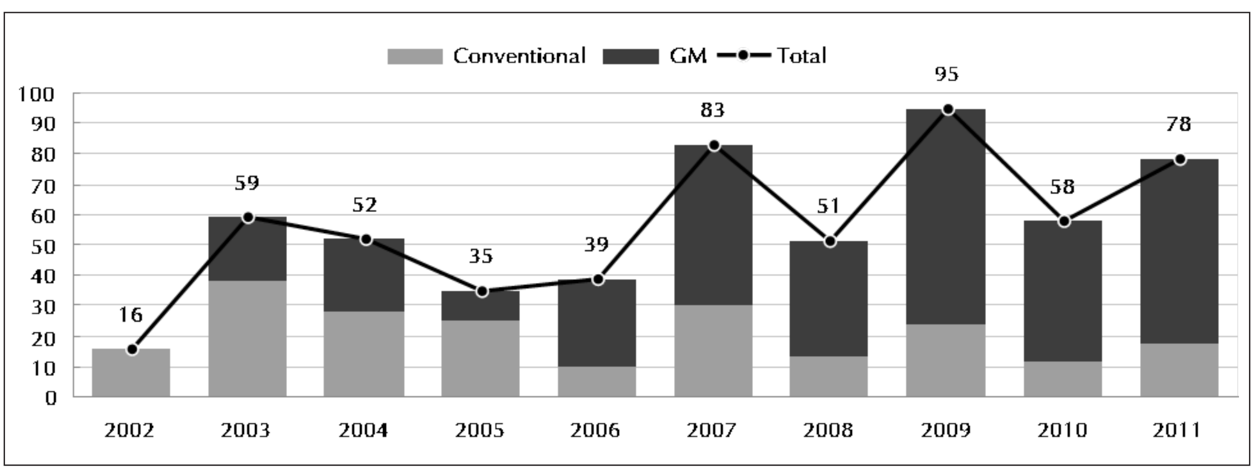
According to data from the Ministry of Agriculture (MAPA/SNRC), from 2002 to 2011, Brazil registered 566 new varieties of soybeans, out of which 352 (62%) were biotech and only 214 (38%) were conventional varieties (38%). In the last years, a predominance of biotech crops was clearly evident versus conventional varieties (Figure 17).

Figure 16. Details of Soybean Direct Production Cost in Brazil, 2011/12 Crop Season (R$/hectare)



Source: CÉLERES®, 2011.

Figure 17. Register of Soybean Varieties in Brazil



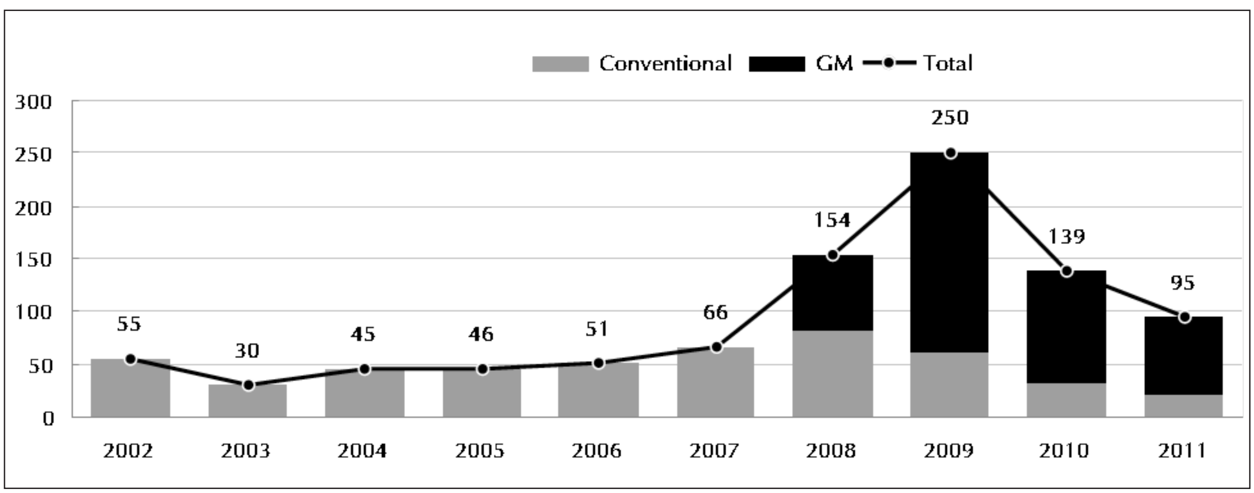
Source: MAPA/SNRC | Elaboration: CÉLERES® | For 2011, as of October, 2011.

The availability of many well-adapted varieties of biotech soybeans has been a key factor and has facilitated the adoption by farmers in Brazil's different regions to appropriate varieties for their specific conditions. Thus, farmers from all the many soybean producing states of Brazil have already planted over 60% of their total area to biotech soybean cultivars (Table 4). Although the commercial production of the stacked trait soybean will start only in 2012, the data in Figure 17 indicate that some hectares will be grown in 2011. These are stacked trait hectares grown under controlled conditions for seed production ready for 2012 when large scale commercial production will occur. This arrangement is based on an agreement made by, and between, stakeholders involved in the production of soybeans in Brazil. Thus, the stacked trait soybean production has not been marketed commercially in 2011/12, and limited to seed multiplication or trials.

The deployment of biotech maize in Brazil is in its fourth year, following its approval by CTNBio. During this period, the biotech maize developers have successfully delivered a significant number of hybrids with biotech traits. According to Brazil's Ministry of Agriculture (MAPA/SNRC), from 2002 to 2011, Brazil registered 931 maize hybrids, out of which 443 (48%) are biotech hybrids – this is a significant achievement given that registration of biotech events has only been in effect over the last four years (Figure 18).

An ample supply of biotech hybrids, adapted to Brazil's different regions, and combined with substantial gains in productivity over last three years, have helped convince Brazilian farmers of the multiple and significant advantages, (both direct and indirect), that biotech maize offers. Accordingly, biotech maize, has already gained the trust and confidence of farmers as a technology and hence its prevalent adoption in the different maize producing states as shown in Tables 5 and

Figure 18. Register of Maize Hybrids in Brazil



Source: MAPA/SNRC | Elaboration: CÉLERES® | For 2011, as of October, 2011.

6. It is noteworthy that there are enormous differences amongst Brazil's crop mega-environments, particularly the differences between summer and winter maize which require quite different technologies and management.

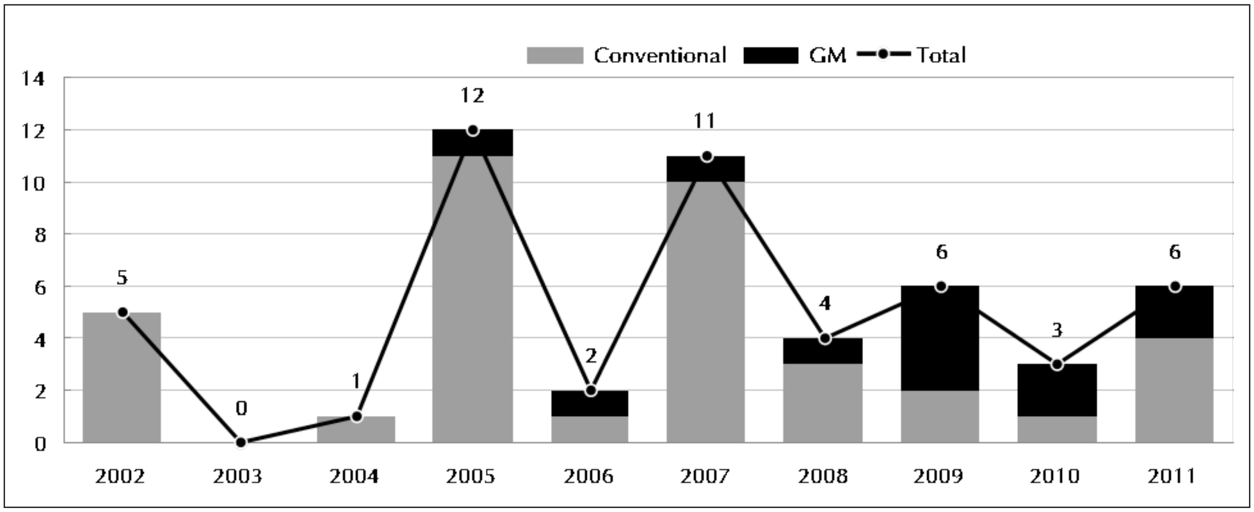
The projections in Table 5 indicate that in 2011/12, the summer maize total planted hectarage is expected to reach 8.3 million hectares (CÉLERES®), of which nearly 2.6 million hectares will be open pollinated cultivars grown under low-tech systems and therefore the 2.6 million hectares do not represent a potential hectarage for biotech maize at this time. Thus, the actual hectarage available for biotech summer maize is 8.3 million hectares minus 2.6 = 5.7 million hectares. Calculating the adoption rate for summer maize, using 5.7 rather than 8.3 million hectares as the reference base results, equivalent to an adoption rate of 78% (4.48/5.7), which is similar to the adoption rate for winter maize at 80.4% (Table 6); the adjusted summer adoption rate of 78% is as expected, similar to winter rate of 80%, because unlike summer maize, winter maize does not have a significant low-tech hectarage of open pollinated varieties.

In the winter maize crop season, the adoption of biotech crops by farmers is greater and more consistent than in the case for summer maize. Practically all of the winter maize is produced by farmers who grow soybeans in the previous summer and are therefore familiar with high-tech crop technologies, including biotech soybean. Thus, as expected the biotech maize adoption rate in the winter crop season is high, reaching a projected 80.4% in the 2011/12 crop season.

In the case of cotton, the technology developers have been delivering new biotech cotton varieties to the market but at a much slower rate than the corresponding technologies for soybean and maize; the number of registered varieties is considered small by farmers and the industry. According to data published by the Ministry of Agriculture (MAPA/SNRC), Brazil registered a total (biotech and conventional) of 50 new cotton cultivars since 2002. Of this number, only twelve varieties are biotech (24% of the total). The approval by CTNBio of stacked traits for cotton in 2010 is already contributing to an increase of registrations of new events in 2011 (Figure 19). Another important aspect of biotech cotton is that a good share of the hectares planted to biotech cotton is with seeds produced by the farmers themselves; this is a disincentive to companies that need to be assured of a return on investment when developing new biotech cotton varieties. Farmer saved seeds is allowed by Brazilian legislation, but has been generating unfavorable conditions for investments in research and development of biotech cotton.

Even with the constraints discussed above, the recent approval of biotech cotton with stacked traits has fostered an increase in the adoption of biotech cotton in Brazil. In the 2011/12 crop season, 39%, or equivalent to 600,000 hectares of the national cotton area will be planted with biotech cotton. This is a significant 142% increase, equivalent to an additional 350,000 hectares of biotech cotton in 2011 and a potential for further growth in 2012. It is worth noting that the decision to plant

Figure 19. Register of Cotton Varieties in Brazil



Source: MAPA/SNRC | Elaboration: CÉLERES® | For 2011, as of October, 2011.

cotton in Brazil can be delayed until the end of December and, in certain regions, until mid-January of 2012. Therefore, there is still the possibility for more, or less biotech cotton to be planted after this Brief goes to press; the most likely figure for the total cotton hectarage is 1.55 million hectares with a 39% adoption of biotech cotton. Confounding all projections for cotton is the fact that the crop is subject to more volatility in prices than other crops and uncertainty about the future market in 2012. Thus, all the cotton projections in this Brief are subject to change which can impact total plantings and adoption of biotech cotton.

Benefits from Biotech Crops in Brazil

An annual global study of benefits from biotech crops concluded that Brazil gained US$4.6 billion during the eight year period 2003 to 2010 and US$1.2 billion in 2010 alone (Brooks and Barfoot 2012, Forthcoming).

Biotech *Phaseolus* bean, resistant to Bean Golden Mosaic Virus (BGMV), developed by EMBRAPA[1], was approved for commercialization in Brazil in 15 September 2011.

[1] EMBRAPA is the Brazilian organization responsible for agricultural research and development in Brazil. EMBRAPA's annual budget (based on average annual exchange rates) grew from US$ 478 million in 2006 to US$ 1.1 billion in 2010 and 2011; In 2008/2009, EMBRAPA launched a governmental plan called "PAC EMBRAPA" to promote EMBRAPA activities in Brazil and overseas including several programs in Africa – see Appendix 6 for budget and world map showing EMBRAPA activities outside Brazil.

On 15 September 2011, in a landmark decision, the National Technical Commission on Biosafety (CTNBio) of Brazil approved a biotech bean (*Phaseolus vulgaris*) that is genetically modified to resist the bean golden mosaic virus (BGMV), the cause of the most devastating disease of beans in Brazil and Latin America (EMBRAPA, 2011). The new biotech bean is named EMBRAPA 5.1. It is also a landmark event because it is the first ever biotech/transgenic crop to be entirely developed by a public institution in a developing country. The biotech bean was developed by Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA* (Brazilian Agricultural and Livestock Research Company). A ten year R&D project was conducted in a partnership between two EMBRAPA institutes – CENARGEN, the EMBRAPA Genetic Resources and Biotechnology Institute and EMBRAPA's Rice and Beans Institute.

Dr. Francisco Aragão, a leading scientist in the project from CENARGEN, observed that the biotech bean was challenged over several years in carefully conducted field trials with severe infestations of the whitefly, *Bemisia tabacciin,* the vector that transmits BGMV. In these trials, the biotech trait consistently conferred complete resistance. Beans, is one of two components in the traditional staple diet of rice and beans and thus has a very high social value for both producers and consumers in Brazil. In Latin American and African societies, beans is not only a staple but the most important legume in the diets of over 500 million people. In Brazil, it is the main vegetable source of protein and iron, and when consumed with rice, it provides a balanced nutritional diet.

World production of *Phaselous* dry beans is 21 million tons per annum and Brazil is the largest producer at 3.5 million tons. In Brazil, beans are cultivated by smaller farmers, with nearly 80% of the production cultivated in less than 100 hectares, which is classified as small in Brazil. Early and severe epidemics of golden mosaic virus can cause 100% damage and crop failure. The Embrapa Arroz e Feijão Institute estimates that the loss caused by the disease annually by BGMV in Brazil would be enough to feed up to 5-10 million people. To meet its significant demand for beans, Brazil has to import up to 200,000 metric tons per year, thus importantly, the increased production from biotech beans will contribute significantly to import substitution. Thus, the biotech BGMV bean will confer significant socio-economic and environmental advantages, including reduced waste, a stable and reliable harvest and reduced use of pesticides.

The biotech bean is expected to be available for commercialization within the next two years or so, following seed multiplication. Dr. Aragão stressed that all the biosafety analyses have been conducted confirming that the biotech bean is as safe, or even safer than conventional varieties for human consumption and for the environment. The development of the biotech bean by EMBRAPA in Brazil has very important implications in a country that is emerging as the engine of growth in biotech crops in Latin America and globally. In 2011, Brazil was second only to the US in terms of hectares planted with biotech crops (30.3 million hectares) and the increase over 2010 was 4.9 million hectares, the largest year-on-year increase for any country in the world. The successful development of the biotech bean confirms Brazil's internationally recognized self-sufficient capability for developing biotech crops which are important for Brazil's fast-growing domestic and export needs as well as its contribution to global food security.

Brazil is the principal exporter of biotech soybeans to China, is also developing an export market for biotech maize, and deploying biotech cotton. Brazil has also sequenced the sugarcane genome as a first step towards developing more efficient biotech sugarcane for sugar and ethanol production. The successful initiative to develop resistance to BGMV in Brazil can serve as a practical model for other developing countries engaged in biotech crops on how to succeed. This applies to both the scientific development of the product and importantly the timely regulatory approval of the biotech bean so that producers, consumers and the country derive maximum benefits from the investment and the technology. Brazil approved no less than a record eight biotech crops in 2010 and an additional six approvals in 2011 (until October), making it the country with the fastest approval rate for biotech crops globally.

ARGENTINA

Total crop hectares in Argentina in 2011 were estimated at an all time record of 23.7 million hectares. Argentina maintained its ranking as the third largest producer of biotech crops in the world in 2011 occupying 15% of global hectarage. In 2011, Argentina was expected to plant a total hectarage of 23.7 million hectares of biotech soybean, maize and cotton, up by 0.9 million hectares or 4% from 22.9 million hectares in 2010. Of the 23.7 million hectares of biotech crops 19.1 million hectares were biotech soybean, 3.9 million hectares biotech maize and 0.7 million hectares were biotech cotton. Biotech soybean was down marginally due to substitution by biotech maize plantings which were up by 0.9 million hectares in 2011 and biotech cotton increased as well. Talks between Argentina and China to export the first Argentinean biotech maize to China in 2011/12 have provided a great incentive and boost for biotech maize in Argentina. Benefits from biotech crops alone for the first 15 years was estimated at US$72.36 billion and the creation of 1.82 million jobs (Trigo, 2011).

Total crop hectares in Argentina in 2011was estimated at an all time record of 23.7 million hectares. Argentina is 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. After retaining the second ranking position in the world for biotech crops area for 13 years, Argentina was narrowly displaced from being the second largest producer of biotech crops in the world in 2009, by Brazil. The 21 biotech crop products approved for commercial planting in Argentina and for import as food and feed products are listed in Table 8 including the designation of the event and the year of approval. It is noteworthy that a significant number of four new biotech crop events were approved in 2011.

ARGENTINA

Population: 39.9 million

GDP: US$328 billion

GDP per Capita: US$8,240

Agriculture as % GDP: 10%

Agricultural GDP: US$32.8 billion

% employed in agriculture: 1%

Arable Land (AL): 33.2 million hectares

Ratio of AL/Population*: 3.3

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

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

Total area under biotech crops and (%) increase in 2011:
23.7 Million Hectares (+4%)

Farm income gain from biotech, 1996-2010: US$12.2 billion

*Ratio: % global arable land / % global population

In 2011, the year-over-year increase, compared with 2010, was 0.8 million hectares with an annual growth rate of 4% over 2010. Of the 23.7 million hectares of biotech crops in Argentina in 2011, 19.1 million hectares were expected to be planted to biotech soybean, down marginally by 0.4 million hectares over 2010. The 19.1 million hectares of biotech soybean is equivalent to 100% of the planting of 19.1 million hectares of the national soybean crop in Argentina in 2011. The marginal decrease in soybean plantings in 2011 over 2010 is due to farmers planting significantly more maize in 2011 than 2010.

The total maize hectarage in 2011 was approximately 4.6 million hectares, of which about 3.9 million hectares were biotech composed of 3.5 million hectares planted to a stacked product Bt/HT maize, 300,000 hectares to the Bt product, and 100,000 hectares to herbicide tolerant maize. The stacked gene Bt/HT maize product, occupied about 90% of the biotech maize and is expected to retain this premier position in the future. Thus, the adoption rate for the 3.9 million hectares of hybrid maize was approximately 85% of the total maize hectarage; the stacked Bt/HT product representing 90% of the biotech area, 8% was HT and 2% Bt. Talks between Argentina and China to export the first Argentinean biotech maize to China in 2011/12 have provided a great incentive and boost for biotech maize in Argentina.

Table 8. Commercial Approvals for Planting, Food and Feed in Argentina, 1996 to 2011

Crop	Trait	Event	Year
Soybean	Herbicide tolerance	40-3-2	1996
Maize	Insect resistance	176	1998
Maize	Herbicide tolerance	T25	1998
Cotton	Insect resistance	MON531	1998
Maize	Insect resistance	MON810	1998
Cotton	Herbicide tolerance	MON 1445	2001
Maize	Insect resistance	Bt11	2001
Maize	Herbicide tolerance	NK603	2004
Maize	Herbicide tolerance × Insect resistance	TC1507	2005
Maize	Herbicide tolerance	GA21	2005
Maize	Herbicide tolerance × Insect resistance	NK603 × MON810	2007
Maize	Herbicide tolerance × Insect resistance	NK603 × TC 1507	2008
Cotton	Herbicide tolerance × Insect resistance	MON1445 × MON531	2009
Maize	Herbicide tolerance × Insect resistance	Bt11 × GA21	2009
Maize	Insect resistance	MON89034	2010
Maize	Herbicide tolerance × Insect resistance	MON88017	2010
Maize	Herbicide tolerance × Insect resistance	MON89034 × MON88017	2010
Maize	Insect resistance	MIR 162	2011
Soybean	Herbicide tolerance	A2704-12	2011
Soybean	Herbicide tolerance	A5547-127	2011
Maize	Herbicide tolerance × Insect resistance	Bt11 × GA21 × MIR162	2011

Source: ArgenBio, 2011 (Personal Communication).

Argentina reported a total planted area of 690,000 hectares of cotton for 2011, up from 400,000 hectares in 2009. Of the 690,000 hectares of total cotton plantings in 2011, 675,000 hectares were biotech comprising 590,000 hectares of Bt/HT stacked product, about 70,000 hectares were herbicide tolerant (HT) cotton, 15,000 hectares Bt and the balance of 15,000 hectares were conventional. The general increase in biotech cotton during the last five 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. It is noteworthy that 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. There has been a shift towards more cotton grown on larger farms due to the damage caused by boll weevil which is more easily controlled by larger farmers than smaller farmers.

Benefits from Biotech Crops in Argentina

Farmers in Argentina have been benefiting immensely from biotech crops for the past fifteen years. A detailed study by Eduardo Trigo was recently released that provide information on the economic impact in Argentina (Trigo, 2011). The press release of that study published in 28 November 2011 is reproduced with permission from the author.

Economic Impact after 15 years of GM crops in Argentina

Agricultural biotechnology afforded the country over 70 billion dollars

Since 1996, when glyphosate-tolerant soybean was introduced, Argentina has been one of the leading countries in the utilization of genetically modified (GM) crops, reaching 22.9 million hectares planted in the last growing season. The adoption process of these technologies has been fast and steady, with an unprecedented dynamics which allowed that GM varieties currently represent practically all the planted area with soybean, 86% in the case of maize and 99% for cotton.

According to a recent study carried out by Dr. Eduardo Trigo for ArgenBio the Argentine Council for Information and Development of Biotechnology – the gross benefit generated by this adoption process for the period 1996-2010 reaches US$72,363 million. These benefits were estimated using SIGMA, a mathematical model developed by INTA (National Institute for Agricultural Technology) that uses data from the Technological Profile of Argentina's Agricultural Sector (INTA), with additional information provided by the Ministry of Agriculture, Livestock and Fisheries, ArgenBio, INDEC (National Institute of Statistics and Census) and FAO.

Economic benefits, by crop

- In the case of glyphosate-tolerant soybean, the benefits mounted to 65,153 million US dollars, 3,231 million attributable to a reduction in production costs (mainly due to less tillage and reduced applications of selective herbicides required by conventional varieties) and 61,917 million due to the expansion of the planted area. Regarding the distribution of the total benefits, 72.3% went to farmers, 21.3% to the National Government – collected through export tax and other taxes – and 6.5% to technology providers (seeds and herbicides).

Table 9. Economic Benefits of Biotech Crops (Million US$) and Percentage Distribution

Crop and Trait	Total Benefits	Amount (Percentage) of Benefits Accrued to		
		Farmers	National Government	Technology Developers
HT Soybean	65,153	47,105.0 (72.3)	13,877.6 (21.3)	4,169.8 (6.4)
Bt/HT Corn	5,375	3,665.8 (68.2)	612.8 (11.4)	1,096.5 (20.4)
Bt/HT Cotton	1,834	1,760.6 (96.0)	0	73.4 (4.0)

- In the case of maize, insect resistance and herbicide tolerance technologies gave benefits for a total amount of 5,375 million US dollars, distributed as follows: 68.2% to growers, 11.4% to the National Government and 20.4% to technology providers (mainly seeds).
- Finally, in the case of insect-resistant and herbicide-tolerant cotton, total benefits reached 1,834 million US dollars that went mainly to farmers (96%), with 4% going to technology providers (seeds and herbicides).

More benefits

In addition, and given the importance of Argentine soybean production worldwide, this study estimated the global impact in terms of savings that the adoption of such technology by Argentine farmers has had on consumer expenditure (by reducing the global price). The total cumulative figure for 1996-2011 was estimated at about US$89 billion. In terms of prices, figures show that if this adoption process had not occurred, the international price of soybean in 2011 would have been 14% higher than it actually was.

On the socio-economic side, the impact that GM technologies have had on job creation was assessed. Based on these estimates, the generation of 1.82 million jobs by the Argentine economy along these 15 years could be attributed to the use of GM technologies.

Dr. Eduardo Trigo's work also analyzed some environmental impacts related to GM crops, with special emphasis on the particular synergy between the expansion of these crops and no-till farming practices, and its positive impact on soil structure and the efficient use of energy.

Future benefits.

Looking ahead and using the same methodology applied for the retrospective analysis, the study estimates the potential benefits that could be generated by two different types of GM crops: an herbicide tolerant and insect resistant soybean, and a drought-resistant wheat, under three different price and adoption scenarios. Results show that, if these technologies were available as from the next growing season, accumulated benefits in the 10 following years could be US$9,131 million to US$26,073 million for soybean and US$526 million to US$1,923 million for wheat, according to different scenarios.

Argentina must remain a leader so as not to miss opportunities

"One of the characteristics of the adoption process of GM crops in Argentina is the fact that our country has been an early adopter worldwide", stated Eduardo Trigo, who explained that ***"the introduction of herbicide-tolerant soybean in our agriculture was made available to farmers practically at the same time as in the American market for which it was originally designed. In this 15 years, this has given us an important amount of economic and other benefits as the study shows."***

"The advantages of being at the front of innovative processes are very clear and, as a consequence, so are the risks or opportunity costs that the country would face it followed a less dynamic technology adoption process than in the past. Keeping the "early adopter" profile is a strategic issue that should include key topics like regulatory processes, the promotion of investments for the sector and the redistribution of benefits into areas like innovation, economic growth and social welfare," said Eduardo Trigo, the author of the Report.

The key to success.

"The biotechnology adoption process in Argentine agriculture has been undoubtedly very successful", said Gabriela Levitus, Executive Director of ArgenBio. ***"Not only because our products have been competitive and the international prices have been good, but also because when this technology was made available, the country was ready to adopt it. There were world class breeder, trained and innovative farmers and there was the political will that resulted in the creation of a pioneer regulatory system, which guaranteed the safe adoption of GM crops in our country from the start. This political will, very clear 15 years ago but quite changeable along the last years, is today strong again; this fact is clearly shown through the new approvals and the recent revision of the regulatory processes boosted by the Ministry of Agriculture, Livestock and Fisheries. Contrary to other times, agricultural biotechnology is now a state policy",*** concluded Levitus.

In the most recent global study on the benefits from biotech crops (Brookes and Barfoot, 2012, Forthcoming) estimates that Argentina has enhanced farm income from biotech crops by **US$12.2 billion in the first fifteen years** of commercialization of biotech crops 1996 to 2010, and the benefits **for 2010 alone were estimated at US$1.8 billion.**

Farmer Experience

Martin Arechavaleta is a soybean grower and a third generation farmer in Victoria, Province of Entre Rios, Argentina. He told of his old farm practices when products were expensive and difficult to apply. ***"We had to live with many problems. Production was half of what we have now,"*** he says.

He first incorporated biotechnology into his farm more than 10 years ago when he started planting glyphosate-resistant soybean. ***"We have seen many advantages over the years with the new products. Before, it was a lot of mechanical work to get rid of weeds. Now, the producer is more free, there is more production and less cost"*** (Arechavaleta, 2010).

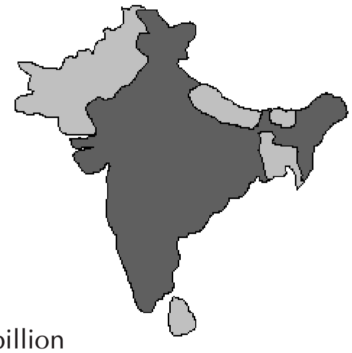
Mario Alberto Sanchez, started his family farm enterprise of around 30 hectares with soybeans, corn, sorghum, and sunflowers. This increased to 3,300 hectares over the past 22 years due to his sustainable cropping practices as well as his adoption of biotech seed and crop protection practices. He has grown glyphosate-tolerant corn and soybeans which led to increased profits and reduced costs. ***"We started using the product because of the quality of the seeds. We began testing and realized that besides the quality improvement, there was an increase in performance,"*** he says, adding that fewer crop protection applications and working in a preventative way is a real plus. ***"With this product we're more relaxed. The leftover time can be devoted to family, or in our case, we can rent or buy more land and then we can advance"*** (Sanchez, 2010).

INDIA

2011 was a special year, which marked the tenth anniversary of a decade of Bt cotton in India, from 2002 to 2011. In the ten years, Bt cotton cultivation, has achieved phenomenal success in transforming the cotton crop into the most productive and profitable crop in the country. In 2011, plantings of Bt cotton surpassed the 10 million hectare mark for the first time, reaching 10.6 million hectares, and occupying 88% of the record 12.1 million hectare cotton crop. The 1.2 million hectare gain in Bt cotton hectares in 2011, was due to an increase from 9.4 million hectares in 2010 to 10.6 million hectares in 2011. The principal beneficiaries were 7 million farmers growing, on average, 1.5 hectares of cotton; this compares with 6.3 million farmers in 2010 growing 9.4 million hectares at an adoption rate of 85% of the 11 million hectare cotton crop. Thus, in 2011, an additional 0.7 million farmers decided to grow Bt cotton, rather than conventional cotton. Historically, the increase from 50,000 hectares of Bt cotton in 2002, (when Bt cotton was first commercialized) to 10.6 million hectares in 2011

represents an unprecedented 212-fold increase in ten years. The annual global study of benefits generated by biotech crops, conducted by Brookes and Barfoot, (2012, Forthcoming) estimated that India enhanced farm income from Bt cotton by US$9.4 billion in the period 2002 to 2010 and US$2.5 billion in 2010 alone. Thus, Bt cotton has transformed cotton production in India by increasing yield, decreasing insecticide applications, and through welfare benefits, contributed to the alleviation of poverty of 7 million small resource-poor farmers and their families in 2011 alone. India has successfully harnessed the significant benefits that Bt cotton offers (from both single and double Bt genes) and the future holds enormous potential as the next generation of biotech cotton offers India a range of beneficial new traits including stacked Bt/HT, salinity and drought tolerance, disease resistance and other traits.

<u>INDIA</u>



Population: 1,186.2 million

GDP: US$1,159 billion

GDP per Capita: US$ 1,020

Agriculture as % GDP: 17%

Agricultural GDP: US$197 billion

% employed in agriculture: 64%

Arable Land (AL): 177.5 million hectares

Ratio of AL/Population*: 0.60

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

Commercialized Biotech Crop: Bt Cotton

Total area under biotech crops and (%) increase in 2011:
10.6 Million Hectares (+13%))

Farm income gain from biotech, 2002-2010: US$9.4 billion

*Ratio: % global arable land / % global population

The ten-year period, 2002 to 2011, has been referred to by some as the white gold revolution on cotton farms in India which produced impressive mounds of raw cotton, which looked like white gold. Notably, subsequent to 2002, millions of marginal cotton farmers, mostly in rainfed areas, have returned to planting Bt cotton year-after-year. Prior to 2002 these former cotton farmers had become disillusioned and given up cotton cultivation because of the unaffordable high costs of production, particularly expensive and ineffective pest control, and despite the high costs they suffered from very low productivity. However, in the last ten years, the situation has changed with Bt cotton offering a new lease of life to cotton farmers, the cotton industry and the farm economy of the country. Ten-significant milestones were achieved during the

first decade, 2002–2011, of Bt cotton cultivation in India; they are listed below and form the basis of the discussion in this chapter on the current status of biotech crops in India.

First and foremost, India planted the highest-ever hectarage of cotton, 12.1 million hectares in 2011-12, increasing from 7.7 million hectares in 2002-03. This significant increase in hectarage in cotton has been attributed, by and large, to Bt technology which has substantially increased the profitability of cotton production in the country. Coincidentally, the number of cotton farmers increased significantly from 5 million small and resource poor cotton farmers in 2002-03 to 8 million cotton farmers in 2011-12. Notably, the number of Bt cotton farmers increased from 50,000 farmers in 2002-03 to 7 million in 2011-12, representing approximately 88% of 8 million cotton farmers in 2011-12 who planted and benefited significantly from Bt cotton hybrids.

Second, India plants more Bt cotton than any other country in the world. In the fifth year of Bt cotton adoption, 2006-07, India for the first time eclipsed China by cultivating 3.8 million hectares of Bt cotton, compared to China's 3.5 million hectares. In 2011-12, the adoption of Bt cotton in India, for the first time soared past the 10 million hectare milestone, reaching 10.6 million hectares – almost 3 times the Bt cotton area of China at 3.9 million hectares.

Third, India is unique in that it is the only country in the world where cotton hybrids, as opposed to varieties, are the principal commercial crop. The first commercial cotton hybrid, H-4 derived from an intra-specific cross (*G. hirsutum* x *G. hirsutum*) was released commercially in 1970 in a landmark event. In 2011-12, 88% of the cotton area featured both intra-specific and inter-specific hybrids; this is almost double the 45% adoption level in 2001-02. The rapid increase in hectares of hybrid cotton is credited to the introduction of Bt technology which spurred hybridization resulting in an increase from 3 Bt cotton hybrids in 2002-03 to 884 Bt cotton hybrids in 2011-12.

Fourth, consumption of insecticides, measured in active ingredient, has exhibited a consistent and significant downward trend since the introduction of Bt cotton in 2002-03. Notably, the large scale adoption of Bt cotton halved insecticide usage from 46% of total insecticides used in 2001-02 to 21% of total insecticide use in India in 2010. The steep decline in the percentage of insecticides applied on cotton relative to total insecticides used on all crops, is a welcome environmental relief, particularly to cotton growers and farm laborers who, prior to 2002, suffered from the intensive usage of insecticides to control the major cotton pest – American bollworm complex, now effectively controlled by Bt.

Fifth, the commercial approval of Bt cotton was a cardinal breakthrough that revived the ailing cotton sector in the country. Prior to 2002, cotton production had stagnated, yields were declining and this resulted in over-reliance on cotton imports for many decades. Coincidental with the steep increase in adoption of Bt cotton between 2002 and 2011, the average yield of cotton in India, (which used to have one of the lowest lint yields in the world), increased from 308 kg per hectare in 2001-02, to 499 kg per hectare in 2011-12; and cotton production increased from 13.6 million bales in 2002-03 to 35.5 million bales in 2011-12, which was a record cotton crop for India. At the same time, the country was transformed from a net importer of raw cotton, until 2002-03, to a net exporter of cotton.

Sixth, India was traditionally a producer of short, medium and medium-long staple cotton due to the prevalent large-scale cultivation of desi cotton varieties. Thus, the country was deficient in long staple and extra-long staple cotton, which is the major raw material demanded by the cotton mills and the textile industry. The introduction of hybrid technology in the seventies and the deployment of Bt technology in 2002 improved cotton hybrids substantially, and changed the composition of total cotton production in favor of long staple cotton; in 1947 there was almost no long staple cotton, but this increased to 38% of supply in 2002-03 and to 77% in 2010-11. Furthermore, the volume of long staple cotton production registered a five-fold increase from 5.1 million bales in 2002-03 to 24.1 million bales in 2010-11.

Seventh, over the ten-year period 2002-2011, Bt cotton has been successfully used as a multiple-purpose crop, to deliver three principal products: firstly, in the form of edible oil as food for human consumption; secondly, de-oiled cake as an animal feed; and thirdly, kapas, for fiber. Impressively, the production of cotton seed, and its by-products, oil and meal, has increased three-fold from 0.46 million tons in 2002-03 to 1.31 million tons in 2011-12. As a result, Bt cotton meal (de-oiled cake) contributes one third of the country's total and increasing demand for animal feed, whereas cotton oil also contributes 13.7% of total edible oil production for human consumption in the country.

Eighth, the introduction of Bt technology in cotton, (the first genetically modified cotton was approved for commercialization in 2002-03), contributed immensely to the establishment of the vibrant hybrid cotton seed and agri-biotech industry

in India. The high adoption rate of Bt cotton by Indian farmers contributed significantly to the steep year-on-year growth in commercial hybrid seeds and the biotech industry in the country from 2002 to 2011. Agri-biotech industry annual revenues grew consistently at a double/triple digit rate during the 2002 to 2011 period. More specifically, the agri-biotech industry market increased twenty-two-fold from Rs.110 crore (US$25 million) in 2002-2003 to Rs. 2480 crore (US$551 million) in 2010-11.

Ninth, the large scale adoption of Bt cotton in India was a major contributor to the doubling of cotton production domestically and also contributed significantly to global cotton production from 2002-03 to 2011-12. In 2011, India contributed 10.6 million hectares of biotech cotton (equivalent to approximately 30% of total global cotton area at 36 million hectares) and a substantial 7% to the global total of biotech cotton hectarage of 160 million hectares in 2011. As a result, Indian cotton now accounts for more than one fifth (21%) of the total world cotton production in 2011-12; this is substantially higher than the 14% in 2002-03. As a result of the higher productivity of Bt cotton India overtook the USA in 2006 to become the second largest cotton producing country in the world, after China.

Last but not the least, the annual global study of benefits generated by biotech crops, conducted by Brookes and Barfoot (2012, Forthcoming), estimated that India enhanced farm income from Bt cotton by US$9.4 billion in the period 2002 to 2010 (nine- year period) and US$2.5 billion in 2010 alone. Typically, yield gains are up to 31%, a significant 39% reduction in the number of insecticide sprays, leading to an 88% increase in profitability, and equivalent to a substantial increase of approximately US$250 per hectare. Thus, Bt cotton has transformed cotton production in India by increasing yield, decreasing insecticide applications, and, very importantly, through welfare benefits, contributed to the alleviation of poverty for over 7 million small resource-poor farmers and their families in 2011 alone, and future prospects look encouraging.

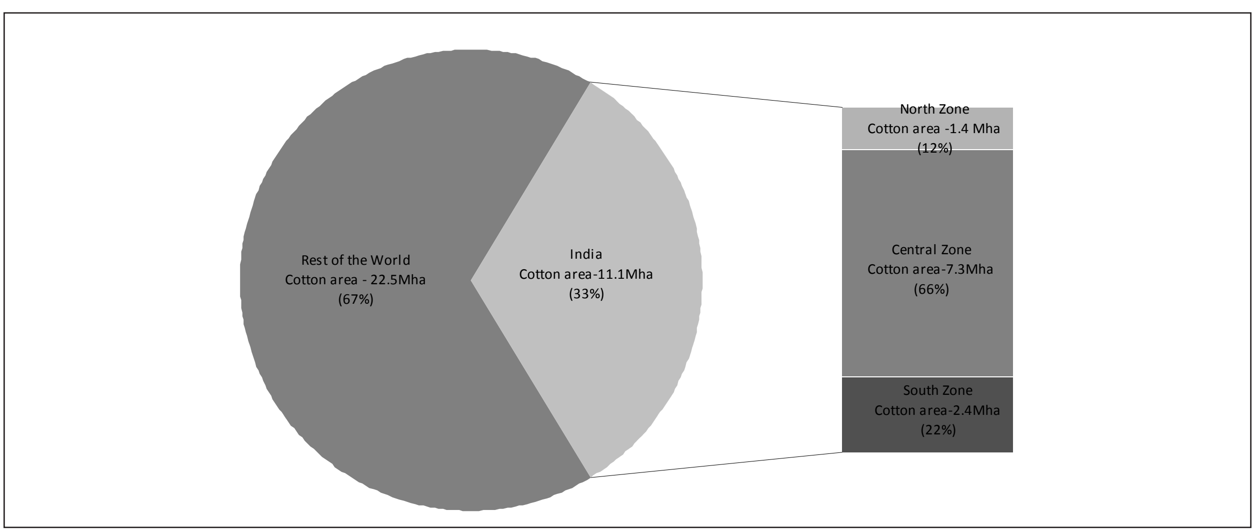
In 2011, India celebrated a decade of Bt cotton cultivation, which has been a great boon to cotton as a crop, to cotton farmers, and to Indian agriculture and the farm economy of the country. Given the sterling record of biotech cotton in India, which is consistent with the experience of 12 other Bt cotton growing countries world-wide, now is the time for India to take urgent action to approve other Bt crops pending approval so that India can also benefit from the application of well-tested Bt technology in other important crops, such as maize, the world's premier feed crop. Failure to take urgent action will lead to a significant opportunity cost for India and a "lock-out" from a critical technology that other emerging countries like Brazil are accelerating by expediting the approval process – Brazil approved 8 biotech crops in 2010 and another six by September 2011 for a total of 14 approved biotech crops whilst India has not approved any new biotech crops.

Cotton – the King of the Crops in India

India has the largest hectarage of cotton of any country in the world. In 2010-11, India accounted for approximately one third of the total cotton area planted in the world – 11.1 million hectares of the 33.6 million hectares of cotton planted in the world. The balance of 22.5 million hectares was grown by about 40 cotton growing countries around the world (Figure 20). Within India, 66% or a majority of cotton is grown in the Central cotton growing zone, mostly rainfed, in the States of Maharashtra, Gujarat, Madhya Pradesh and Odisha. In percentage terms, the Central cotton growing zone occupies about one-third, of the cotton area in India. The Northern zone, which consists of the States of Punjab, Haryana and Rajasthan grows cotton in irrigated belt of 1.41 million hectares whereas, the States of Andhra Pradesh, Karnataka and Tamil Nadu which form the Southern Zone grows cotton on 2.41 million hectares or 22% of the total cotton grown in India. The Central and Southern zone primarily grow the long duration cotton crop mostly in rainfed conditions and thus allow farmers to reap multiple harvests of the long staple cotton during the season. In contrast, the irrigated cotton in Northern zone is mostly a short duration crop that befits perfectly into the cotton-wheat cropping system.

Year 2011 set a new record of 12.1 million hectares of cotton cultivation in India – an attribute to the ever growing acceptance of Bt cotton hybrids by the Indian cotton farmers. Notably, India achieved

Figure 20. The Zone-Wise Spatial Distribution of Cotton Area, 2010-11



Source: ICAC, 2011; Cotton Advisory Board, 2011.

unparalleled progress on three fronts: highest ever hectarage under cotton cultivation – 12.1 million hectares; largest ever production of cotton at 35.5 million bales and a sustained cotton yield of more than 500 kg per hectare despite significant increases in cotton hectarage. Based on the latest estimates (Table 10), the Directorate of Cotton Development, Ministry of Agriculture reports that the total hectarage of cotton in India was 12.1 million hectares in 2011, approximately 10% higher than the 11 million hectares in 2010, and farmed by more than 8 million farmers in 2011 as compared to 7.4 million farmers in 2010 – based on the latest official data, the average cotton holding per farm in India is 1.5 hectares. In the period 2002-03 to 2011-12, a large number of additional farmers preferred to grow cotton due to low cost of cultivation, superior yield & production and high income. As a result, the number of small farmers cultivating cotton increased significantly from 5 million in 2002-03 to ~8 million farmers in 2011-12, an increase of 3 million additional cotton farmers in 2010-11 as compared to 2002-03. Similarly, the number of farmers growing Bt cotton hybrids in India has increased from 50,000 in 2002 to 100,000 in 2003, 300,000 small farmers in 2004, to 1 million in 2005, with over a two-fold increase of 2.3 million farmers in 2006, 3.8 million farmers in 2007, 5 million in 2008, 5.6 million in 2009 and 6.3 million farmers in 2010. In 2011, the number of farmers

Table 10. Land Holdings Distribution and Production of Cotton in India, 2010-2011

No.	State	Average Cotton Holding per Farm (Hectare)	Area of Cotton (Million Hectare)	Production (Million Bale)	Average Yield (Kg/ha)	No. of Cotton Farmers (Million)
1	Punjab	2.64	0.53	1.6	513	0.2
2	Haryana	1.72	0.495	1.4	481	0.3
3	Rajasthan	0.98	0.334	0.9	458	0.3
4	Gujarat	1.80	2.633	10.2	659	1.5
5	Maharashtra	1.46	3.973	8.2	351	2.7
6	Madhya Pradesh	1.38	0.651	1.7	444	0.5
7	Andhra Pradesh	1.45	1.776	5.3	507	1.2
8	Karnataka	1.56	0.534	1	318	0.3
9	Tamil Nadu	0.52	0.13	0.5	654	0.3
10	Odisha	0.76	0.075	0.2	453	0.1
11	Others	0.30	0.03	0.2	-	0.1
	(Weighted Average) or Total	**(1.50)**	**11.06**	**31.2**	**440**	**7.4**

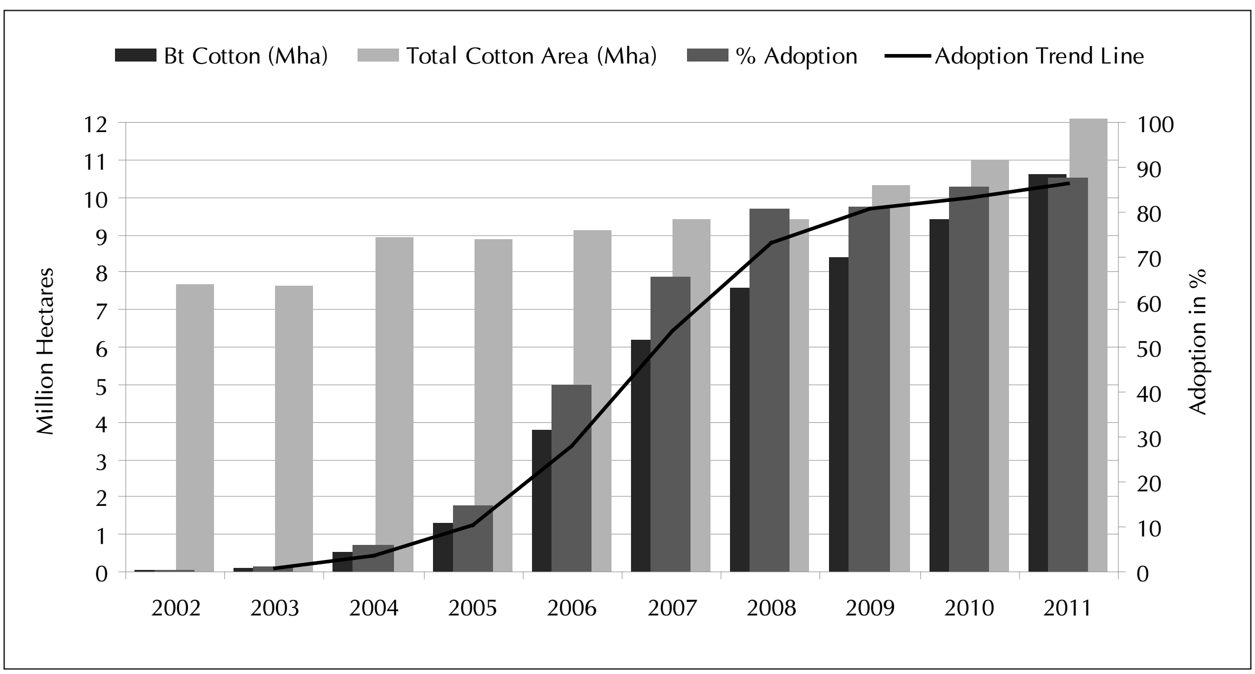
Source: Ministry of Agriculture, 2010; Cotton Advisory Board, 2011.

cultivating Bt cotton increased substantially to more than 7 million farmers, up from 6.3 million Bt cotton farmers in 2010. This is the largest increase in number of farmers planting biotech crops in any country in 2011. The 7 million small and resource-poor farmers who planted and benefited significantly from Bt cotton hybrids in 2011 represented approximately 87% of the total number of 8 million farmers who grew cotton in India in 2011-12. The adoption of Bt cotton hybrids by 7 million farmers is approximately the same high level of adoption for biotech cotton in the mature biotech cotton markets of the USA and Australia.

Adoption of Bt Cotton Hybrids in India, 2002 to 2011

Bt cotton, which confers resistance to important insect-pests of cotton, was first adopted in India as hybrids in 2002. There were 54,000 farmers who grew approximately 50,000 hectares of officially approved Bt cotton hybrids for the first time in 2002 which doubled to approximately 100,000 hectares in 2003 (Figure 21). The Bt cotton area increased four-fold in 2004 to reach half a million hectares. In 2005, the area planted to Bt cotton in India continued to scale up reaching 1.3 million hectares, an increase of 160% over 2004. In 2006, the adoption record increased which 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

Figure 21. A Decade of Adoption of Bt Cotton Hybrids in India, 2002 to 2011



Source: Compiled by ISAAA, 2011.

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 Bt cotton area from 3.8 to 6.2 million hectares, to become the largest hectarage of Bt cotton in any country in the world. In 2008, the Bt cotton area increased yet again to a record 7.6 million hectares from 6.2 million hectares in 2007. Maintaining double digit growth, the Bt cotton area increased to 8.4 million hectares in 2009, over 7.6 million hectares in the previous year. The high adoption of 81% in 2009 provided a solid platform to further support an increase in Bt cotton hybrid hectarage in 2010, which grew by over 10% to 9.4 million hectares which is equivalent to 85% of the total cotton area of 11 million hectares in 2010. In 2011, the adoption of Bt cotton surpassed the 10 million hectares mark reaching to 10.6 million hectares by registering a robust 12.7% growth over previous year which was at all time high in the ten year period. Notably, an increase of 1.2 million hectares in 2011, when Bt cotton was already at 85% of its adoption in 2010 was driven by the increase in total cotton area from 11 million hectare in 2010 to 12.1 million hectare in 2011. The 10.6 million hectares of Bt cotton represents 88% of total cotton grown in 2011, up from 85% in 2010. Despite a very high level of adoption in previous years, 2011 was the eighth consecutive year for India to have a significant year-on-year percentage growth; a 160% increase in 2005, followed by a 192% increase in 2006, a 63% increase in 2007, 23% increase in 2008, 11% increase in 2009 and 2010 and approximately 13% increase in 2011 (Figure 21).

Table 11 and Figure 22 show the adoption and distribution of Bt cotton in the major growing states from 2002 to 2011. The major states growing Bt cotton in 2011, listed in order of hectarage, were Maharashtra (3.96 million hectares) representing 37% of all Bt cotton in India in 2011, followed by Gujarat (1.93 million hectares or 18.5%), Andhra Pradesh (1.82 million hectares or 17%), Northern Zone (1.34 million hectares or 12.6%), Madhya Pradesh (0.64 million hectares or 6%), and the balance in Karnataka, Tamil Nadu and other cotton growing States including Odisha. In the ten year period, the adoption of Bt cotton has evenly spread across all the cotton growing States in the country. The high percentage adoption of Bt cotton by farmers across the different States reflects the priority of controlling the menace of the American bollworm complex, a group of deadly borer insects that caused heavy damage to cotton crop in the past. In 2011, 88% of the total cotton area was planted with Bt cotton, irrespective of the size, location and land holdings.

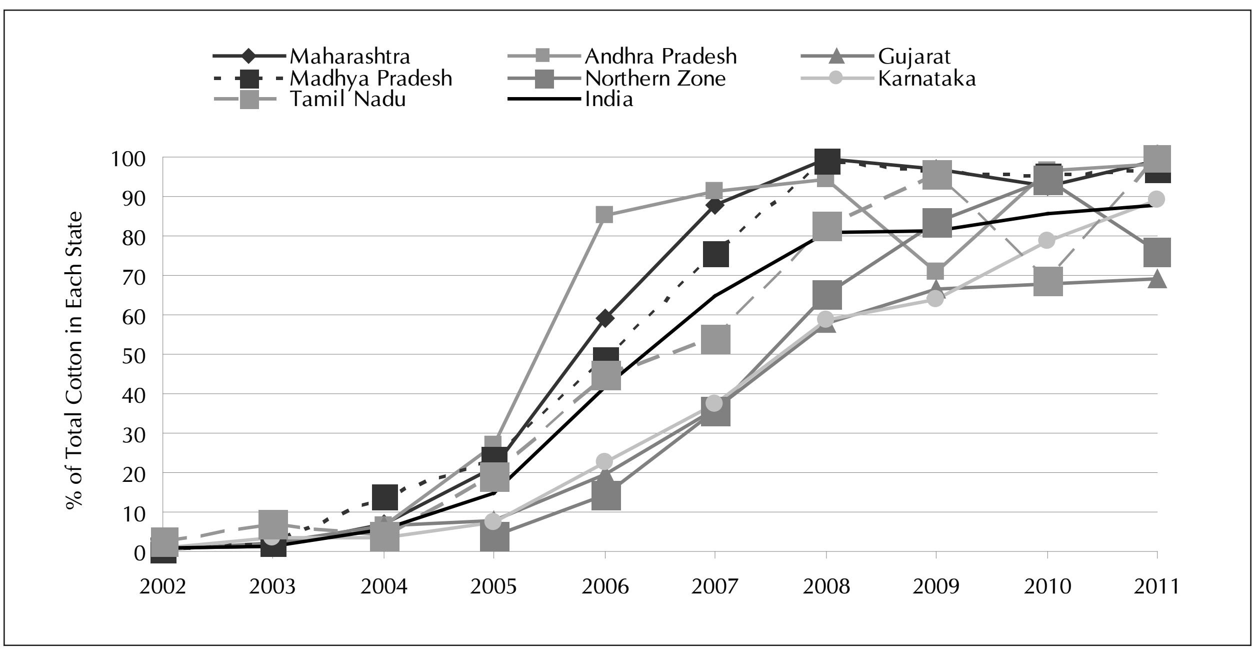
Over the years, there has been an increasing trend to adopt double gene Bt cotton hybrids by cotton farmers in India (Table 12 and Figure 23). The first two-gene event MON15985, commonly known as Bollgard®II (BG®II) was developed by Mahyco and sourced from Monsanto, featured the two genes *cry1Ac* and *cry2Ab*, and was approved for sale for the first time in 2006 – four years after the approval of the single gene event MON531 Bt cotton hybrids in 2002-03. In the first year 2006-07, the double gene Bt cotton hybrids were planted on 0.15 million hectares whilst single gene Bt cotton hybrids occupied 3.65 million hectares equivalent to 96% of all the Bt cotton planted.

Table 11. A Decade of Adoption of Bt Cotton in India, by Major States, 2002 to 2011 (Thousand Hectares)

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Maharashtra	25	30	200	607	1,840	2,800	3,130	3,396	3,710	3,960
Andhra Pradesh	8	10	75	280	830	1,090	1,320	1,049	1,650	1,820
Gujarat	10	36	122	150	470	908	1,360	1,682	1,780	1,930
Madhya Pradesh	2	13	80	146	310	500	620	621	610	640
Northern Region*	-	-	-	60	215	682	840	1,243	1,162	1,340
Karnataka	3	4	18	30	85	145	240	273	370	570
Tamil Nadu	2	7	5	27	45	70	90	109	110	220
Others	-	-	-	-	5	5	5	8	8	120
Total	**50**	**100**	**500**	**1,300**	**3,800**	**6,200**	**7,605**	**8,381**	**9,400**	**10,600**

Source: Compiled by ISAAA, 2011.

Figure 22. Percent Adoption of Bt Cotton in India and in Different States Expressed as Percent Adoption Within States and Nationally in India, 2002 to 2011



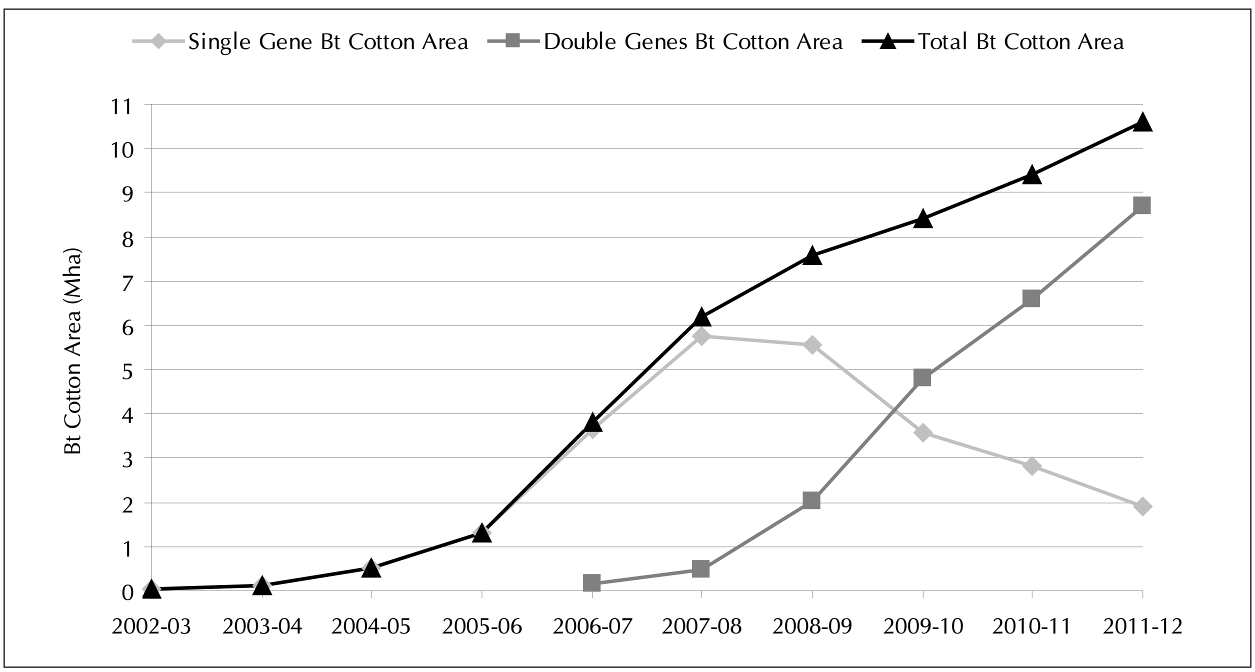
Source: Compiled by ISAAA, 2011.

Table 12. Adoption of Single and Multiple Gene Bt Cotton Hybrids in India, 2006 to 2011 (Millions Hectares and Percentage)

Number of Genes	2005	2006	2007	2008	2009	2010	2011
Double	-	0.15 (4%)	0.46 (8%)	2.04 (27%)	4.82 (57%)	6.60 (70%)	8.70 (82%)
Single	1.3 (100%)	3.65 (96%)	5.74 (92%)	5.56 (73%)	3.58 (43%)	2.80 (30%)	1.90 (18%)
Total	1.3 (100%)	3.80 (100%)	6.20 (100%)	7.60 (100%)	8.40 (100%)	9.40 (100%)	10.6 (100%)

Source: Compiled by ISAAA, 2011.

Figure 23. Adoption of Single and Double Gene Bt Cotton Hybrids, 2002 to 2011



Source: Compiled by ISAAA, 2011.

The area under single gene Bt cotton hybrids increased to 5.74 million hectares in 2007 and then registered a decline of 5.56 million hectares in 2008 and 3.58 million hectares in 2009, 2.8 million hectares in 2010 and to the lowest of 1.9 million hectares in 2011 coinciding with the release and preference of farmers to adopt double gene Bt cotton hybrids. During this time, double gene Bt cotton area grew rapidly to 0.46 million hectares in 2007 to 2.04 million hectares in 2008. In 2009, the double gene Bt cotton hybrids were planted for the first time on more area (57%) than single gene Bt cotton hybrids occupying 4.82 million hectares as compared to 3.58 million (43%) occupied by single gene Bt cotton hybrids. Since its commercial release, farmers continued to prefer double gene (only two genes) Bt cotton hybrids over single gene Bt cotton hybrids. In 2010, 6.6 million hectares were planted with double gene Bt cotton hybrids as compared to 2.8 million hectares of single gene Bt cotton hybrids. In essence, double gene Bt cotton hybrids occupied 70% of the total Bt cotton area whereas the remaining 30% was planted with single gene Bt cotton hybrids. The cotton farmers across the different States continued to prefer planting of double gene Bt cotton hybrids over single gene Bt cotton hybrids. In 2011-12, a record of 8.7 million hectares was planted with double gene Bt cotton which is 82% of the total Bt cotton planted in 2011 in the country. The usages of single gene Bt cotton hybrids dropped to 1.9 million hectares or 18% of the Bt cotton grown in 2011-12. It is estimated that the double gene Bt cotton hybrids will entirely replace the single gene Bt cotton hybrids in 2012-13. It is noteworthy to mention that the double gene Bt cotton hybrids provide additional protection to *Spodoptera* (a leaf eating tobacco caterpillar) while it also increases efficacy of protection to both American bollworm, Pink bollworm and Spotted bollworm. It is reported that double gene Bt cotton farmers earn higher profit through cost savings associated with fewer sprays for *Spodoptera* control as well as increasing yield by 8-10% over single gene Bt cotton hybrids.

Of the estimated 12.1 million hectares of cotton in India in 2011, 88% or 10.6 million hectares were Bt cotton hybrids – a remarkably high proportion of Bt cotton in a fairly short period of ten years equivalent to an **unprecedented 212-fold increase from 2002 to 2011**. Of the 10.6 million hectares of Bt cotton hybrids, 35% was under irrigation and 65% rainfed. A total of 884 introductions (883 Bt cotton hybrids and one Bt cotton variety) were approved for planting in 2011 compared with 780 Bt cotton hybrids in 2010, 522 in 2009, 274 in 2008, 131 in 2007, 62 in 2006, 20 in 2005 and only 4 Bt cotton hybrids in 2004. Over the last ten years, India has greatly diversified deployment of Bt genes and genotypes, which are well-adapted to the different agro-ecological zones to ensure equitable distribution to small and resource-poor cotton farmers.

India is the only country in the world that grows cotton hybrids for many years. As a part of technological advancement in agriculture, the first generation commercial cotton hybrid H-4 was developed based on the intra-specific (*G. hirsutum* x *G. hirsutum*) crosses and released for large scale cultivation in the country in 1970. Twenty three years later, India released the first inter-specific (*G. hirsutum* x *G. barbadense*) diploid hybrid DH-7 in 1983 which paved the way forward for harnessing the genetic potential of all four species of cotton cultivated in India including *Gossypium arboreum* and *G. herbaceum* (Asian cottons), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American upland cotton). The ICAR's Central Institute of Cotton Research, CICR Vision 2030 document released in 2011 noted the development of the first cotton hybrid as one of the most spectacular achievements that stands-out as a technology that had the greatest influence on cotton in India (CICR, 2011). In the first thirty years of hybridization from 1971 to 2001, a large number of cotton hybrids, both intra-specific and inter-specific cotton hybrids were released for commercial cultivation by both public and private sector institutions in the country. However, by 2001, the adoption of cotton hybrids reached only 45% of the total cotton area planted in 2001 – a year prior to the commercial release of Bt technology in India in 2002. In 2011, India occupied 10.6 million hectares under (Bt) cotton hybrids or 88% of total area planted with cotton, which is double the 45% cotton hybrid area occupied in 2001. The significant increase in area under hybrid cotton cultivation is credited to the introduction of Bt technology which spurred the hybridization of cotton from 3 Bt cotton hybrids in 2002-03 to 884 Bt cotton hybrids in 2011-12 and at the same time, the area of cotton hybrids increased significantly to 88% in 2011-12 from 45% in 2001-02.

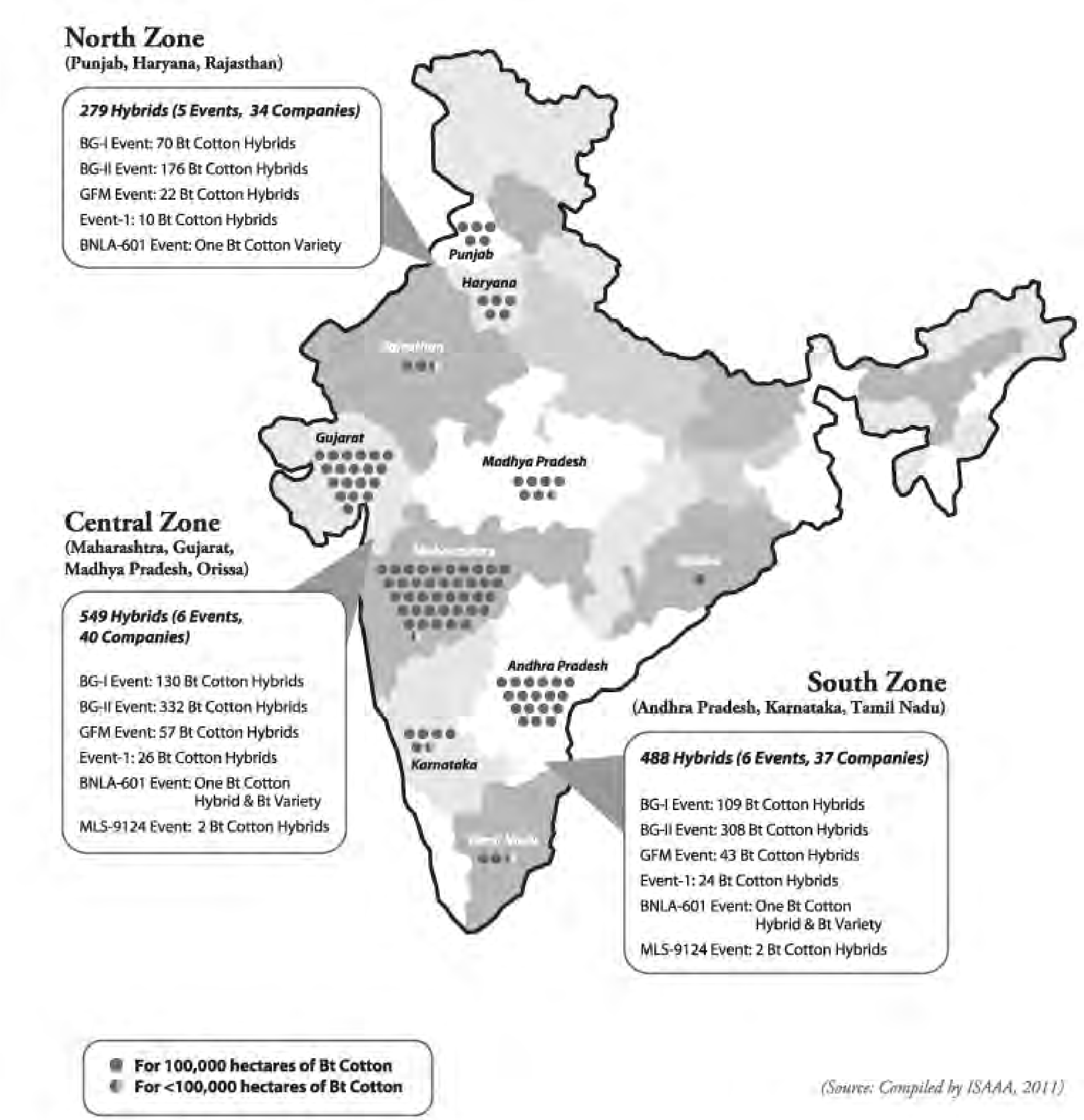
Approval of Events and Bt Cotton Hybrids in India, 2002 to 2011

The number of events as well as the number of Bt cotton hybrids and companies marketing approved hybrids have all increased significantly from 2002, the first year of commercialization of Bt cotton in India. In 2011, the number of Bt cotton hybrids increased substantially to 884 introductions (883 hybrids and one variety) from 780 in 2010, 522 in 2009, 274 hybrids in 2008, 131 hybrids in 2007, 62 hybrids in 2006, 20 hybrids in 2005, 4 hybrids in 2004 and 3 hybrids in 2003 and 2002, respectively. Importantly, this increase in number of hybrids has provided much more choice year after year to farmers in the North, Central and Southern regions, where specific hybrids have been approved for cultivation in specific regions (Appendix 4 and Figure 24). In 2011, a total of six events were approved for incorporation in a total of 104 hybrids with a publicly-developed Bt cotton event BN Bt incorporated in both cotton variety, *Bikaneri Nerma* (BN), approved in 2008 and the publicly-bred Bt cotton hybrid NHH-44 which was approved for commercial cultivation in 2009. The sixth event MLS-9124 was approved for the first time in 2009 (Table 13).

The first event, MON531, Bollgard®I (BG®I), featuring the *cry1Ac* gene, developed by Maharashtra Hybrid Seeds Company Ltd. (Mahyco) and sourced from Monsanto was approved for commercial cultivation in 2002. In 2011, for the tenth consecutive year, a total of 215 hybrids consisting of MON531 were approved for sale in the North, Central and South cotton growing zones.

The second event, MON15985, Bollgard®II (BG®II) developed by Mahyco and sourced from Monsanto, that featured the first two-gene *cry1Ac* and *cry2Ab*, and was approved for sale for the first

Figure 24. Approval of Events and Bt Cotton Variety and Hybrids in India, 2011



(Source: Compiled by ISAAA, 2011)

Table 13. Commercial Release of Different Bt Cotton Events in India, 2002 to 2011

No.	Crop	Event	Developer	Status	Year of Approval
1	Cotton*	MON-531	Mahyco/Monsanto	Commercialized	2002
2	Cotton*	MON-15985	Mahyco/Monsanto	Commercialized	2006
3	Cotton*	Event-1	JK Agri-Genetics	Commercialized	2006
4	Cotton*	GFM Event	Nath Seeds	Commercialized	2006
5	Cotton**	BNLA-601	CICR (ICAR) & UAS, Dharwad	Commercialized	2008
6	Cotton*	MLS-9124	Metahelix Life Sciences	Commercialized	2009

*Bt cotton hybrid; ** Bt cotton variety and Bt cotton hybrid
Source: Compiled by ISAAA, 2011.

time in 2006 in the Central and South zones. This event was approved for commercial cultivation for the first time in the Northern zone in 2007. In 2011, a total of 528 hybrids consisting of MON15985 were approved for sale in the North, Central and South cotton growing zones.

The third event, known as Event-1 developed by JK Seeds featuring the *cry1Ac* gene, sourced from IIT Kharagpur, India was approved for commercial sale in 2006 in the North, Central and South cotton growing zones. In 2011, a total of 41 hybrids consisting of Event-1 were approved for sale in the North, Central and South cotton growing zones.

The fourth event is the GFM event which was developed by Nath Seeds, sourced from China, and features the fused genes *cry1Ab* and *cry1Ac* and was approved for commercial sale in 2006. In 2011, a total of 96 hybrids consisting of GFM event were approved for sale in the country.

In contrast to the above four events, which were all incorporated in cotton hybrids, notably the fifth event known as BNLA-601 was approved for commercial sale in an indigenous publicly-bred cotton variety named *Bikaneri Nerma* (BN) expressing the *cry1Ac* gene. It was approved for commercial release in the North, Central and South cotton growing zones in India during *Kharif*, 2008. The approval of the Bt cotton variety BN will help farmers in varietal growing areas which were previously disadvantaged because they were unable to benefit from the insect resistant Bt cotton hybrids cultivated widely across all three cotton growing zones. In 2009, a publicly-bred Bt cotton hybrid BNLA-601 expressing the *cry1Ac* gene is the first indigenous Bt cotton event developed by the Central Institute of Cotton Research (CICR) – one of the premier public sector institutes of the

Indian Council of Agricultural Research (ICAR) – along with University of Agricultural Sciences, Dharwad, Karnataka.

The sixth new event, MLS-9124, was developed indigenously by Metahelix Life Sciences and features a synthetic *cry1C* gene and was approved for commercial sale in 2009 for Central and Southern zones. In 2011, the cotton hybrids consisting of event MLS-9124 were not made available to farmers for planting.

There are four new cotton events that are undergoing the biosafety assessment and field-testing which would be considered for commercial approval in India between 2012 to 2015 (Table 14).

The seventh event (#1 in Table 14), Bollgard®II (BG®II) Roundup Ready Flex (BGIIRRF®) is being developed by Mahyco and sourced from Monsanto, features, for the first time in India, the stacking of two events, insect resistance and herbicide tolerance, in cotton. Bollgard®II (BG®II) Roundup Ready Flex (BG®II RRF) expresses three genes; *cry1Ac* and *cry2Ab* to confer insect resistance and *CP4EPSPS* genes to impart herbicide tolerance. In 2010, four BG®II RRF cotton hybrids including two hybrids for North zone and two for Central and South zones were approved for seed production in an area of 25 acres per hybrid.

The eighth event (#2 in Table 14), Widestrike™ is being developed by Dow AgroSciences, expressing double genes including *cry1F* gene and *cry1Ac* (Event 3006-210-23 and Event 281-24-236) and has two genes for insect protection.

Table 14. Bt and Bt/HT Cotton Events Field-tested and Pending Approval for Commercialization in India, 2012-2015

No.	Crop	Event	Developer	Status	Year of Approval
1	Cotton	MON 15985 × MON 88913	Mahyco/Monsanto	Field Tested	–
2	Cotton	Widestrike Event 3006-210-23 and Event 281-24-236	Dow AgroSciences, Mumbai	Field Tested	–
3	Cotton	Event 1 and Event 24	JK Agri Genetics Ltd., Hyderabad	Field Tested	–
4	Cotton	*2mEPSPS gene*	Bayer Biosciences Pvt. Ltd.	Field Tested	–

Source: Compiled by ISAAA, 2011.

The ninth event (#3 in Table 14), known as a combination of Event-1 x Event-24 is being developed by JK Seeds featuring two genes *cry1Ac* and *cry1Ec*, sourced from IIT Kharagpur and NBRI Lucknow, India.

The tenth cotton event (#4 in Table 14), Glytol cotton, expresses herbicide tolerance in cotton and is undergoing elite event selection in field trials in 2011. Glytol cotton event was developed by Bayer Biosciences and contains the *2mEPSPS* gene conferring tolerance to cotton hybrids sprayed with the herbicide Glyphosate.

The commercial deployment of the first five events in hybrids and sixth event in both variety and hybrids in India is summarized in Appendix 4, and their regional distribution is detailed in Table 15. The variety *Bikaneri Nerma* was approved in 2008 and commercialized by CICR, Nagpur and the University of Agricultural Sciences (UAS), Dharwad in the three zones of North, Central and South India. In addition, NHH-44 Bt cotton hybrids was commercialized by CICR, Nagpur and University of Agricultural Sciences (UAS), Dharwad, and approved for planting in Central and South cotton growing zones in 2009. In 2011, farm saved seeds of BN Bt variety would probably have been grown by those farmers who either could not afford to buy Bt cotton hybrid seeds or preferred to grow BN Bt varieties.

The number of Bt cotton hybrids as well as the number of companies offering Bt cotton hybrids in India has increased dramatically over the last 10 years since the first commercialization in 2002. The number of Bt cotton hybrids increased to 884 in 2011 from 780 (including one variety) in 2010, 522

Table 15. Deployment of Approved Bt Cotton Events/Hybrids/Variety by Region in India in 2011

Event	North (N)	Central (C)	South (S)	North/ Central (N/C)	North/ South (N/S)	Central/ South (C/S)	N/C/S	Total Hybrids
BG-I[1]	42	50	42	14	1	53	13	215
BG-II[2]	109	102	82	8	6	168	53	528
Event-I[3]	9	8	6	0	0	17	1	41
GFM Event[4]	21	28	14	4	0	28		96
BNLA-601[5]	0	0	0	0	0	1	1*	2
MLS-9124[6]	0	0	0	0	0	2	0	2
Total	181	188	144	26	7	269	69	**884**

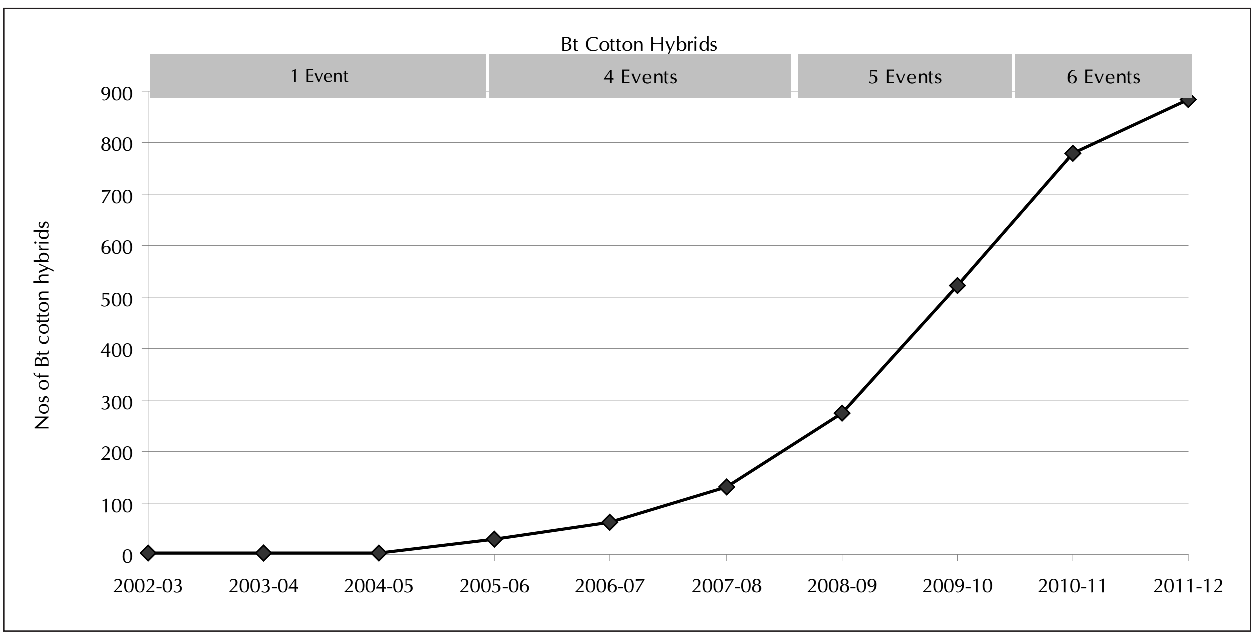
*Bt cotton variety
[1,2] Mahyco [3] JK Seeds [4] Nath Seeds [5] CICR (ICAR) and [6] Metahelix
Source: Compiled by ISAAA, 2011.

(including one variety) in 2009, 274 in 2008 and 131 in 2007 with 40 companies and one public sector institution undertaking the marketing of those hybrids and one variety in three cotton-growing zones in 2011 (Figure 25). The deployment of the six events in 884 hybrids in 2011 is summarized in Appendix 4 and Appendix 5, as well as the corresponding distribution of hybrids in 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009 2010, and 2011. In 2011, the Genetic Engineering Appraisal Committee (GEAC) approved 104 new Bt cotton hybrids for commercial cultivation in the 2011 season, in addition to the 780 Bt cotton hybrids approved for sale in 2010, for a total of 884 Bt cotton hybrids. This provided farmers in India's three cotton-growing zones significantly more choice of hybrids for cultivation in 2011.

Savings of Insecticides due to Bt Cotton, 2001 to 2010

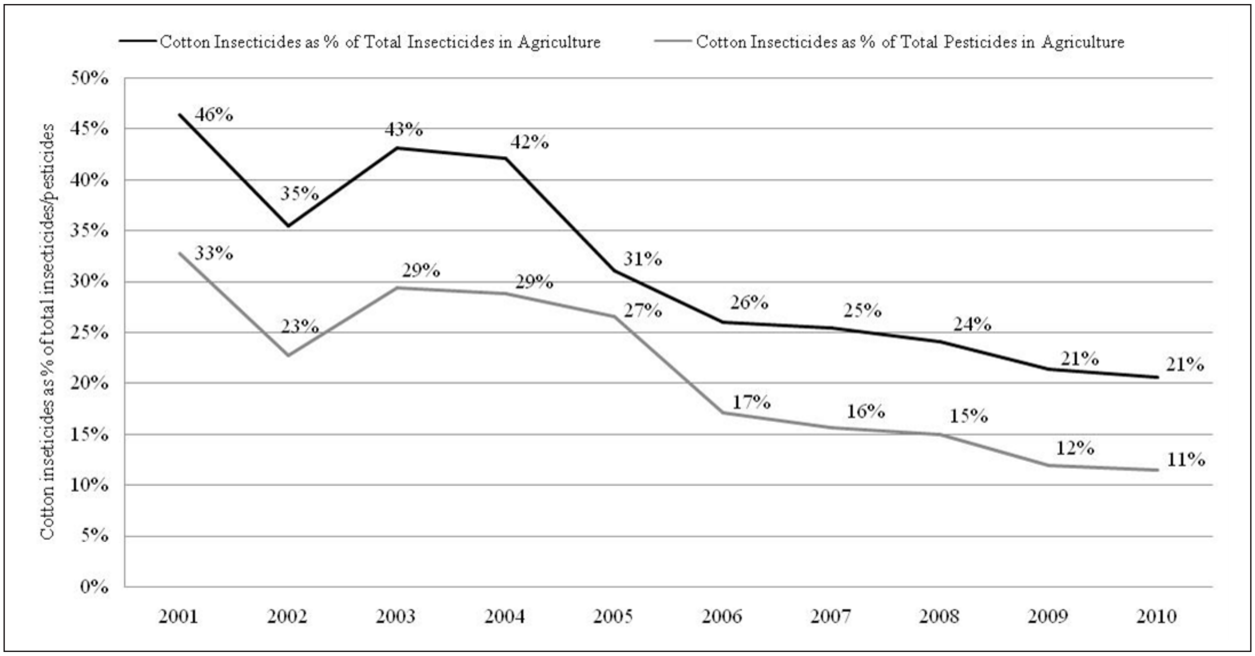
Traditionally, cotton consumed more insecticides than any other crop in India and was a significant proportion of the total pesticide (insecticides, fungicides and herbicides) market for all crops. For example, of the total pesticide market in India in 2001 valued at US$713 million (Figure 26 and Table 16), 33% was for cotton insecticides only, which were equal to 46% of the total insecticide market for all crops in India (CICR, 2011). Subsequent to the introduction of Bt cotton, cotton consumed only 18% of the total pesticide market, in 2006, valued at US$900 million as compared to a much higher 30% in 1998. Similarly, the market share for cotton insecticides as a percentage of

Figure 25. Release of Bt Cotton Hybrids in India, 2002 to 2011



Source: Compiled by ISAAA, 2011.

Figure 26. Percentage Reduction of Insecticides on Cotton Relative to Total Insecticides/ Pesticides Used in Agriculture in India, 2001 to 2010



Source: Compiled by ISAAA, 2011.

Table 16. Value of the Total Pesticide Market in India in 2001 and 2010 Relative to the Value of the Cotton Insecticide Market

Item/Year	2001	2006	2010
Total pesticide market (in million US$)	US$713 million	US$748 million	US$1,707 million
Cotton insecticides as % of total pesticide market	33%	17%	11%
Total insecticide market (in million US$)	US$504 million	US$404 million	US$952 million
Cotton insecticides as % of total insecticide market	46%	26%	21%
Value in US$ millions of cotton bollworm market & (savings due to Bt cotton) in 2004 over 2010	US$160 million (in 2004)	-	US$25 million (Savings of US$135 million, or 85%, compared with 2004)

Source: CICR, 2011.

total insecticides declined from 46% in 2001 to 26% in 2006 and to 21% in 2010. The percentage of cotton insecticides to the total insecticides used in agriculture in India halved to 21% in 2010 from 46% in 2001, prior to the introduction of Bt cotton in India in 2002. At the macro-level, the percentage of cotton insecticides to the total pesticides market in India registered a steep decline from 33% in 2001 to 11% in 2010 at the time when total pesticides market in the country more than doubled from US$713 million in 2001 to US$1,707 million in 2010.

Figure 26 reports a consistent downward trend in the consumption of cotton insecticides measured as percentage of the total insecticides and pesticides used in agriculture in India from 2001 to 2010. The steep reduction in the percentage of cotton insecticides/pesticides as a percentage of total insecticides/pesticides in agriculture dropped to 21% and 11%, respectively, in 2010 from highs of 46% and 33% in 2001. Contrary to the trend in cotton insecticides, the total usage of insecticides in agriculture increased significantly from US$504 million in 2001 to US$952 million in 2010. A steep decline in the percentage of insecticides applied on cotton to total insecticides used in agriculture is a clear sign of relief to cotton growers and laborers in the country who traditionally suffered from the intensive usage of insecticides to control a major cotton enemy – American bollworm complex, which is now effectively controlled by Bt cotton technology.

This saving in insecticides between 2004 and 2010 coincided with the large scale adoption of Bt cotton from half a million hectares in 2004 to 9.4 million hectares in 2010-11, equivalent to 85% of the hectarage of the cotton crop in 2010-11. More specifically, the sharpest decline in insecticides occurred in the bollworm market in cotton, which declined from US$160 million in 2004 to US$25 million in 2010 – an 85% decrease, equivalent to a saving of US$135 million in the use of insecticides to control cotton bollworm in 2010. Thus, insecticide use for control of bollworm dropped significantly at the same time when approximately 85% of the cotton area (9.4 million hectares) was benefiting from controlling bollworm with Bt cotton.

The trends in decreased use of pesticides in agriculture in India noted by the Central Insecticides Board and Registration Committee (CIBRC) of the Ministry of Agriculture in India (Lok Sabha, 2010; CIBRC, 2011), are correlated with insecticide savings from Bt cotton which provides an alternate control of bollworm (CICR, 2011). Data in Table 17 confirm that the amount of pesticide active ingredient used nationally has decreased from 2001-02 to 2009-10 despite an increase in registered pesticide for other crops during the same period. The data in Table 17 confirms a consistent general downward trend of pesticide consumption from 48,350 metric tons in 2002-03, the year Bt cotton was first introduced to 41,822 in 2009-10 when Bt cotton occupied 8.4 million hectares or 81% of the total hectarage of cotton in India in 2009-10. It is noteworthy that the decline in pesticide usage between 2002-03 and 2010-11 has occurred at a time when hectarage of cotton has actually increased by 57% from 7.7 million hectares in 2002-03 to 12.1 million hectares in 2011-12. In

Table 17. Consumption of Pesticides in India, 2001-02 to 2009-10 (Metric Tons of Technical Grade or Active Ingredient)

Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-2010
Total Pesticide	47,020	48,350	41,020	40,672	39,773	37,959	43,630	43,860	41,822

Source: Lok Sabha, 2010; Central Insecticides Board and Registration Committee (CIBRC), 2011.

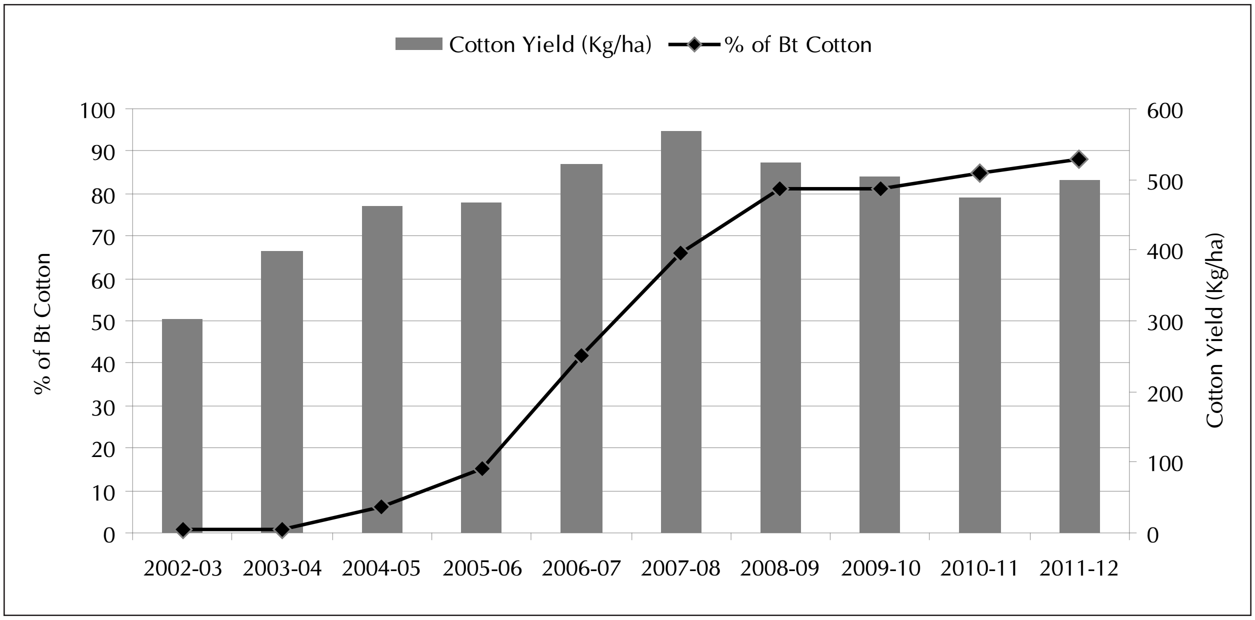
summary, the adoption of Bt cotton in 2002 in India has led to a significant decrease in insecticide usage for the control of cotton bollworm, which in 2010 was estimated at approximately US$25 million or 85% lower than the US$160 million in 2004.

Cotton Production, Yield and Imports/Exports, Since the Introduction of Bt Cotton in 2002

The commercial approval of Bt cotton in 2002 was a breakthrough step to revive the ailing cotton sector in the country – stagnation in cotton production, decelerating trend in cotton yield and overreliance on cotton import for over many decades. Coincidental with the steep increase in adoption of Bt cotton between 2002 and 2011, the average yield of cotton in India, which used to have one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02, to 567 kg per hectare in 2007-08 and continue to hover close to 500 kg per hectare in 2011-12; cotton production increased from 13.6 million bales in 2002-03 to 35.5 million bales in 2011-12, which was a record cotton crop for India. At the same time, the country was transformed from a net importer of raw cotton until 2002-03 to net exporter of cotton. Figure 27 shows the upward trend in cotton yield which remained stagnant at 300 kg per hectare until the introduction of Bt technology in 2002-03. The cotton yield almost doubled from 302 kg per hectare in 2002-03 to 567 kg per hectare in 2007-08 and was correlated with the large scale adoption of Bt cotton in the major cotton growing areas; yields remained at approximately 500 kg per hectare from 2008 to 2011 with seasonal variation due to many factors. In 2011-12, it is projected that average cotton yield could be as high as 499 kg per hectare despite the fact that some of the substantial increase in cotton area in the last two years includes relatively more marginal land (Figure 27).

It is clear that at the national level, Bt cotton has been 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, 28 million bales in 2006-07, and 31.5 million bales in 2007-08, which was a record cotton crop for India (Cotton Advisory Board, 2008). Subsequently, cotton production declined to 29 million bales in 2008-09 before again showing an upward trend to 29.5 million bales in 2009-10 seasons due to

Figure 27. Impact of Adoption of Bt Cotton on Cotton Yield in India, 2002 to 2011

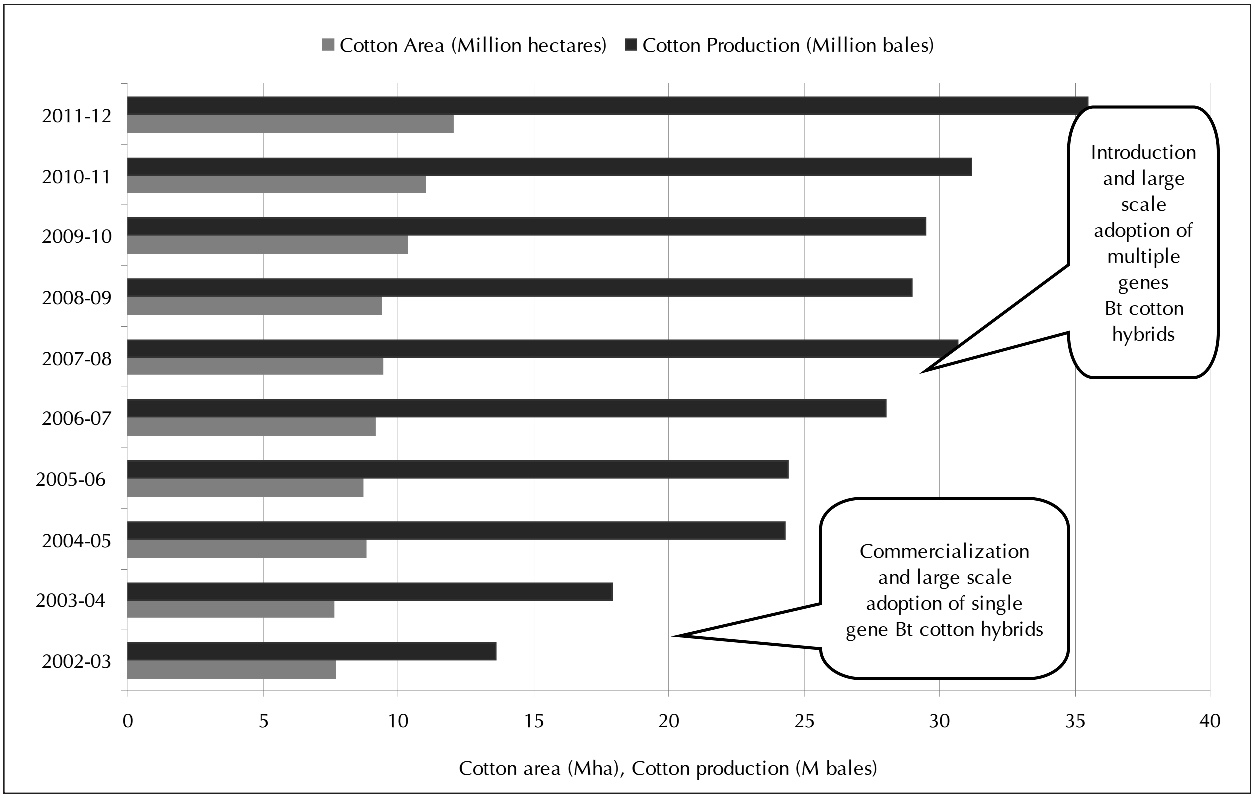


Source: Cotton Advisory Board, 2011; Compiled by ISAAA, 2011.

prevailing unfavorable climatic condition in 2008 including a delayed monsoon with erratic rainfall and flooding at the time of boll maturity and cotton picking in the Central and Southern cotton growing zones in 2009. The Cotton Advisory Board reported higher cotton production to 31.2 million bales in 2010-11 and projected the largest ever cotton production of 35.5 million bales in India for 2011-12 – this is a significant increase in overall cotton production over 2010 and the previous years. This quantum leap in cotton production since 2002-03 has been due to improved seeds particularly the ever-increasing hectarage of improved Bt cotton hybrids in the ten cotton-growing states. The first phase of substantial gains were realized with the large scale adoption of the single gene Bt cotton hybrids from 2002-03 to 2006-07. The impact of second generation double genes Bt cotton hybrids was associated with the largest ever cotton production gains culminating in 35.5 million bales in India in 2011-12 (Figure 28). Recognizing the remarkable progress achieved in cotton production in the last ten years, India's Ministry of Agriculture has invested in R&D, infrastructure and human resource development in order to harness the full potential of biotechnology in agriculture in the coming years.

With the boom in cotton production in the last ten years, India has become transformed from a net importer to a net exporter of cotton. Exports of cotton have registered a sharp increase from a meager 0.05 million bales in 2001-02 to 5.8 million bales in 2006-07 before touching a high of 8.8 million bales in 2007-08 (PIB, 2007). In 2008-09, raw cotton export recorded a modest 3.5 million

Figure 28. Cotton Hectarage and Production in India, 2002 to 2011

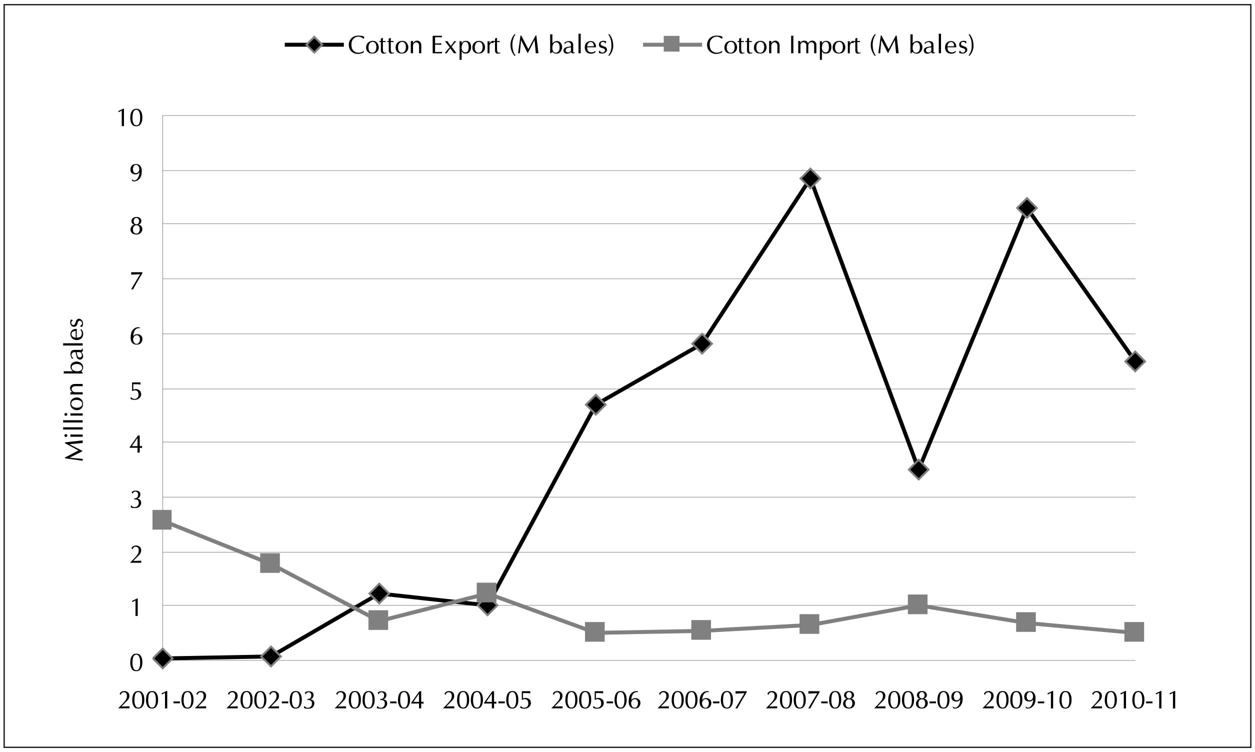


(1 Bale = 170kg)

Source: Cotton Advisory Board, 2011; Compiled by ISAAA, 2011.

bales. In 2009-10, cotton export rebounded to 8.3 million bales realizing the best international price for cotton farmers and traders (Figure 29). During these years, the import of cotton to India, in terms of market value has declined substantially from Rs. 2029 crore in 2001-02 to Rs. 1196 crore in 2009-10. At the same time, the value of exported cotton from India has increased manifold – Rs. 44 crore in 2001-02 to an impressive Rs. 10,270 crore in 2009-10. However, the high international cotton price put pressure on domestic cotton prices making it expensive for India's growing textile sector. In order to address concerns on high price of domestic cotton the Government of India initiated several policy interventions in early 2010. These included an export duty on raw cotton, banning export of cotton for a certain period in mid-2010, and placing exports of raw cotton in the licensed category (DGFT, 2010a & 2010b; PIB, 2010a), which was exempted again in 2011 due to high cotton production (PIB, 2011). It is expected that the export of cotton will further increase to 8 million bales in 2011-12 due to the expected high production and availability of cotton in the domestic market in 2011-12.

Figure 29. Export and Import of Cotton in India, 2001 to 2011



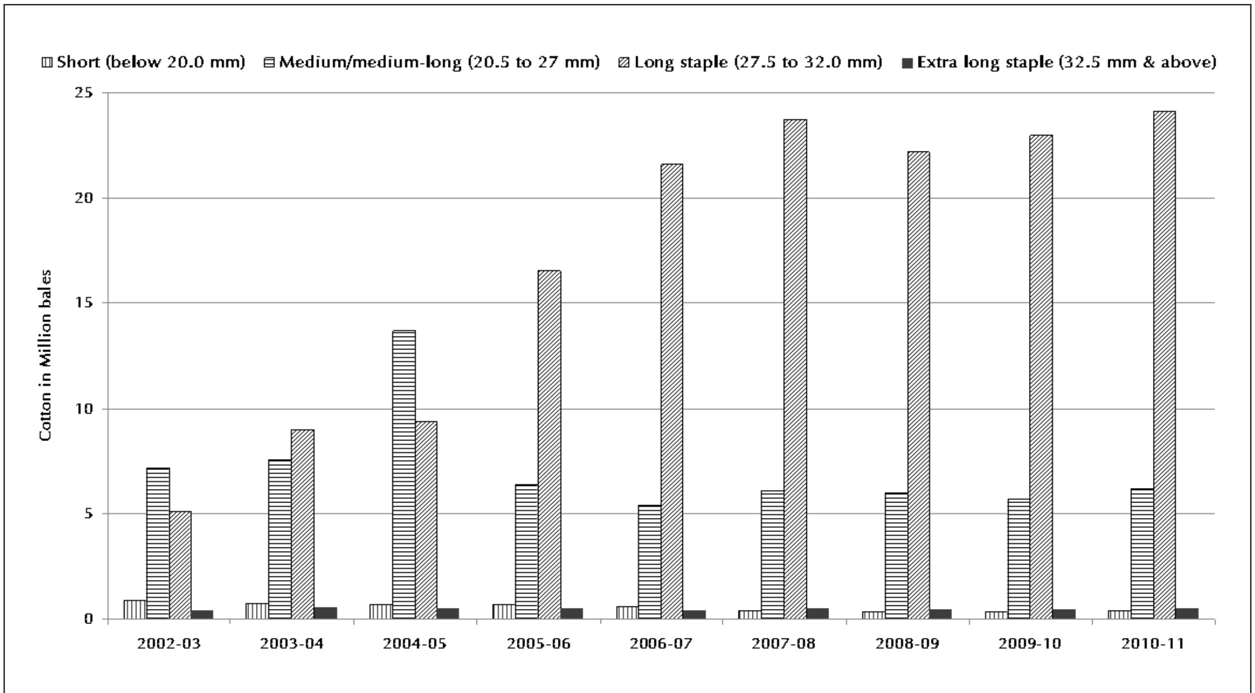
(1 Bale = 170kg)

Source: Cotton Advisory Board, 2011; Cotton Corporation of India, 2011.

Staple-Wise Cotton Production in India, 2002 to 2011

India has been traditionally a producer of short, medium and medium-long staple cotton due to the large scale cultivation of desi cotton varieties. The country remained deficient of long staple and extra-long staple cotton, which is the major raw material for the cotton mills to meet the demand of the textile industry. The introduction of hybrid technology in the seventies and deployment of Bt technology in improved cotton hybrid substantially changed the composition of total cotton production in favor of long staple cotton, with almost no long staple cotton in 1947 to 38% in 2002-03 to 77% long staple cotton produced domestically in 2010-11, more than three-quarters of total cotton production in the country. The volume of long staple cotton production registered a five-fold increase from 5.1 million bales in 2002-03 to 24.1 million bales in 2010-11 (Figure 30). Notably, the long and extra long staple cotton are the premium category of cotton that spins high quality yarn for manufacturing the high value added cotton textile products in the country.

Figure 30. Growth of Long Staple Cotton in India, 2002 to 2011



Source: Cotton Corporation of India, 2011.

Food, Feed and Fiber Usage of Bt Cotton, 2002 to 2011

ISAAA Brief 42 included a detailed overview of Bt cotton and its by products that are gaining popularity as a multipurpose crop in India. It reported that roughly 67% of the cotton produced is consumed directly as food or feed with the remaining 33% used as fiber in the textile sector in India. Cotton lint and cottonseeds are the principal products of the cotton plant. Cotton lint is the fiber part of the cotton plant whereas the cottonseeds yield three important by-products including linters, hulls and kernels. Linters are specially used for manufacturing of various products including production of propellants used for gun ammunition and also for missiles in the defense sector. Along with the de-oiled meal, the decorticated cottonseeds cake or commonly known as hulls are also directly fed to livestock such as cattle and buffaloes for producing milk and meat. A significant portion of the crushed kernel are consumed either as edible oil or mixed with other edible oils for direct human consumption.

Over the years, cotton fiber has been used as a principal raw material for textile industry, whereas the use of cottonseed oil and meal (de-oiled cake) has been gaining popularity. Notably, for every

1 kg of fiber, the cotton plant produces around 1.65 to 1.85 kg of cottonseed – a rich source of oil and high quality protein. This attribute makes cotton the second largest field crop in India in terms of edible oilseed tonnage (Sunikumar et al. 2006; AICOSCA, 2010). Amongst all the sources of edible oil seeds, cottonseeds production registered the most significant increase from 2003 to 2011 – cottonseeds production almost doubled from 4.21 million tons in 2002-03 to 9.67 million tons in 2010-11 and estimated to exceed 11 million tons in 2011 (Table 18). Bt cotton contributes more than 88% of the total cottonseeds and its by-products, oil and meal, in 2011.

In 2009-10, cotton oil contributed 1.08 million tons to the total production of 7.88 million tons of edible oil from all domestic sources, including cotton oil which is equivalent to 13.7% of total edible oil production in the country. In 2011-12, the cotton oil contributed 1.31 million tons to the total edible oil consumption in the country. During the ten year period from 2002-03 to 2011-12, the production of cotton oil registered a three-fold increase from 0.46 million tons in 2002-03 to 1.31 million tons in 2011-12 (Table 18). Due to the high nutritional content of cotton oil, it is marketed after blending with different vegetable oils. It is estimated that cotton oil has the potential to significantly meet the need for imports of edible oil provided that effective measures are undertaken to improve: cottonseed storage; scientific processing by delinting/dehulling prior to ginning & pressing; reduce direct consumption of oil-content meal; promote decorticated meal as feed; enhance percent oil recovery; and use modern methods in processing other by-products (Bajoria, 2010; AICOSCA, 2010).

More importantly, in India cotton meal (de-oiled cake) constitutes the largest share in terms of total availability of meal, followed by soy cake, rapeseed and rice bran in the country. It is important to

Table 18. Break-down of Cotton By-products from 2002-03, 2009-10, 2010-11 and 2011-12

Item	2002-03	2009-10	2010-11	2011-12
Cotton production (million bales)	13.6	29.5	31.2	35.5
Cottonseed production @ 310kg/bale (million tons)	4.21	9.15	9.67	11
Retained for sowing & direct consumption (million tons)*	0.50	0.50	0.50	0.50
Marketable Surplus (million tons)	3.71	8.65	9.17	10.5
Production of washed cottonseed oil (12.5%) (million tons)	0.46	1.08	1.15	1.31

* Very few farmers retain cotton seed for sowing over the last nine years as cotton hybrid seed planting increased to 90% of cotton area. Cotton hybrid seed production is undertaken separately by specialised cottonseed growers and marketed by private seed sector in the country.

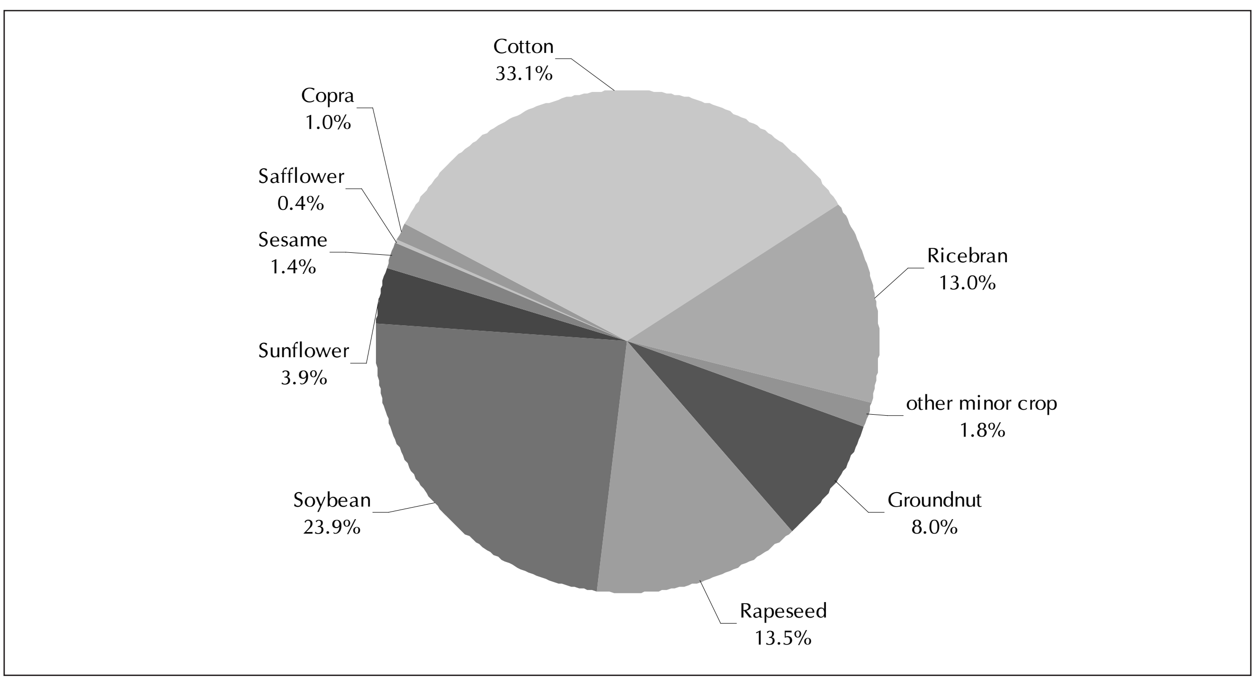
Source: Compiled by ISAAA, 2011; COOIT, 2010; AICOSCA, 2010.

note that cotton meal contributes one third of the total meal consumed, and is the preferred feed for cattle and buffaloes in the country (Figure 31). Cottonseed is also a major source of protein, as its by-product oil cake contains a high quality protein (23%) – a necessary ingredient for animal feed. De-oiled cotton cake assumes a special significance as an important component of animal feed given that traditional cattle feeds have been replaced by the nutritionally balanced compound cattle feed in India. The All India Cottonseed Crushers' Association (AICOSCA) estimates that the availability and access to large quantities of de-oiled cake as a proteinaceous cottonseed extraction would significantly boost the manufacturing prospects of compound cattle feed, fish feed and also poultry feed in India (AICOSCA, 2010).

Hybrid Cotton Seeds and Crop Biotech Industry in India, 2002 to 2011

Concurrent with the boom in cotton production, the Indian cotton hybrid seeds and crop biotech 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. In 2010-11, the overall Indian biotechnology industry registered a 21.5% growth in Rupee terms, with record revenue of Rs.17,249 crore (US$4 billion) from Rs.14,199 crore (US$3 billion) in 2009-10 and Rs. 12,137 crore (US$2.7) billion (based on Rupees 45 per US$) in 2008-09. The Indian biotech sector revenue, for the first time, has reached

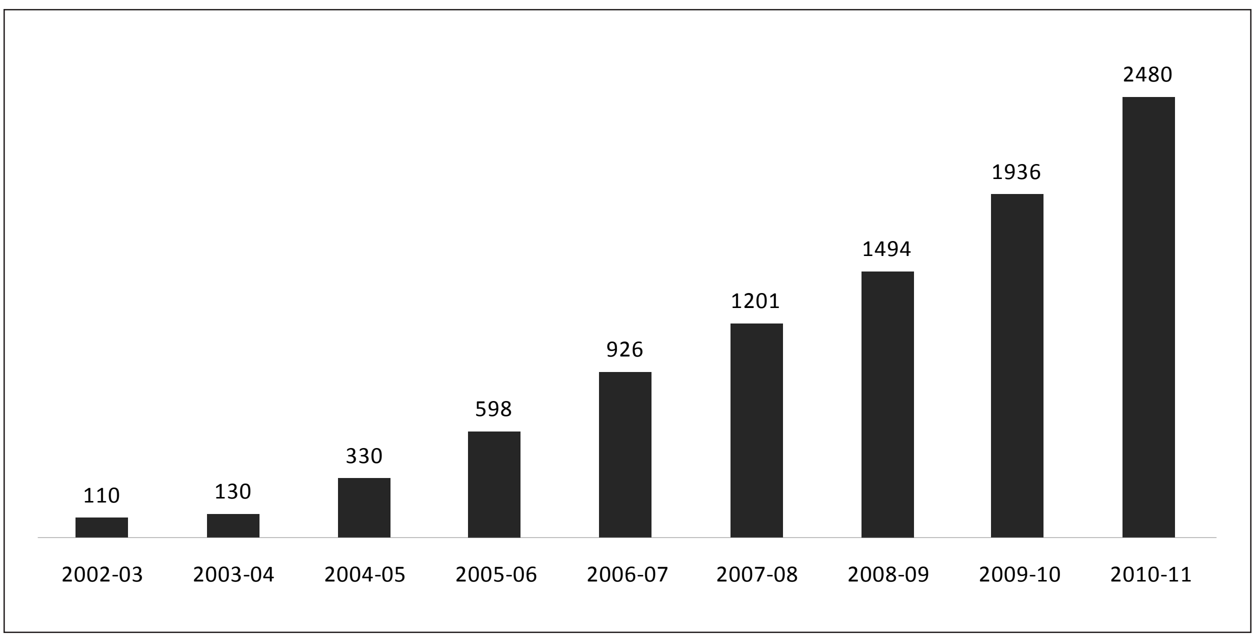
Figure 31. Crop-wise Composition of the Availability of Meal (oilcake) in India, 2007-08



Source: COOIT, 2010.

the benchmark of US$4 billion in 2010-11. According to the survey conducted by BioSpectrum-ABLE in 2010-11, the crop biotech sector grew by 28% to Rs. 2,480 crore (US$551 million) in 2010-11 from 1936 crore in 2009-10 and Rs. 1,494 crore (US$332 million) in 2008-09 – crop biotech sector registered the largest growth among various segments of biotech sector in India. The BioSpectrum-ABLE biotech industry survey 2011 reported the crop biotech segment has increased its market share in the last five years – from less than five percent to over 14 percent in 2011. Notably, Bt cotton is the only biotech crop product that continues to grow with increasing adoption of Bt cotton hybrids by farmers in India. During the last nine years (2002-2010), the period covered in the survey, Bt cotton sustained growth of the biotech crop segment in the Indian biotech industry. In 2010-11, the share of the crop biotech segment increased to 14.38% compared to 13.63% in 2009-10, 12.31% in 2008-09 of the Indian biotech sector revenue – a trend that has been consistent since the introduction of Bt cotton hybrids in 2002. More specifically, the biotech crop revenues grew consistently at a double digit rate of 28% in 2010-11, 37% in 2009-10, 24% in 2008-09, 30% in 2007-08, 54.9% in 2006-07, 95% in 2005-06; it increased twenty two-fold from Rs.110 crore (US$25 million) in 2002-2003 to Rs. 2,480 crore (US$551 million) in 2010-11 (Figure 32). In 2009, the share of the crop biotech segment increased from 12.31% in 2008-09 to 13.63% in 2009-10 to 14.38% in 2010-11. The biopharma segment continued to account for the largest share, 61.77% of the biotech industry revenues followed by 18.82% for bioservices, 14.38% for biotech crop, 3.63% for bioindustrial and the remaining 1.41% for the bioinformatics sector (BioSpectrum, 2011).

Figure 32. Bt Cotton Hybrid Market in India (in Rupee Crore), 2002 to 2011



(1 Crore = 10 Million Rupees)
Source: BioSpectrum, 2011.

Impact and Socio-Economic Benefits from Bt Cotton in India, 2002 to 2011

The annual global study of benefits generated by biotech crops, conducted by Brookes and Barfoot (2012, Forthcoming), estimated that India enhanced farm income from Bt cotton by US$9.4 billion in the period 2002 to 2010 (nine- year period) and US$2.5 billion in 2010 alone. Typically, yield gains are approximately 31%, a significant 39% reduction in the number of insecticide sprays, leading to an 88% increase in profitability, equivalent to a substantial increase of approximately US$250 per hectare (Gandhi and Namboodiri, 2006). Thus, Bt cotton has transformed cotton production in India by increasing yield, decreasing insecticide applications and through welfare benefits contributed to the alleviation of poverty for over 7 million small resource-poor farmers in 2011.

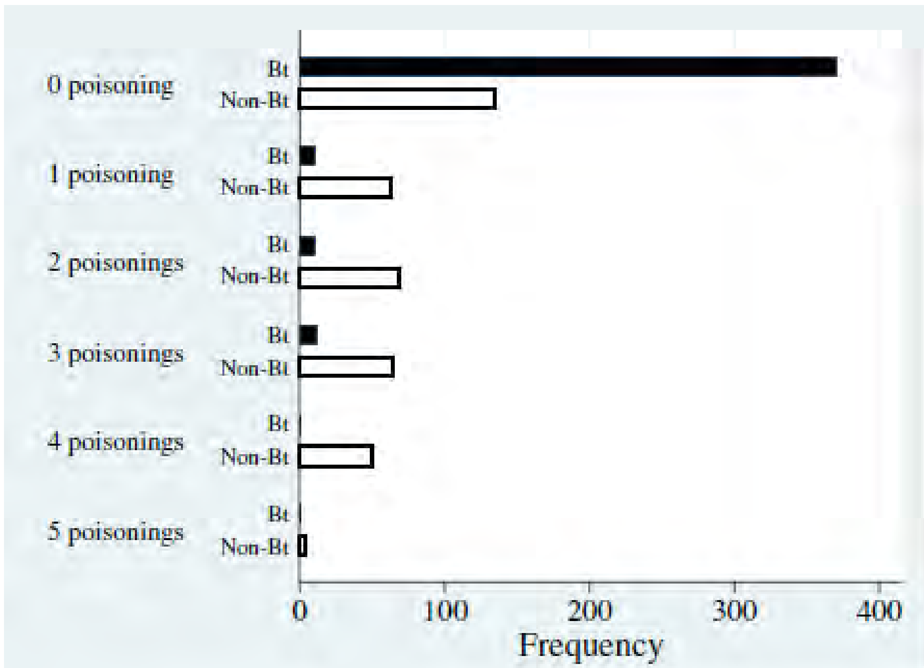
In addition to the annual global socio-economic study conducted by Brookes and Barfoot (2012, Forthcoming), a large number of socio-economic benefits and impact studies were conducted by the researchers from within and outside India. These studies employed different econometric modelling and socio-analytic methodologies that covered a range of impact parameters including production and yield, cost of cultivation, profitability, employment, income, expenditure, gender and household living standards. These studies, summarized in Table 19, and briefly reviewed at the end of this chapter, have been covered in detail in previous ISAAA Briefs and readers are referred to them. In this Brief, a selection of more recent studies are selected and discussed in the following paragraphs. Qaim et al. (2009) has published two studies the first on ***"Impact of Bt cotton on pesticide poisoning in smallholder agriculture – a panel data analysis"*** and the second on ***"Are the economic benefits of Bt cotton sustainable – evidence from Indian panel data"*** in 2011.

"Impact of Bt cotton on pesticide poisoning in smallholder agriculture – a panel data analysis" (Kouser & Qaim, 2011).

The study analyzed the impact of Bt cotton on pesticide poisoning among smallholder farmers in India and focused on the farmers health impacts resulting from Bt related changes in chemical pesticide use. The most significant outcome of the study is that ***"Bt has notably reduced the incidence of acute pesticide poisoning among cotton growers. These effects have become more pronounced with increasing technology adoption rates. Bt cotton now helps to avoid several million cases of pesticide poisoning in India every year, which also entails sizeable health cost savings."***

As evident from Figure 33, the study reported that ***"on average, only 0.19 poisoning cases per cotton season were reported by Bt farmers, as compared to 1.60 cases by non-Bt farmers. The majority of Bt farmers reported no poisoning incidences, whereas non-Bt farmers have a significantly higher frequency for each count of pesticide poisonings. On average, each case of poisoning entails a health cost of Rs. 264 (US$5.7), including Rs. 172 for medical***

Figure 33. Frequency of the Incidence of Acute Pesticide Poisoning Among Bt and non-Bt Cotton Farmers



Source: Adopted from Kouser and Qaim, 2011.

treatment and travel costs, and Rs. 92 for lost labor time due to sickness. Bt farmers also spend significantly less on smoking."

In conclusion, the study noted that the incidence of pesticide poisoning among smallholder farmers in India reduced substantially with the wide-spread use of Bt cotton and increasing adoption of Bt cotton over the ten years period, 2002 to 2011. While extrapolating the estimation results to India as a whole, the study conclude that ***"Bt cotton now helps to avoid at least 2.4 million cases of pesticide poisoning every year, which is equivalent to a health cost saving of US$14 million. These are lower-bound estimates of the health benefits, because they neglect the positive spillovers that Bt cotton entails. Alternative estimates suggest that Bt cotton may avoid up to 9 million poisoning incidences per year, which translates into a health cost saving of US$51 million. In any case, the positive health externalities are sizeable"*** (Kouser & Qaim, 2011).

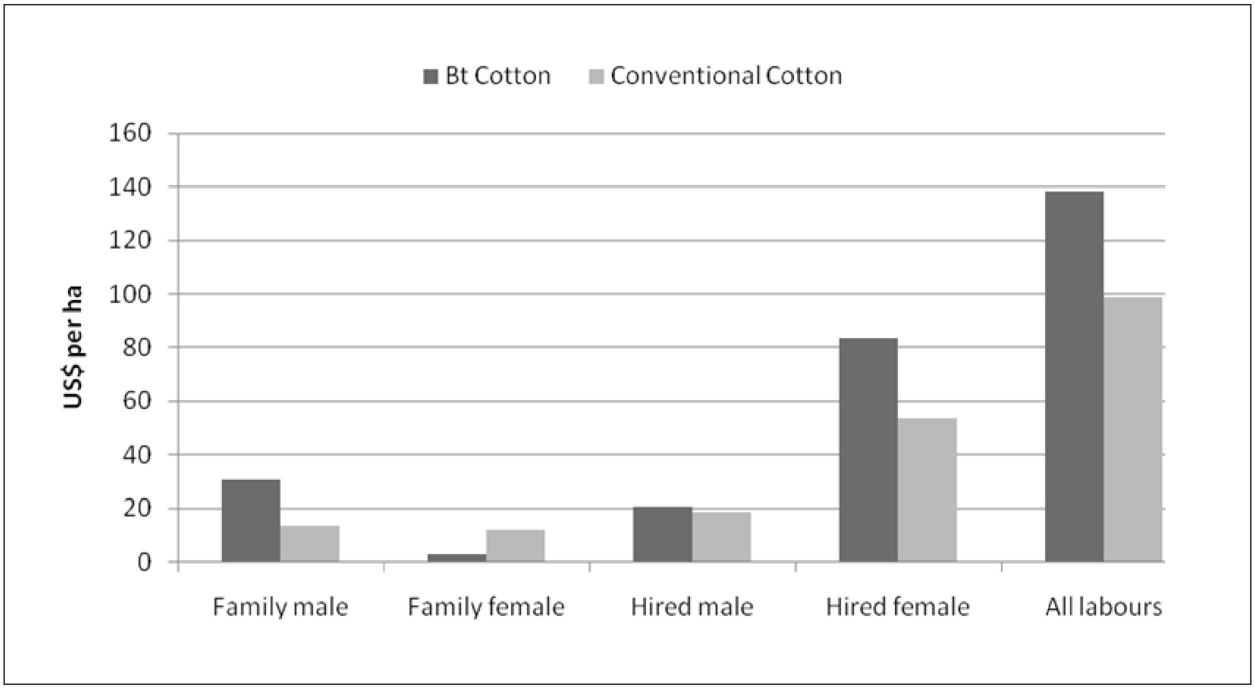
"Are the economic benefits of Bt cotton sustainable – evidence from Indian panel data" (Kathage & Qaim, 2011)

The study conducted in 2011 confirms that **Bt adoption has positive and significant net impacts which has increased cotton yields by 24% per acre and profits by 50% per acre.** Furthermore, it indicated that the benefits in terms of yields and profits may even have increased over time. Notably, the study also showed that the adoption of Bt cotton raised consumption expenditures of Bt cotton households by 18% or US$345 per household (based on estimation of US$62 per acre) during the 2006-2008 period. In 2010, Bt cotton, which was adopted on 23 million acre would have contributed the aggregate annual gain equivalent to US$1.43 billion in the living standards of cotton farmers in the country. Finally, the study concluded that *"Bt cotton has created large and sustainable benefits, which contribute to economic development in India"* (Kathage & Qaim, 2011).

University of Warwick Study (Subramanian, 2010)

In 2010, researchers at the University of Warwick (Subramanian, 2010) published a research paper entitled ***"GM crops and gender issues"*** and another report ***"The Impact of Bt Cotton on Poor Households in Rural India"*** taking into account the use of a microeconomic modeling approach and comprehensive survey data from India to analyze welfare and distribution effects in a typical village economy – this study places much more emphasis on the welfare benefits than the previous eleven socio-economic studies conducted from 1998 to 2009, which place more emphasis on direct benefits related to productivity of Bt cotton. The Warwick study noted that the use of Bt cotton in India has produced massive gains in women's employment and income in the country. ***"Planting of insect-resistant Bacillus thuringiensis toxin cotton generated not only higher income for rural workers but also more employment, especially for hired female labor,"*** reports the study (Subramanian, 2010). The report concluded that, Bt cotton generates additional employment, raising the total wage income by US$40 per hectare, as compared with conventional cotton (Figure 34). The study also reported that since Bt cotton was introduced in India in 2002, higher yields compared with conventional cotton have led to additional labor employed to pick the increased production. The study reported that employment for cotton picking increased significantly for hired females who benefited 55% more than male laborers, which translates to about 424 million additional employment opportunities for female earners for the total Bt cotton area in India (Subramanian, 2010). The study noted that Bt cotton also improved female working conditions since less family male labor was needed for scouting and spraying for pests, making that labor available for other household economic activities traditionally done by female family members. Finally, the study concluded that "overall, Bt cotton enhanced the quality of life of women through increasing income and reducing 'femanual' work" (University of Warwick, 2010; Subramanian, 2010).

Figure 34. Returns to Labor from Bt Cotton and Conventional Cotton in Rural India, 2010



Source: Adopted from Subramanian, 2010.

Summary of Major Findings of Previous Socio-Economic Studies (Table 19), reported in earlier ISAAA Briefs

In addition to the above studies, a collection of twelve other economic studies on the impact of Bt cotton, all conducted by public sector institutes over the period 1998 to 2010, covering both pre and post-commercialization of Bt cotton are referenced chronologically in Table 19. The first three studies were based on two sets of data to estimate the overall economic advantage of cotton including a field trial data set for 1998/99 to 2000/01 from the Department of Biotechnology analyzed by Naik (2001) and the second set was an ICAR field trial data set for 2001-2002 analyzed and published by ICAR (2002) and Qaim (2006). The other eight studies/surveys were conducted on large numbers of Bt cotton farmers' fields from 2002 to 2007, by different public sector institutions listed in Table 19. The studies have consistently confirmed 50 to 110% increase in profits from Bt cotton (compared with conventional), equivalent to a range of 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 ranged usually from 30 to 60% and the reduction in number of insecticide sprays averaged 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 during the eight year period 2002 to 2009.

Table 19. Twelve Studies Conducted by Public Institutes on the Benefits of Bt Cotton in India for the Years, 1998 to 2010

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	[8]CESS 2007	[9]Subramanian & Qaim 2009	[10]Sadashivappa & Qaim 2009	[11]Qaim *et. al* 2009	[12]Subramanian & Qaim 2010
Period studied	1998-99 & 00-01	2001	2001-2002	2002 & 2003	2004	2005	2006	2004-05	2004-05	2006-07	1998-06	2006-07
Yield increase	38%	60-90%	34%	45-63%	31%	30.9%	46%	32%	30-40%	43%	37%	43%
Reduction in no. of spray	4 to 1 (75%)	5-6 to 1 spray (70%)	6.8 to 4.2 (50%)	3 to 1	39%	–	55%	25%	50%	21%	41%	21%
Increased profit	77%	68%	69%	50% or more gross margins	88%	–	110%	83%	–	70%	89%	134%
Average increase in profit/hectare	$76 to $236/ hectare	$96 to $210/ hectare	$118/ hectare	–	$250/ hectare	–	$223/ hectare	$225/ hectare	$156/ hectare or more	$148 / hectare or more	$131/ hectare or more	$161/ hectare or more

Sources:
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: 48-58.
4. Bennett R. et al. 2006. "Farm-level economic performance of genetically modified cotton in Maharastra, India," Review of Agricultural Economics, 28: 59-71.
5. Gandhi, V and Namboodiri, NV. 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.
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.
8. Dev SM and NC Rao. 2007. "Socio-economic impact of Bt cotton", CESS Monographs, Centre for Economic and Social Studies (CESS), Hyderabad, A.P.
9. Subramanian A and M Qaim. 2009. Village-wide Effects of Agricultural Biotechnology: The Case of Bt Cotton in India, World Development. 37 (1): 256–267.
10. Sadashivappa P and M Qaim. 2009. Bt Cotton in India: Development of Benefits and the Role of Government Seed Price Interventions, AgBioForum. 12(2): 1-12.
11. Qaim M, A Subramanian and P Sadashivappa. 2009. Commercialized GM crops and yield, Correspondence, Nature Biotechnology. 27 (9) (Sept 2009).
12. Subramanian A and M Qaim. 2010. The impact of Bt cotton on poor households in rural India. Journal of Development Studies, Vol.46 (No.2). pp. 295-311. 2010.

Pre-commercialization Bt cotton data analyzed by Naik (2001) indicated that the overall economic advantage of Bt cotton in 1998/99 ranged from US$76 to US$236 per hectare, equivalent to an average 77% gain, compared with conventional cotton. Naik reported a 38% yield increase and 75% reduction in numbers of insecticides spray on Bt cotton over non-Bt counterparts.

An overview of the twelve studies conducted by public sector institutions on the benefits and socio-economic impact of Bt cotton in India from 1998 to 2010 have been reported in the ISAAA Brief 42 "the Global Status of Commercialized Biotech/GM Crops, 2010" (James, 2010). It included three studies conducted prior to the commercialization of Bt cotton from 1998 to 2001 and nine studies reported post commercialization of Bt cotton from 2002 to 2010. The results of these studies on Bt cotton were consistent with the study undertaken by Gandhi and Namboodiri in 2006 showing yield gains of approximately 31%, a significant 39% reduction in the number of insecticide sprays, leading to an 88% increase in profitability, equivalent to a substantial increase of approximately US$250 per hectare (Gandhi and Namboodiri, 2006). In addition, the only published impact studies of Bt cotton in 2008/09 was conducted by IMRB International (IMRB, 2009) which focused on the agronomic and economic benefits. The only published study specifically on the social impact of Bt cotton was conducted by Indicus Analytics in 2007 (Indicus, 2007).

The 2008 ISAAA Report (James, 2008) projected that the adoption rate of Bt cotton in India in 2009 would reach more than 80%, whereas the actual level in 2009 was 81% (James, 2009) which further increased to 85% in 2010 and 88% in 2011. Given the significant and double agronomic, economic and welfare benefits that farmers derive from Bt cotton in India, the adoption of approved Bt cotton hybrids and varieties in India continued to increase modestly to 88% in 2011 due to substantial increase in total plantings of cotton from 111 million hectare in 2010 to 12.1 million hectares in 2011. Despite the unprecedented high adoption rate of 88% of Bt cotton by 7 million farmers, the majority of whom have first-hand experience of up to ten years of the significant benefits it offers, and the consistent high performance of Bt cotton compared with conventional, anti-biotech groups still continue to vigorously campaign against biotech in India, using all means to try and discredit the technology, including filing public interest writ petitions and pursuing litigation in the Supreme Court contesting the biosafety of biotech products.

Political Will and Support

In 2011, The Prime Minister of India Dr. Manmohan Singh, while inaugurating the 83rd Foundation Day of Indian Council of Agricultural Research (ICAR) in New Delhi on 16 July 2011 called upon agriculturists to judiciously use biotechnology to improve productivity and enhance the farmers' income. Expressing concern over stagnated crop yields over the years, he emphasized that India needs to focus on all measures to accelerate farm sector growth, he said, ***"We clearly need a second green revolution that is broad-based, inclusive and sustainable."*** The Prime Minister emphasized that there is need to step up spending in agriculture research, increase irrigation facilities and promote biotechnology carefully to boost crop productivity and enhance farmers' income. He said ***"I would like to touch upon two other areas that we need to focus on for accelerating our agricultural performance. The first is the protection of crops, animals and farm produce against new and emerging diseases and pathogens. The second is careful application of biotechnology to improve productivity, enable better resilience to stress and also enhance the incomes of our farmers."***

In 2010, The Prime Minister of India Dr. Manmohan Singh. While inaugurating the 97th Indian Science Congress in Thiruvanthapuran, Kerala on 3 January, 2010 lauded the resounding success of Bt cotton in India and emphasized the need for developments in biotechnology for greatly improving the yield of major crops in India. His speech was of particular significance because the congress is the apex body for science and technology in India and has focused on *"Science and Technology Challenges of 21st Century-National Perspective"*. He said ***"Developments in biotechnology present us the prospect of greatly improving yields in our major crops by increasing resistance to pests and also to moisture stress. Bt Cotton has been well accepted in the country and has made a great difference to the production of cotton. The technology of genetic modification is also being extended to food crops though this raises legitimate questions of safety. These must be given full weightage, with appropriate regulatory control based on strictly scientific criteria. Subject to these caveats, we should pursue all possible leads that biotechnology provides that might increase our food security as we go through climate related stress."***

In 2011, **Mr. Sharad Pawar, the Union Minister of Agriculture and Food Processing Industries,** called on the scientific community to engage in result-based agricultural research while delivering the address during the ICAR 83rd Foundation Day held on 16th July 2011 in New Delhi, India. The Minister emphasized that ***"the key to success would be enhanced application of modern day science, technologies and techniques. Biotechnological approaches including genetically modified crops and molecular crop breeding that will go a long way in achieving our goals. All efforts should be made to mitigate the adverse effects of climate change on agricultural production."*** The Minister also informed that the production of food grains has reached 241 million tonnes in 2010-11. In conclusion, he stressed the need for technological breakthroughs and innovative agriculture development programmes to maintain the current momentum as well as to increase the input use efficiency for sustained increase in agricultural production.

In 2009, **Prof. M. S. Swaminathan, Member of Parliament, Rajya Sabha (Upper House), the Parliament of India and Chairman, MSSRF.** Prof. M. S. Swaminathan in his article *"GM: Food for Thought"* published in the Asian Age, Delhi, 26th August 2009 stated that ***"The world population has crossed six billion and is predicted to double in the next 50 years. Ensuring an adequate***

food supply for this booming population is a major challenge in the years to come. GM foods promise to meet this need in a number of ways… GM foods have the potential to solve many of the world's hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides."

In 2011, a record 7 million farmers planted Bt cotton on 10.6 million hectares in India. The majority of these farmers are small, marginal and resource poor. Their livelihood depends on the success or failure of the cotton crop, and more specifically the comparative advantage of Bt cotton over conventional cotton. In the past, ISAAA highlighted the testimonials of randomly selected small farmers both men and women from all nine cotton growing states of India (see previous ISAAA Briefs). Testimonials included details of farmers, their family, and their experience with growing both the single gene and double gene Bt cotton hybrids. Two additional farmers from Rajasthan and Haryana who grow commercial Bt cotton on their own land and on leased land share their experiences, reproduced in their own words below:

Mr. Rammurthy grows Bt cotton on his own farm and on 3 keela (equivalent of 3 acres) of leased land and lives in his Village, Dhanna Kalla, District Hanshi of Haryana.

"My name is Rammurthy resident of Dhanna Kalla. My village is located 2 kms from the land where I cultivate Bt cotton. I have five members in my family including 2 boys and a girl. My boys studied 10th standard like me and left school to work with me in my farm. I am a farmer with 3 acres of land since I left school many years ago. I cultivate Bt cotton on a leased land and pay approximately Rs. 10,000 per season to the owner of the land. In addition, I also grow Bt cotton on my own farm which is located close to my village. Since the introduction of Bt cotton, I grow cotton on leased land as I find it comfortable and profitable to grow cotton now. I take two crops in a year, cotton in Kharif and wheat in Rabi season. I also grow some vegetables as well. Bt cotton yields around 30 to 40 mann (12 to 16 quintal per acre) with negligible cost on spraying, which has come down to 2 to 3 sprays from 15 sprays in the past. With Rasi Bt cotton hybrids, I earned approximately Rs. 20,000 per acre after paying Rs. 10,000 to land owner. I will be getting my daughter married soon."

Mr. Mal Singh Jalla is a Bt cotton farmer from *Tamariya* village, Banswara district of Rajasthan.

"I am a born farmer in this irrigated belt of Banswara district of Rajasthan. I own 10 bigga (approximately 2.5 acre) of land inherited from my family. Fortunately my farm is located on the main highway which gives me early exposure to various new technologies as many experts visit my farm regularly. I have two boys who are in private job in Vadodara district of Gujarat. I myself cultivate land to grow various crops including corn, cotton, wheat and

vegetables like chilli and brinjal. I started growing Bt cotton after it was formerly introduced in Rajasthan in 2005. This year, I am undertaking Bt cotton seed production program on my 2.5 acre of land. This is the new way of doing farming in my life. I am very excited to continue Bt cotton hybrid seed production program where I earn more money than growing commercial Bt cotton hybrids on my farm in the past. I believe farmers should be allowed to choose various options where they can make more money from their limited land. Last year, I reaped around 10-12 quintals per acre of cotton by planting Bt cotton hybrids and earned significantly more than growing other crops like traditional maize on my land. In the past, I used to grow cotton hybrids including Shankar 4 and Shankar 6 cotton hybrid. I have also undertaken seed production program of castor on a leased land this year. I am very optimistic of my new venture of Bt cotton hybrid seed production."

CANADA

In 2011, Canada retained its fifth place in world ranking. Growth in biotech crop area continued in Canada in 2011 to reach a record 10.4 million hectares with a substantial net gain of 1.6 million hectares, equivalent to an 18% year-over-year growth for the four biotech crops of canola, maize, soybean and sugarbeets, with virtually all the growth due to higher plantings of canola and a record 96% adoption compared with 94% in 2010. Biotech hectares for maize and soybean and sugarbeet were similar to 2010. The average economic benefit from herbicide tolerant canola in western Canada during the three year period 2005 to 2007 was approximately Ca$400 million per year.

Canada is a member of the group of six "founder biotech crop countries", having commercialized herbicide tolerant canola in 1996, the first year of commercialization of biotech crops. In 2011, Canada retained its fifth place in world ranking. Growth in biotech crop area continued in Canada in 2011 with a net gain of approximately 1.6 million hectares, equivalent to an 18% year-over-year growth, with a total biotech crop area of 10.4 million hectares for the four biotech crops of canola, maize, soybean and sugarbeets, with most of the growth due to higher plantings of canola with a record 96% adoption, compared to 94% in 2010, with some growth in soybean. The largest biotech crop area 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 2011 was a record 8.0 million hectares, up 19% from the 6.7 million hectares in 2010. In 2011, the national adoption rate for biotech canola was a record 96% up 2% compared with 94% in 2010, 93% in 2009, 86% in both 2008 and 2007, 84% in 2006 and 82% in 2005 (Figure 35). In 2011, biotech herbicide tolerant canola was grown on approximately 7.7 million hectares, 22% more than the 6.3 million hectares of biotech canola grown in 2010, 6.0 million hectares in 2009, 5.5 million hectares in 2008, 5.1 million hectares in 2007 and 4.5 million hectares of biotech canola in 2006. 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 record high national adoption rate of 96%.

In Ontario and Quebec, the major provinces for maize and soybean hectarage, the total plantings of maize for all purposes in 2011 were 1.4 million hectares and 1.6 million hectares for soybean, the same as last year. The 2011 total plantings of sugarbeets were the same as 2010 at approximately 18 thousand hectares of which 96% was herbicide tolerant, the same as last year. In 2011, the area of biotech maize, was 1.3 million hectares, the same as last year. Canada is one of only nine countries (the others are the USA, Brazil, Argentina, the Philippines, South Africa, Uruguay, Honduras and Chile) which grow maize with double stacked traits for herbicide tolerance and Bt for insect resistance. Similarly, except for the USA, Canada is the only country to grow a triple stack with one gene for European corn borer, a second for root worm control and a third for herbicide tolerance. Of the biotech maize in Canada in 2011, only 1% contained a single gene, compared with 25% in 2010, 46% in 2009, and 68% in 2008. In 2011, 76% contained 2 or 3 stacked genes compared with 70% in 2010, and 54% in 2009. This growth in double and triple stacked genes versus single genes is typical of the shift in favor of stacked genes compared with single genes that has occurred in all seven countries that deploy stacked genes in maize. In 2011, of the total soybean hectarage of 1.6 million hectares, the biotech soybean hectarage was 1.3 million hectares, the same as last year.

CANADA

Population: 33.2 million

GDP: US$1,501 billion

GDP per Capita: US$45,070

Agriculture as % GDP: 3%

Agricultural GDP: US$45 billion

% employed in agriculture: 3%

Arable Land (AL): 49.9 million hectares

Ratio of AL/Population*: 6.0

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

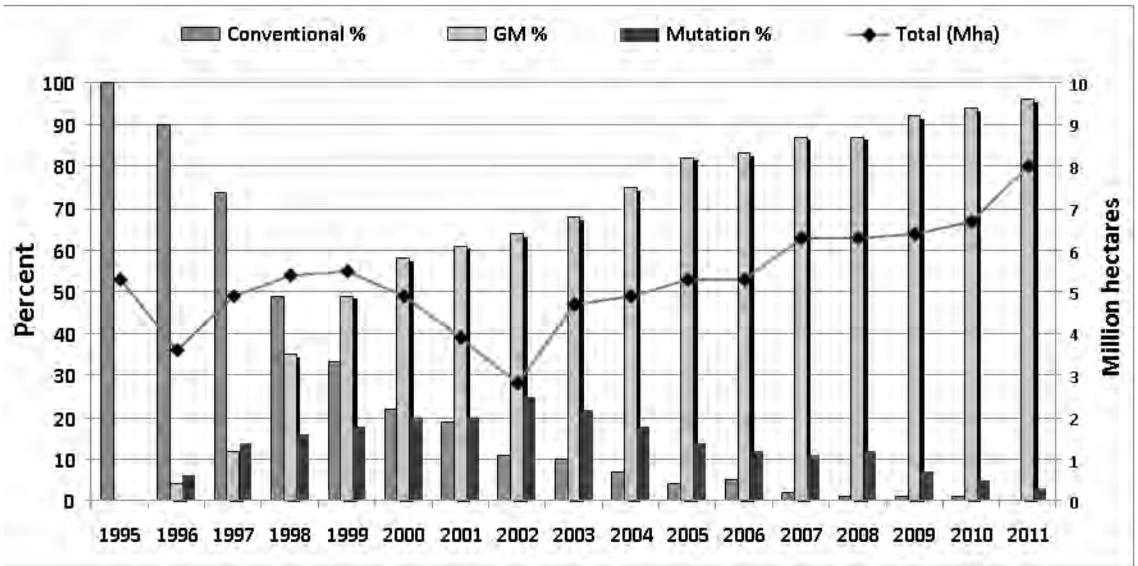
Commercialized Biotech Crops:
- HT Canola
- HT/Bt/HT-Bt Maize
- HT Soybean
- HT Sugarbeet

Total area under biotech crops and (%) increase in 2011:
10.4 Million Hectares (+18%)

Farm income gain from biotech, 1996-2010: US$3.3 billion

*Ratio: % global arable land / % global population

Figure 35. Percentage of Conventional, Biotech and Mutation-based Herbicide Tolerant (HT) Canola Planted in Canada, 1995 to 2011 (Million Hectares)



Source: Based on Canola Council of Canada data, Personal Communication, 2010.

Biotech RR®sugarbeets were planted in Canada in 2011, for the fourth time after being launched in 2008. It is estimated that in 2011, 96% (same as 2010) of the sugarbeets in Canada, equivalent to approximately 18,000 hectares were RR®sugarbeets. This was the fourth year of planting in Ontario in Eastern Canada, (with the beets transported and processed in the USA) and the third year of production in Western Canada where they were also processed.

It is estimated that approximately 2% of the Canada canola production will be used for biofuel by 2012. Canada is a major producer of wheat and several of the current principal wheat varieties have been developed through mutagenesis – there is increased interest in biotech wheat. Maize with higher levels of lysine is undergoing field tests. The RR®alfalfa from the USA has also been approved for import to Canada.

Global jet fuel consumption, excluding military, exceeds 319 billion liters annually, and demand is growing. The International Air Transport Association (IATA), and its member airlines seek to be "carbon neutral" by 2020. This will require the addition of bio-based jet fuel to the current fuel mix. The American Society for Testing Materials, the organization responsible for approving fuel specifications worldwide, has approved the use of up to a 50% blend of biofuels which translates to a potential new demand of over four billion liters of bio-based jet fuel by 2020. In a 22 September 2011 joint press release from Ag-West Bio from Saskatchewan, Canada, and Agriculture and Agri-Food Canada, they reported a proposed study to evaluate the feasibility of developing oil crops for processing into bio-jet fuels (Ag-West Bio, 2011).

The two most promising oil seed crops are *Camelina sativa* (camelina) and *Brassica carinata* (carinata). The study will determine the potential benefit to producers, opportunities for accompanying processing and refining businesses, and for Saskatchewan's economy. Kevin Hursh, executive director of the Saskatchewan Mustard Development Commission, observed that ***"Mustard producers have invested research money into the development of carinata as a cropping option, but we need to know that the crop can be profitable for producers as well as all segments of the value chain."*** The bio-based jet fuel industry is a very specialized field and Ag-West Bio will use external service providers with expertise in each of the critical activities. Mike Cey, VP Corporate & Business Development for Ag-West Bio, the project leader said that ***"Ag-West Bio has established a Steering Committee that comprises all the stakeholders. The committee will aim to understand the economics, logistics, the challenges and opportunities for production of these dedicated industrial oilseed crops, through to processing and commercial use"*** (Ag-West Bio, 2011).

Benefits from Biotech Crops in Canada

Canada is estimated to have enhanced farm income from biotech canola, maize and soybean by US$3.3 billion in the period 1996 to 2010 and the benefits for 2010 alone is estimated at US$0.6 billion (Brookes and Barfoot, 2012, Forthcoming).

The detailed benefit study of biotech canola, conducted by the Canola Council of Canada in 2007 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. 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 the 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 8,090,000 hectares of biotech canola were grown for a gain of US$464 million and the additional 19,809,000 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.

A more recent analysis reported in 2010, on 2005 to 2007, data by Smyth et al. (2010) concluded that herbicide tolerant canola in western Canada had generated between Ca$1.063 billion and Ca$1.192 billion in direct and indirect/spill-over benefits for producers during the three year period 2005 to 2007 with an average annual economic benefit of almost Ca$400 million (Ca$397) (Table 20). The authors concluded that the economic benefits were partly attributed to lower production costs and to improved weed control. The findings of the survey were similar to earlier studies (Canola Council of Canada, 2007). The 2010 Report (Smyth et al. 2001) ***"refutes the claims and accusations made by critics of agricultural biotechnology that genetically modified crops do not benefit farmers and are harmful to the environment"*** – on the contrary it reports that the economic and environmental benefits are numerous and substantial.

Table 20. Direct and Spill-over Benefits of HT Canola (Ca$M)

Year	Million Acres	Direct	Spill-over		Reduced tillage	Cost of volunteer control	Total Benefits	
			Low	High			Low	High
2005	12.6	141	63	103	153	14	343	383
2006	12.8	143	64	105	153	14	346	387
2007	14.8	165	73	121	153	17	374	422
Average	13.4	150	67	110	153	15	354	397
Total							**$1,063**	**$1,192**

Source: Smyth et al. 2010.

Farmer Experience

Brian Chorney operates the family-owned John Chorney Farms in East Selkirk, Manitoba, Canada. The farm which was established by his grandfather was used to having a summer fallow to control weeds. Today, Chorney has access to a wide range of tools to improve crop productivity and enable sustainable farming including biotech products such as herbicide-tolerant soybeans and canola to control difficult weeds. ***"Biotechnology adds tools to our toolbox as farmers. We can look at different methods of controlling weeds,"*** says Chorney, ***"Prior to crop protection products and biotechnology, the only method of controlling weeds was cultivation. Now I don't have planned summer fallow and I can clean up fields by growing different crops."*** With the wide variety of crops to choose from Chorney said, ***"Biotech crops have given us the opportunity to look at our crop rotation on a holistic approach. If you look at a canola, winter wheat, soybean, spring wheat type rotation, it is a diverse approach that is sustainable long-term for our farm viability"*** (Chorney, 2010).

Jim and Denise Timmings operate a 4,000 acre Timstar Farms in Rockwood, Southern Ontario, Canada. The 40-year family farm business was made profitable and sustainable in the last decade due to the family's hard work and their adoption of agricultural innovations such as plant biotechnology and crop protection products. ***"Growing the crops we grow is difficult, if not impossible, without crop protection products,"*** says Timmings. ***"We have to control the weeds, we have to maintain the yields in order to be profitable and biotech crops have allowed us to do some different things to be sustainable "*** (Timmings, 2010).

CHINA

Biotech phytase maize, and Bt rice approved for biosafety on 27 November 2009, are now undergoing extensive and rigorous field trials that all new improved crops, conventional and biotech, must undergo prior to commercial approval. These two products have momentous implications for China, Asia and the world in the near, mid and long term, because rice is the most important food crop in the world and maize the most important feed crop in the world. In China alone, Bt rice can benefit 110 million rice households totaling 440 million beneficiaries, assuming four per family. With 250 million rice-growing households in Asia, the number of potential beneficiaries of biotech rice is a momentous 1 billion people. Rice yield in

China in 2009 was 6.59 tons/ha with a national production at 197 million tons. China needs to increase its rice yield to 7.85 tonnes per hectare and 235 million tons production respectively by 2030, to meet the demand of its population of 1.6 billion. China's demand of 235 million tonnes of paddy in 2030, is equivalent to one third of global production of 750 million tonnes. Whereas rice is the most important food crop in China, maize is the most important feed crop. Over 30 million hectares of maize is grown by an estimated 100 million maize-growing households (400 million potential beneficiaries) in China alone. Phytase maize can increase the efficiency of meat production, an important new and growing need, as China becomes more prosperous and consumes more meat. China has 500 million pigs (50% of the global swine herd) and 13 billion chickens, ducks and other poultry which need feed. Given the significant increased demand for maize, and rising imports it is likely that biotech maize, as a feed crop, will be commercialized by China before biotech rice, the principal food crop of China and the crop that feeds half of humanity. China has recently reiterated the strategic importance of biotech crops to the country and its commitment to ensure safe testing of the products before deployment. China also indicated that priority was assigned to biotech maize in the short term.

<u>CHINA</u>

Population: 1,336.3 million

GDP: US$4,327 billion

GDP per Capita: US$3,270

Agriculture as % GDP: 11%

Agricultural GDP: US$476 billion

% employed in agriculture: 41%

Arable Land (AL): 143.5 million hectares

Ratio of AL/Population*: 0.45

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

Commercialized Biotech Crops:
- Bt Cotton
- Bt Poplar
- PRSV Papaya
- VR Sweet Pepper
- DR, VR Tomato

Total area under biotech crops and (%) increase in 2011:
3.9 Million Hectares (+11%)

Increased farm income for 1997-2010: US$10.9 billion

*Ratio: % global arable land / % global population

Consistent with an increase in global cotton hectarage to 35.7 million hectares in 2011, up 7% from 2010, China also grew more cotton in 2011. Total cotton plantings were estimated at 5.5 million hectares, compared with 5.0 million hectares in 2010.

Adoption rate of Bt cotton in China was 71.5% in 2011 (compared with 69% in 2010) when an estimated 3.9 million hectares of Bt cotton were planted. Thus, the increase in hectarage of Bt cotton in China from 3.45 million hectares in 2010 to approximately 3.9 million hectares in 2011 is due to the increase in total hectarage of cotton planted in 2011 and a small increase in adoption rate from 69% to 71.5%. Economic gains at the farmer level from Bt cotton for the period 1997 to 2010 was US$10.9 billion and US$1.8 billion for 2010 alone. In 2011, approximately 7 million small and resource-poor farmers in China continued to benefit from planting 3.9 million hectares of Bt cotton. Research in northern China indicates that there maybe up to an additional 10 million beneficiary farmers cultivating 22 million hectares of crops other than cotton, which also host cotton bollworm, but where infestations have decreased up to ten-fold. Thus, the actual number of beneficiary farmers of biotech crops in China alone may exceed 15 million.

China has also approved and successfully grown biotech papaya, a fruit food crop for five years, since 2007. In Guangdong province, the principal province in China for papaya, virtually all of the papaya is now biotech papaya, resistant to the lethal papaya ring spot virus (PRSV) disease. The adoption rate in 2011 is estimated at 99%, the same as 2010. The adoption of virus-resistant biotech papaya in China has increased in absolute hectarage to a record 5,300 hectares in 2011, a 15% increase over the 4,625 hectares in 2010. The percentage adoption has also increased to 99% in 2011 and 2010 from 90% in 2009, 88% in 2008, and 70% adoption, equivalent to 3,550 hectares in 2007 when it was first commercialized in China. Moreover a biosafety certificate has been granted for planting in Hainan Island in 2011 so the total hectarage of virus resistant papaya will increase in 2012. It is noteworthy that Japan approved biotech papaya for import as a fresh fruit/food from the US in 2011. In addition, plantations of Bt poplar in China, with improved insect resistance, continued to be successfully grown on approximately 490 hectares, up from 453 hectares in 2010.

The Chinese Government's assignment of high priority to agriculture, and more specifically crop biotechnology, championed by Premier Wen Jiabao, is strategically extremely important for China, particularly for their two premier food and feed crops, biotech rice and maize. This exertion of leadership and high priority for crop biotechnology also reflects China's increasing academic excellence in crop biotechnology. Agricultural science is China's fastest-growing research field, with China's share of global publications in agricultural science growing from 1.5% in 1999 to 5% in 2008. In 1999, China spent only 0.23% of its agricultural GDP on agricultural R&D, but this increased to 0.8% in 2008 and is now close to the 1%

recommended by the World Bank for developing countries. The new target for the Chinese Government is to increase total grain production to 540 million tons by 2020 and to double Chinese farmers' 2008 income by 2020, with biotech crops expected to provide an important contribution.

China approves biotech rice and maize in landmark decision on 27 November 2009.

In November 2009, China completed its approval of a troika of key biotech crops – fiber (Bt cotton already approved in 1997), feed (phytase maize) and food (Bt rice). China's Ministry of Agriculture (MOA) granted three biosafety certificates on the same day. Two certificates were issued for biotech rice, one for a rice variety (Huahui-1) a restorer line, and the other for a hybrid rice line (Bt Shanyou-63), both of which expressed *cry1Ab/cry1Ac* and developed at Huazhong Agricultural University (James, 2009a). The approval of Bt rice is extremely important because rice is the most important food crop in the world that feeds 3 billion people or almost half of humanity; furthermore and importantly, rice is also the most important food crop of the poor. The third certificate was for biotech phytase maize; this is also very important because maize is the most important animal feed crop in the world. The phytase maize was developed by the Chinese Academy of Agricultural Sciences (CAAS) and licensed to Origin Agritech Limited after 7 years of study at CAAS. **The three certificates of approval have momentous positive implications for biotech crops in China, Asia and the whole world in the near, mid and long term.** It is important to note that the MOA conducted a very careful due diligence study, prior to issuing the three certificates for full commercialization, pending completion of the standard registration field trials which applies to all new conventional and biotech crops. It is noteworthy that China has now completed approval of a troika of the key biotech crops in an appropriate chronology – first was FIBER (cotton), followed by FEED (maize) and FOOD (rice). The potential benefits of these 3 crops for China are enormous and summarized below.

- **Bt cotton.** China has successfully planted Bt cotton since 1997 and in 2011, up to 7.0 million small farmers in China have already increased their income by approximately US$220 per hectare (equivalent to approximately US$1 billion nationally) due, on average, to a 10% increase in yield, and a 60% reduction in insecticides, both of which contribute to a more sustainable agriculture and the prosperity of small poor farmers. China is the largest producer of cotton in the world, with an estimated 71.5 % of its 5.5 million hectares successfully planted with Bt cotton in 2011.

- **Bt rice** offers the potential to generate benefits of US$4 billion annually from an average yield increase of up to 8%, and an 80% decrease in insecticides, equivalent to 17 kg per hectare on China's major staple food crop, rice, which occupies 30 million hectares (Huang et al. 2005). It is estimated that 75% of all rice in China is infested with the rice-borer pest, which Bt rice controls. China is the biggest producer of rice in the world (178 million tons of paddy) with 110 million rice-growing households (a total of 440 million people based on 4 per family) who could benefit directly as farmers from this technology, as well as China's 1.3 billion rice consumers. Bt rice will increase productivity of more affordable rice at the very time when China needs new technology to maintain self-sufficiency and increase food production to overcome drought, salinity, pests and other yield constraints associated with climate change and dropping water tables. Crops that use water efficiently and the development of drought tolerant crops is top priority for China. **China needs to increase its rice yield to 7.85 tons per hectare by 2030 when its population will be 1.6 billion** (Chen et al. 2010). **Thus, in 2030, China will need approximately 235 million tonnes of paddy annually, equivalent to one third of global production of approximately 750 million tones.**

- **Phytase maize.** China, after the USA, is the second largest grower of maize in the world (30 million hectares grown by 100 million households); it is principally used for animal feed. Achieving self-sufficiency in maize and meeting the increased demand for more meat in a more prosperous China is an enormous challenge. For example, China's swine herd, the biggest in the world, increased 100-fold from 5 million in 1968 to over 500 million today. Phytase maize will allow pigs to digest more phosphorus, resulting in faster growth/more efficient meat production, and coincidentally result in a reduction of phosphate pollution from animal waste into soil and extensive bodies of water and aquifers. Maize is also used as feed for China's huge number of domesticated avian species – 13 billion chickens, ducks and other poultry, up from 12.3 million in 1968. Phytase maize will allow animal feed producers to eliminate the need to purchase phytase with savings in equipment, labor and added convenience. The significance of this maize approval is that China is the second largest grower of maize in the world with 30 million hectares (USA is the largest at 37 million hectares). As wealth is rapidly being created in China, more meat is being consumed which in turn requires significantly more animal feed of which maize is a principal source. China imports 5 million tons annually at a foreign exchange cost of over US$1 billion. It is noteworthy that phytase maize is China's first approved feed crop. The only country in Asia that has approved and already growing biotech maize is the Philippines where it was first deployed in 2003; Bt maize, herbicide tolerant (HT) maize and the stacked Bt/HT product were grown on approximately ~645 thousand hectares in the Philippines in 2011. Biotech maize is likely to be commercialized in China before Bt rice given the significant increased demand currently being met by increased imports.

In China, it is very important to note that all three approved biotech crops, Bt cotton, Bt rice and phytase maize, were all developed with public resources by Chinese public sector institutions. The significant advantages that these products offer China also apply to other developing countries, particularly in Asia (but also elsewhere in the world), which have similar crop production constraints. Other Asian countries, which could benefit from biotech maize, include India (8 million hectares), Indonesia (3 million hectares), Thailand, Vietnam and Pakistan, all with approximately 1 million hectares each of maize. Asia grows and consumes 90% of the production from the world's 150 million hectares of rice, and Bt rice will have enormous impact in Asia. Not only can Bt rice contribute to an increase in productivity and self-sufficiency but it can also make a substantive contribution to the alleviation of poverty of poor small farmers who represent 50% of the world's poor. Similarly, there are up to 50 million hectares of maize in Asia that could benefit from biotech maize. China's exertion of global leadership in approving biotech rice and maize in 2009 will likely result in a positive influence on acceptance and speed of adoption of biotech food and feed crops in Asia, and more generally globally, particularly in developing countries. This approval is exemplary for other countries in pursuit of "self-sufficiency" (optimizing productivity and production of home-grown food) as opposed to "food security", (enough food for all) – the distinction is important and the two goals are not mutually exclusive. China can serve as a model for other developing countries, particularly in Asia, which could have substantive implications for:

- a more timely and efficient approval process for biotech crops in developing countries;
- new modes of South-South technology transfer and sharing, including public/public and public/private sector partnerships;
- more orderly international trade in rice and reduction in probability of recurrence of 2008-type price hikes, which were devastating for the poor; and
- shift of more authority and responsibility to developing countries to optimize "self-sufficiency" and provide more incentive for their involvement to deliver their share of the 2015 Millennium Development Goals.

From a long term perspective, Bt rice and phytase maize should be seen as only the first of many agronomic and quality biotech traits to be integrated into improved biotech crops, with significant enhanced yield and quality, which can contribute to the doubling of food, feed and fiber production on less resources, particularly water and nitrogen, by 2050. The approval by China of the first major biotech food crop, Bt rice, can be a catalyst for both the public and private sectors from developing and industrial countries to work together in a global initiative towards the logical goal of "food for all and self-sufficiency" in a more just society. The issuance of three biosafety certificates for rice and maize reflects China's intent to practice what it preaches and to approve for commercialization its home-grown biotech fiber, feed and food crops (biotech papaya – a fruit/food crop that has been successfully cultivated commercially since 2006/07) that offer significant economic and environmental benefits, and perhaps more importantly, allows China to be least dependent on others for food, feed and fiber – a strategic issue for China. It is noteworthy that Japan approved biotech papaya for import as a fresh fruit/food from the US in 2011.

Like the USA, Argentina and Canada, China is a member of the group of six "founder biotech crop countries", having first commercialized biotech crops in 1996, the first year of global commercialization. The national area planted to cotton in China in 2011, at 5.5 million hectares was significantly higher than that planted in 2010 at 5.0 million hectares, and thus a parallel increase has been triggered in hectares of Bt cotton. The area planted to Bt cotton in 2011, 3.9 million hectares was higher in absolute terms, and the percentage adoption was slightly higher than 2010 (69%) at 71.5%. 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 approximately 0.6 hectare. Currently, 64 varieties of Bt cotton are grown in China. An estimated 7 million small and resource-poor farmers grew Bt cotton in China in 2011. An important paper in Science (Wu et al. 2008) suggested that the potential number of small farmers actually benefiting indirectly from Bt cotton in China might be as high as 10 million more. It is noteworthy that a paper by Hutchinson (2010) based on studies in the USA draws similar conclusions to Wu et al. (2008) – indeed it reports that the indirect benefits for conventional crops grown in the same area where biotech crops are deployed, are actually greater than the direct benefits from biotech crops. For more details see the Chapter on the USA in this Brief.

Following the extensive planting of Bt cotton in six northern provinces of Hebei, Shandong, Jiangsu, Shanxi, Henan and Anhui in China, during the period 1997 to 2006, Wu et al. (2008) reported that cotton bollworm populations decreased markedly by up to 10-fold (approximately 90% from around 3,000 in 1997 to 300 in 2006) in other crops that also host the cotton bollworm – these include maize, peanut, sesame, legumes, wheat, sorghum, vegetables and melons. Whereas cotton occupies only about 3 million hectares and farmed by an estimated 5 million farmers in the six northern provinces in China, host crops of cotton bollworm occupy 7 times the area at 22 million hectares and are farmed by more than 10 million farmers receiving indirect benefits from Bt cotton – i.e. farmers deriving indirect benefits from Bt cotton number twice the number of Bt cotton farmers (5 million) that derive direct benefits from Bt cotton. Thus importantly, his study concludes that Bt cotton not only provides control for the damaging cotton bollworm on cotton but results in the suppression of cotton bollworm on several other important host crops that occupy more than seven times the area of Bt cotton. The dramatic reduction by 90% in the level of cotton bollworm in host crops other than cotton has implications for insecticide savings, which may translate to a significant decrease in the need for insecticide sprays on these host crops, other than cotton, cultivated by approximately 10 million farmers. This important finding may mean that the number of farmers that could benefit directly and indirectly from Bt cotton in northern China, may number an additional 10 million, compared with the 5 million that benefit from Bt cotton directly in the six northern provinces of China. Thus, past estimates of the benefits associated with Bt cotton in China in terms of the number of beneficiary farmers, and economic, agronomic and environmental benefits may have been grossly underestimated because the benefits to farmers cultivating crops other than cotton that host cotton bollworm were not known and have not been considered.

Coincidentally, as a result of the decrease in use of broad spectrum sprays for the control of cotton bollworm in cotton in northern China, mirids, which were previously a secondary insect pest of relatively low economic importance have not surprisingly become relatively more important. This demonstrates the need and importance for a broad integrated pest management strategy for the control of insect pets featuring both biotechnology and other means of control.

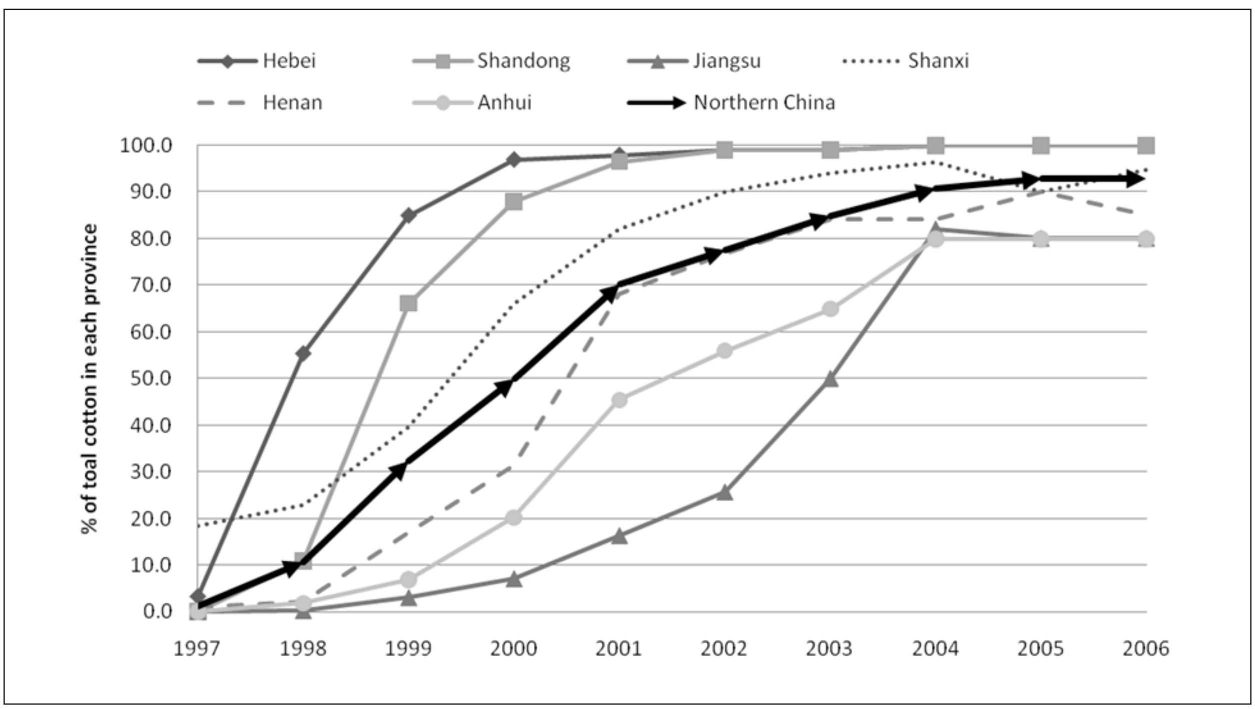
Entomologists A. M. Shelton Ph.D., Mao Chen Ph.D. and Jianzhou Zhao, Ph.D., all affiliated with Cornell (Personal Communication, 2010) offered the following important commentary on the success of Bt cotton in China and a proposed strategy for controlling the increasingly important mirids, and other pests, not controlled by Bt cotton.

> "The cotton bollworm (*Helicoverpa armigera*) and pink bollworm (*Pectinophora gossypiella*) are the most devastating pests on cotton in China and are the key pests that Chinese cotton farmers have traditionally had difficulty in controlling, even with frequent insecticide spray programs. Bt cotton has changed this situation. The high adoption rate of Bt cotton in China has resulted in effective suppression of both species on cotton and also regional suppression of the polyphagous *H. armigera* on a number of other crops (e.g. peanuts, soybean and vegetables). This situation has resulted in dramatic reductions in the use of traditional, broad-spectrum insecticides which, in turn, have led to decreased environmental harm and fewer farmer poisonings. However, since Bt cotton only controls the caterpillar pests, in some cases other arthropod populations have increased. This includes cotton aphids (*Aphis gossypii, A. atrata, A. medicaginis,* and *Acyrthosiphon gossypii*), mirids (*Adelphocoris suturalis, A. lineolatus, A. fasciaticollis, Lygus lucorum,* and *L. pratensis*), spider mites (*Tetranychus cinnabarinus, T. truncates, T. turkestani,* and *T. dunhuangensis*), thrips (*Frankliniella intonsa, Thrips tabaci,* and *T. flavus*), and whiteflies (*Bemisia argentifolii* and *B. tabaci*).
>
> Management programs for the insect complex not affected by Bt proteins need to be put into place and these include the use of some systemic insecticides which are far safer on the environment and natural enemies. From the pest management standpoint, conservation of such natural enemies, through the use of Bt plants and selective insecticides is key for managing the entire pest complex of cotton and is part of an overall integrated pest management (IPM) approach needed for sustainable cotton production. Such comprehensive IPM programs have proven effective for key and secondary arthropod pests in the US where Bt cotton adoption continues to climb and reached ~90% of all upland cotton production in the US in 2011. Chinese scientists are exploring strategies so that they can also obtain similar comprehensive IPM programs."

The field data from China's Ministry of Agriculture used in the same study by Wu et al. (2008) also clearly demonstrated the unusually high and rapid adoption of Bt cotton in each of the six provinces of northern China during the period 1997 to 2006 (Figure 36). It is noteworthy that adoption of Bt cotton was fastest in the two provinces of Hebei and Shangdong reaching over 95% in the short span of 5 years and 100% in 8 years. The adoption rates in the provinces of Jiangsu, Shanxi, Henan and Anhui were almost as fast, reaching 80 to 90% in 8 years or less (Figure 36). In northern China, as a region, more than 66% adoption of Bt cotton was reached in only 5 years. These adoption rates are remarkably high by any standard and reflect the vote of confidence and trust of farmers in Bt cotton, which has delivered multiple and significant economic, agronomic and socio-economic benefits consistently from 1997, the first year of commercialization, to the present.

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 (CCAP) of the Chinese Academy of Sciences (CAS), 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

Figure 36. Adoption of Bt Cotton in Each Province of Northern China, as Percentage, 1997 to 2006



Source: Wu et al. 2008, Data in Annex from China's Ministry of Agriculture.

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 invariably 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 out-performed their old varieties, and it took several years before hybrid maize was fully adopted.

The level of Bt cotton adoption in China seems to have plateaued at around 70% (71.5%). This plateauing is partly due to the fact that the large cotton areas in the province of Xing Xang are subject to much less pest pressure than provinces such as Hebei where pest pressure is high and where adoption rates are 100% and well above the national average of around 70%. In the absence of a sample survey to specifically determine the presence or absence of Bt genes in cotton in Xing Xang, it is estimated that about 20 to 30% of the cotton area in Xing Xang is planted with Bt cotton, while some observers estimate that the adoption rate could be significantly higher in Xing Xang.

No additional information was available in 2011 regarding a preliminary earlier report from 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. New Bt cotton hybrids could boost farmer income 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 provides slightly higher yields and can pave the way for new hybrids 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 has served China well in the development of biotech crops like Bt rice and Phytase maize, and for other biotech crops in the future.

In September 2006, China's National Biosafety Committee recommended for commercialization a locally developed biotech papaya resistant to papaya ring spot virus (PRSV) (Table 21). The technology features the viral replicase gene and was developed by South China Agricultural University; the papaya biotech variety is highly resistant to all the local strains of PRSV. This approval and eventual commercialization in China was 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 **virtually all (99%) of the papaya is now biotech papaya, resistant to the lethal papaya ring spot virus (PRSV) disease. The adoption rate in 2011 is estimated**

Table 21. Approval of Biotech Crops in China

Crop	Year of Approval
Cotton	1997
Petunia	1997
Tomato	1998
Sweet Pepper	1998
Poplar Trees	2003
Papaya	2006
Rice (Bt)	2009 (27 November, biosafety approval)
Maize (Phytase)	2009 (27 November, biosafety approval)

Source: Compiled by Clive James, 2011.

at 99%, the same as 2010. The adoption of virus-resistant biotech papaya in China in 2011 has increased in absolute hectarage to a record 5,300 hectares, a 15% increase over the 4,625 hectares in 2010 (Personal Communication, Prof Li, South China Agricultural University). **The percentage adoption was 99% in 2011 and 2010 and increased from 90% in 2009, 88% in 2008, and 70% adoption, equivalent to 3,550 hectares in 2007 when it was first commercialized in China.** Moreover a biosafety certificate has already been granted for planting in Hainan Island in 2011 so the total hectarage of virus resistant papaya will increase in 2012, taking into account plantings in both Guangdong and Hainan Island. Thus, the adoption of virus- resistant biotech papaya in China has increased in both absolute hectarage and proportion every single year to a high of 5,300 hectares or 99% in 2011 from a 70% adoption, equivalent to 3,550 hectares in 2007, when it was first commercialized in China.

Biotechnology has also been applied to trees in China and Bt poplars (*Populus nigra*) have been approved for commercialization. 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 by the year 2015, China will need 330-340 million cubic meters of timber, of which approximately half, or 140-150 million cubic meters, will have to be produced in China, with the balance imported. In order to meet this challenging goal, the development of improved tree plantations in China was accelerated. Some fast-growing trees, such as poplar, eucalyptus, larch, and Chinese fir, were carefully selected and widely planted in China. During the past 20 years, a total of 7.04 million hectares of selected poplar clones were planted in China for commercial production; this represents a significant 19% of total tree plantations in China. However, it was observed that these mono-clonal plantations were susceptible to insect pests which caused severe infestations resulting in significant damage, estimated at millions of US dollars annually.

In order to develop poplars that were more tolerant to insect attack, GM/biotech poplars were developed in China. More specifically, *Populus nigra* clones (12, 172 and 153) were developed with *cry1Aa* and a hybrid white poplar, clone 741, was transformed with a fusion of *cry1Aa* and *API* (coding for a proteinase inhibitor from *Sagittaria sagittifolia*). Under rigorous testing, the Bt poplar clones have exhibited a high level of resistance to leaf pests, resulting in a substantial 90% reduction in leaf damage. The two clones were first commercialized in 2003 in Northern China, and by 2011 they occupied 490 hectares compared with 453 hectares in 2010, (although the 30 hectare plantation in Huairou, Beijing was felled in 2011), 447 hectares in 2009 and 400 hectares in 2008. The transgenic poplar plantations have effectively inhibited the fast-spread of target insect pests and have significantly reduced the number of insecticide applications required. The performance of the Bt black poplar plantations are significantly better than the clones deployed locally. The availability of commercial Bt poplar plantations has made it possible to empirically assess gene flow via pollen and seeds, and also for assessing the impact of Bt poplar on the insect community when intercropping with Bt cotton. The transgenic *Populus nigra* has also been used for hybridizing with non-transgenic *P. deltoides* to generate an insect resistant source in a breeding program designed to generate new hybrid clones. There are now 3 transgenic poplar lines approved for environmental release in China, and another 5 have been deployed in small-scale field trials. Transformation of poplar with diverse traits such as tolerance to freezing, control of flowering and modification of wood specifications with improved pulping qualities and more efficient saccharification (conversion of lignocellulose to sugar) are in progress.

About 91% of the 490 hectares in 2011 were Bt *Populus nigra* clones, and the balance of 9% was clone 741 featuring *cry1Aa* and *API*. A new clone under development, a hybrid white poplar clone 84K transformed with the *Bt886Cry3Aa* resistance gene, has already undergone testing in nurseries and the preliminary results are promising. Clone 84K with *Bt886Cry3Aa* is tolerant to the economically important Asian longhorn beetle, which attacks the trunks of poplars and can cause significant damage. Comparisons between Bt poplar and non-Bt checks, confirm that Bt poplars require no insect pest control in the first 6 years, compared with the checks, which required 2 to 3 insecticide sprays (Lu M-Z, 2010, Personal Communication). This is consistent with experimental data (Table 22) confirming that Bt clones performed better and grew faster than their conventional counterparts. For example, at 10 years old, the tree trunk diameter was 28.2 cms for the Bt clone at the Beijing location versus 25.4 cms for the non- Bt clone “Zhonglin 46”. Similarly, the Bt clone at the Hebei location had 20.9 cm diameter after 8 years, versus 18.6 cms compared to the non-Bt clone “*P. deltoides* cv Chuangxin”.

As of the end of 2010, 33 field trials had been approved and implemented featuring tolerance to insects, diseases, drought, and wood quality traits. Biotech/transgenic *Populus tomentosa* with antisense CCoAOMOT (coding for a key enzyme involved in lignin monomer) is currently being tested under an environmental release permit, prior to being submitted for commercialization approval.

Table 22. Comparisons Between Performance of Bt Poplar Clones and non-Bt Clones in China in the Period 2001 to 2011

Location	Clone	Trunk Diam, cms.	Tree Age Years	Area (hectares)
Huairou Beijing	Bt Poplar *P. nigra*	28.2	10	30
Huairou Beijing	Non Bt *P. euramerican* Zhonglin 46	25.4	10	45
Renqiu, Hebei	Bt Poplar *P. nigra*	20.8	8	22
Renqiu, Hebei	Non-Bt *P. deltoides* cv Chuangxin	18.6	8	30

Source: Lu M-Z, 2011, Personal Communication.

One of the noteworthy features of crop biotechnology in China is the emergence of private seed companies, which conduct R&D in crop biotechnology, and develop and distribute both conventional and biotech hybrid seed. One such company is Origin Agritech Limited, which is based in Beijing, and trades on the NASDAQ in the US as SEED – it is China's lead vertically integrated biotech seed company. It was founded in 1997 and conducts R&D to produce conventional and biotech hybrid seed, of which conventional maize is currently the principal commercial crop. Origin operates in China and South East Asia and has a large network of 3,800 primary distributors and 65,000 secondary distributors. Origin prepares financial statements according to the US GAAP accounting procedures. For the third quarter, 1 April to 30 June 2010, revenues were approximately US$68 million with a gross profit of US$28 million (Business Wire, 30 August 2010).

On 22 September 2010, Origin announced that it had reached an agreement with the Institute of Plant Protection of the Chinese Academy of Agricultural Sciences (CAAS) for the worldwide exclusive rights of the Bt gene developed by the Academy; Origin already had the rights to use the Bt gene in China. Under the new agreement Origin has the right to sublicense the Bt gene and/or to improve its performance (Business Wire, 22 September 2010).

Earlier, Origin had also acquired the rights to phytase maize from CAAS and this product was approved for biosafety by China on 27 November 2009 (Origin Agritech, 2009). The potential phytase maize market worldwide is estimated at US$500 million per year, of which US$200 million is in China alone. To put this into context, the current conventional maize seed market in China is estimated to be worth over US$1 billion per year. Phytase maize is expected to be the first biotech maize to be commercialized in China by Origin followed by glyphosate tolerant maize, which is currently in Phase 3 of environmental field tests, and then Bt maize. Origin has already submitted Bt maize for phase 3 field trials and stacking all three genes coding for phytase, glyphosate tolerance and Bt, is a future option. Many maize growing countries have already successfully implemented the option of stacking genes with herbicide tolerance and Bt insect resistance but China is likely to be the first to deploy phytase maize; this is a very important product for China given the importance of pork as a meat, in the country which has over 500 million swine, equivalent to approximately half of the global swine herd. Phytase maize will also be beneficial to the Chinese US$13 billion poultry industry, the largest in the world, and will coincidentally result in less ecological pollution by phosphates of ecological zones and waterways.

There is a growing number of collaborative initiatives between Chinese institutions and foreign companies and institutions. For example, the China National Seed Group (China Seed) and Monsanto have agreed to extend their respective investments in their joint venture company, CNSGC-DEKALB Seed Company Ltd. (CNDK) – the agreement is pending approval by the Chinese Government. CNDK was formed in 2001 to market maize hybrids in China, the second largest market for maize hybrids in the world, after the USA. In November 2009, Monsanto announced the establishment of its Biotechnology Research Center in Zhongguancun, Beijing that will allow the company to strengthen its links with Chinese Research Institutions in plant biotechnology and genomics. In November 2008, Bayer Crop Science signed an MOU with the Chinese Academy of Agricultural Sciences (CAAS) for joint development and global marketing of new agricultural products which will strengthen and expand the seed and traits business of both parties in China.

The decision by China on 5 September 2008 to approve for import the RR2Yield™ soybean was a major development with significant implications (McWilliams, 2008). China, the most populous country in the world is also the largest consumer of edible soybean in the world. China spent US$4 billion importing US soybean in 2007 which accounted for 38% of all US soybean exports. Prior to the Chinese approval, RR2Yield™ soybean had already been approved as safe for food, feed in the USA, Canada, Mexico, Taiwan, Japan, the Philippines, Australia and New Zealand which collectively import 30% of all US soy exports. The approval from China means that over two thirds (68%) of the US soybean export markets have already been cleared with China representing more than half (38% out of 68%).

Support for Biotech Crops in China

It is evident that after the 27 November 2009 biosafety approvals of both biotech rice and maize, that Chinese policymakers view agricultural biotechnology as a strategic element for increasing productivity and self-sufficiency, improving national food security and ensuring competitiveness in the international market place. There is no doubt that China is now one of the world leaders in crop biotechnology since Chinese policymakers have concluded that there are unacceptable risks of being dependent on imported technologies for food security. In addition to cotton which is already deployed and the approved Bt rice and phytase maize, China has an impressive portfolio of a dozen other biotech crops being field-tested, including wheat, potato, tomato, soybean, cabbage, peanut, melon, papaya, sweet pepper, chili, rapeseed, and tobacco.

It is instructive to trace the increasing political will, support and confidence in biotech crops prior to the 27 November 2009 approval of Bt rice and phytase maize. In June 2008, **Chinese Premier Wen Jiabao** addressed the Chinese Academy of Science and stated that, ***"To solve the food problem, we have to rely on big science and technology measures, rely on biotechnology, rely on GM."*** This was a remarkably strong statement of support for biotech crops from China's cabinet and Premier Wen Jiabao, who urged authorities to ***"waste no time to implement the program and understand the urgency and importance of the program."*** In July 2008, Premier Wen Jiabao, in his capacity as Chairman of the State Council, announced that the cabinet had approved a significant increase in budget for GM crops of 4 to 5 billion Yuan, equivalent to US$584 million to US$730 million in the coming years. As of 2006, China had approved 211 field trials for a total of 20 crops.

In September 2008, **Xue Dayuan, chief scientist on biodiversity,** noted that the new US$3.5 billion R&D initiative announced by Premier Wen Jiabao ***"will spur the commercialization of GM varieties"*** (Stone, 2008). It is noteworthy that funding for the program is resourced in a novel way from local governments and indigenous agbiotech companies. A significant component in the new initiative is a public awareness program to educate the public about biotech crops, consistent with the mission of ISAAA. The aim of the program is to ***"obtain genes with great potential commercial value whose intellectual property rights belong to China, and to develop high quality, high yield, and pest resistant genetically modified new species"*** (Shuping, 2008; Stone, 2008). Thus, biotech crops in China are assigned the highest level of political support. Premier Wen's and the cabinet's very supportive comments on biotech crops had direct implications for biotech rice in China and is viewed in a very positive light by Dr. Dafang Huang, former director of the Biotechnology Research Institute (BRI) in the Chinese Academy for Agricultural Sciences and by Dr. Jikun Huang, senior economist at the Chinese Academy of Science. Dr. Jikun Huang commented that, ***"The plan's approval is a very positive signal to the future of research and commercialization of more GMO crops."*** Dr. Jikun Huang has been involved in the development of biotech crops in China, since the genesis of biotech crops in China and has projected benefits of US$4 billion per year from

Bt rice – this projection is based on extensive pre-production field trials conducted to determine the benefits of biotech rice. The biosafety approval of biotech rice by China on 27 November 2009 has enormous implications for all the rice growing countries of Asia which represent 90% of global production, with more than 110 million households growing rice in China alone, and more than a quarter billion (250 million) rice households in Asia, the majority of which represent the poorest people in the world. In the context of decreasing agricultural land, rapidly dropping water tables and increased demand for food grains, China has set challenging targets to produce 500 million tons of grains by 2010 and 540 million by 2020 whereas demand in 2008 is already at 518 million tons (Shuping, 2008).

Indications that China was considering commercialization of biotech rice in the near term were attributed to comments made by the Vice Minister of Agriculture Niu Dun, and reported by the China Daily on 25 August 2009. More specifically Nui Dun said ***"China has worked on research of transgenic rice and is strongly considering its commercialization."*** Government officials observed that the GM/biotech rice being considered for approval was more resistant to pests and tastier and indicated that final approval to sell GM rice was close. Observers in China opined that a change in attitude regarding the approval of biotech rice began last year when the State Council approved a major R&D project on GM crops, meats and other products worth 20 billion yuan (US$3 billion at 6.8 yuan per US$). Government officials said that ***"By 2020, China could be a leader in GM foods, cloning, large-scale transgenic technology and new breed promotion. Rice and corn are the items nearest commercialization."*** Given that rice is a crucial staple in Asia and throughout the Pacific area, officials said ***"Increased production would make a massive difference."***

Over the last 30 years, China's national rice production has almost doubled from 304 million tons in 1978 to 528 million tons in 2008. China's population is expected to grow to 1.6 billion by 2020, when it is estimated that 630 million tons of rice will be needed. China has embraced biotechnology and more specifically highlighted biotech crops in a well planned innovative scientific strategy that offers the best promise for doubling food, feed and fiber production sustainably in China by 2050. Dr. Cao Mengliang, a researcher on molecular rice at China's National Hybrid Rice R&D Centre, said that ***"In China, the safety of transgenic food is not only a scientific issue, but one with economic and political importance. Studies of the safety of the technology have been completed. Discussions about whether to open it up to the market are now in the final stages. Now, the safety certificate is the last thing needed before commercialized production. The technology will mainly focus on insect resistance, pesticide implications and disease control and upon improvements to quality and taste"*** (China Daily, 2009).

Observers monitoring the situation in biotech/GM rice in China predict that following the 27 November 2009 approval, biotech rice will be welcomed by farmers because of its potential to increase yield, reduced need for pesticides and labor, and thus its potential to generate increased return which can contribute to a better quality of life for the 110 million rice households in China who are some of the poorest people in the world. Thus, biotech crops are entirely consistent with the policy of the Chinese Government which has assigned the highest priority to poverty alleviation and increased prosperity for the rural population of China which represents approximately two-thirds of China's 1.3 billion people.

The Chinese Government's assignment of high priority to agriculture, and more specifically crop biotechnology, championed by Premier Wen Jiabao, is resulting in handsome returns for China both in terms of strategically important new crops like biotech rice and maize and reflects the growing academic excellence of China at a global level in biotech crops. A November 2009 Report (Adams, 2009) noted that agricultural science is China's fastest-growing research field. From 1999 to 2008, growth in agricultural science papers outpaced growth in all other topics. From 2004 to 2008, agricultural researchers published four times more scientific papers compared with the period 1999 to 2003. China's share of global publications in agricultural science grew from 1.5% in 1999 to 5% in 2008. Professor Lin Min, Director of the Chinese Academy of Agricultural Sciences' Biotechnology Research Center, opined that China's agricultural ascent in agricultural science is due to ***"rich research resources, constant governmental investment and support, and an expanding pool of world-class talents."***

In 1999, China spent only 0.23% of its agricultural GDP on agricultural R&D but this increased to 0.8% in 2008 and is now close to the 1% recommended by the World Bank for developing countries (Lin, 2009). Allocation by the Chinese Government of substantial agricultural research resources, have been the key to driving the rapid growth especially in biotechnology: ***"Otherwise you could only conduct model research rather than application research. The return of an increasing number of overseas-trained and world-class Chinese agricultural scientists is also helping and they are lured back by China's rapid economic development and attractive job offers and at the same time, China's home-grown agricultural researchers are also catching up quickly,"*** said Lin (2009).

The US$19.2 billion Initial Public Offering (IPO) of China's Agriculture Bank in July 2010 was not only one of the largest ever IPOs in world stock market listings, but it was also a landmark transformation of China's gigantic financial institutions to support agriculture that competes or surpasses other listed financial institutions in the western industrial western world (The Economist, 8 July 2010). The emergence of China's state banks has been spectacular by any standards. The size of China's agricultural bank is enormous with 441,000 staff and "more branches than Wall street has desks" – China, sometimes referred to as the "Middle Kingdom" is once more becoming a dominant player on the world scene, having injected US$420 billion into its five biggest banks since 1998 alone. In 2009, the Agricultural bank's credit grew by an enormous 41%, fuelled by a one-third increase in credit to its customers.

Elsewhere in Asia, outside China, there are also significant R&D investments on biotech rice featuring agronomic and quality traits. For example, a team at the University of Tokyo, Japan has developed biotech rice that can tolerate iron deficiency, which is a very prevalent constraint in the rice growing countries of Asia (Takanori et al. 2008). Deployment of a rice tolerant to iron deficiency is one of many biotechnology applications, including pest and disease resistance and pro-Vitamin A enhanced Golden Rice (expected to be available in Asia in 2013) that could contribute to higher productivity and improved nutritional quality of rice. Rice is not only the most important food crop in the world but is also the most important food crop of the poor in the world. This is particularly true in Asia where 90% of the world's rice is produced and consumed and where rice has a very important cultural role. In Asia, rice is the staple of 600 million extremely poor rural people, mostly subsistence farmers and the rural landless who are completely dependent on agriculture for their livelihood. Hence, biotech rice with improved attributes can make an enormous contribution to the alleviation of poverty and hunger in Asia but also in Latin America and Africa where rice is important, particularly for the poorer in rural communities.

China is very much cognizant of the essential need for biosafety management in order to ensure protection of the environment and consumers, and this was the major consideration in the biosafety approval of Bt rice in November 2009. 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 was equivalent to an 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 *Xa21* 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; insect borers, which can be controlled by Bt, are prevalent on up to 75% of approximately 30 million hectares of rice in China (Jikun Huang, 2009. Personal Communication).

Whereas ISAAA has no knowledge of biotech rice being approved in any other country except China, the previous administration in Iran did temporarily officially release a Bt rice in 2004 to coincide with the celebration of the International Rice Year. The biotech rice, a high quality rice named *"Tarom molaii"*, was estimated to have been cultivated on 2,000 hectares in 2004 and was grown successfully on 4,000 hectares by more than 500 farmers in 2005, because it yielded significantly more than its conventional counterpart. The National Biosafety Council of Iran is now apparently reviewing the dossier on biotech rice as part of the process of approving and commercialization of rice in Iran.

Even though the global price of rice has modulated to approximately US$600 per ton in recent months, the unprecedented increase in the price of rice to US$1,000 a ton in April 2008 (a significant 2.5-fold increase over the 2006 price of US$300 a ton), spurred unparalleled political support for biotech crops and provided an important incentive for the expedited adoption of biotech rice because of its potential to significantly increase productivity per hectare leading to increase in supply and in turn to modulate rice prices.

With the approval of biotech rice in November 2009, this leaves 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 rice and maize in Asia will, in due course, greatly facilitate and expedite the approval and adoption of biotech wheat. The first biotech wheat to be approved in China in about 7 years may be virus resistant (yellow mosaic virus), which is being field tested. A "sprout tolerant" wheat is also being developed in China. Wheat with improved resistance to *Fusarium* and thus lower levels of mycotoxin is also under development as well as quality traits, and for the longer term, the more challenging task of improved drought resistance.

The near-term food and feed needs of China, and more broadly Asia, are not limited to the major crop 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 an impressive stable of its own home-grown biotech crops with various traits which can be complemented with products developed by the public and private sectors from the global crop biotech market. China has estimated the potential benefits from both biotech cotton and rice at US$5 billion per year and can complement these gains by applying biotechnology to the other staples of maize and wheat, and up to a dozen other crops in the near, medium and long term. 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 would lead to a bio-economy boom (China Daily, 15 September 2005). China currently has 200 government funded biotechnology laboratories and 500 companies active in biotechnology.

In summary, there is little doubt, now that China has approved both biotech rice and maize, the country will seek to further enhance its role as a world leader in crop biotechnology. The 2008 statements of Premier Wen Jiabao backed by a substantial commitment of an additional US$3.5 billion over the next 15 years to crop biotechnology is evidence of very strong political will at the cabinet level for crop biotechnology in China. In October 2008, Wen Jiabao (2008) reinforced his support for biotech crops when he stated that, ***"I strongly advocate making great efforts to pursue transgenic engineering. The recent food shortages around the world have further***

strengthened my belief." The substantial economic, environmental, and social benefits from Bt cotton have provided China with its first-hand experience of biotech crops. It is almost certain that the rich experience with Bt cotton served China well in its consideration and approval of biotech rice and maize in November 2009.

China considers food safety and self-sufficiency top priorities and importantly, as basic human rights. China is committed to transform agriculture from a traditional to a modern agriculture with high priority assigned to crop biotechnology. China has consistently maintained a grain self-sufficiency of 95% or more in recent years, and has made a significant contribution to the alleviation of poverty (People's Daily, 2009). In 2008, total grain production in China reached 525 million tons, compared with only 113 million tons in 1949. In 2007, per capita rural income was 4,140 Yuan (US$608), five times what it was in 1978. The number of rural poor has declined from 250 million in 1978 to 15 million today. China, with the exception of India, is one of very few developing countries which has increased investments in agriculture significantly and as a result reaped handsome benefits. The Chinese Government increased its investments in agriculture by 30% in 2007, by 38% in 2008 and by another 20% in 2009. Maize yield increased from 1.18 tons in 1961 to 5.61 tons per hectare in 2007, rice from 2.0 to 6.3 tons and wheat from 0.6 tons to 4.6 tons per hectare, in the same period. The new target for the Chinese Government is to increase total grain production to 540 million tons by 2020 and to double Chinese farmers' 2008 income by 2020 (Xinhua, 2009). These are challenging and formidable targets but past experience and perseverance in successfully attaining equally formidable goals would indicate that for China, they are feasible. The major challenge is to increase crop productivity significantly in the face of water scarcity, loss of fertile land and slowing agricultural productivity constrained by the law of diminishing returns, slowing gains from successful past technologies. Despite all these formidable challenges, China is also boldly investing in more collaborative programs designed to assist other developing countries in agriculture with a more pragmatic **"do as I do"** philosophy and not the **"do as I say"** philosophy practiced by most other development donors. China is currently setting up 20 agricultural technology demonstration centers in the developing world and plans to double the number of Chinese agricultural experts assigned to agricultural development projects in Asia, Africa and Latin America.

Benefits from Biotech Crops in China

Bt cotton – In 2011, Bt cotton was planted by 7 million small and resource-poor farmers on 3.45 million hectares, which is 69% of the 5 million hectares of all cotton planted in China in 2010. 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 10%, 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 livelihood as the income of many cotton farmers can be as low as around US$1 per day (Jikun Huang, 2008, Personal Communication). At the national level, it is estimated that increased income from Bt cotton will be approximately US$1 billion per year in 2010. **It is estimated that China has enhanced its farm income from biotech cotton by US$11 billion in the period 1997 to 2010 and by US$1.8 billion in 2010 alone (Brookes and Barfoot, 2012, Forthcoming).**

Biotech rice – The biotech hybrid rice is resistant to specific pests (insect borers). The product, based on CCAP's study, increased yield by up to 8%, 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 (Jikun Huang, Personal Communication).

Political Support for Biotech crops in China

The President of China Hu Jintao emphasized that ***"Science and technology are the basis of building an innovative country, speeding up the transformation of economic development. China should vigorously develop modern science and technology by developing high quality, efficient, and safe agriculture and related bio-industries; and ensuring security of food and major agricultural products."*** These thoughts were shared by the Chinese President Hu Jintao during the 15th Academician Conference of the Chinese Academy of Sciences. At the 10th Academician Conference of the Chinese Academy of Engineering on June 7, 2010 in Beijing, the President also stressed that ***"China will fully develop advanced breeding techniques to improve the quality, yield and disease resistance of agricultural products. He said that this will assure sustainable development and competitiveness of the nation's agricultural sector"*** (Hu, 2010).

Chinese Vice Minister for Agriculture Zhang Taolin called for the need to promote the development of the seed industry in China. Zhang, speaking at the first China Agricultural Scientific and Technological Innovation Forum, emphasized the need to speed up technological innovations in the seed industry. Zhang also called authorities to ***"scale up management of seed industry, revise and improve relevant regulations and rules, improve examination criteria of varieties and threshold of market access, and standardize the examination, production and operation of genetically modified organisms (GMOs)"*** (Zhang, 2010).

Dr. Dafang Huang, former Director of the Biotechnology Research Institute under the Chinese Academy of Agricultural Sciences (CAAS), in an interview by the Xinhua News Agency said that, ***"We***

are technically advantageous in hybrid rice planting. The genetically modified technology could ensure China's superiority in food production." Supporting Dr. Huang's statement was **Dr. Wu Yongning**, a scientist at the Chinese Center for Disease Control and Prevention, ***"I am not ruling out all possible risks, but those risks of genetically-modified food are no greater than that of traditional ones, given the heavy use of pesticide in growing traditional food"*** (Huang, 2010).

At the 43rd Shanghai Academician Salon held in the Hall of Science, Shanghai, China on April 13, 2010, **Prof. Lin Hongxuan, Academician of Chinese Academy of Sciences, Chinese Academy of Engineering**, discussed biotechnology applications for breeding of new crop varieties with desirable traits and its role in modern agriculture production and said that ***"This reform in bio-breeding is irreversible, and we should face it actively,"*** said Prof. Lin. ***"The bio-breeding (biotechnology) industry should be promoted on the basis of scientific evaluation through multi-channel and multi-level public education"*** (Lin, 2010).

Deputy Minister Chen Xiaohua of China's Ministry of Agriculture confirmed that ***"China will continue its development of GM crops because this is an important strategic move to the whole nation"*** (Global Times 30 September 2011). Chen reassured observers that China will develop GM technologies in strict accordance with relevant regulations and ensure the safety of GM products adding that ***"the Ministry is drawing up plans to expand corn production to meet increasing domestic demand."***

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. Niu's experience with Bt cotton is captured in the following comments. ***"We could not even plant cotton if there is no insect resistant cotton (Bt cotton). We could not control bollworm infestation before planting insect resistant 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 the number of sprays he used on conventional cotton prior to the introduction of Bt cotton (Qingjun, 2007).

Before 1997, **Zu Maotang** was one of the cotton farmers across China who were having problems with bollworms. He was using 13 to 15 pesticide sprays per mu (1 mu = 1/15 hectare) and worms were already becoming resistant to the insecticide. He learned about experiments on Bt cotton from Dr. Guo Sandui at the Chinese Academy of Sciences, and a partnership between the farmer and scientist took place. Mr. Zu had a chance to save his livelihood, while Dr. Guo had Mr. Zu's farm for crop testing. Mr. Zu became the first biotech cotton farmer in China, and since then he has enjoyed more than a 10-fold increase in yield (180-190 kg per ha). He has improved the financial status of the family and proudly purchased a family flat in a nearby city. He now shares his expertise through an agricultural association he set up to help farmers in his community. As he says, ***"Deng Xiaoping gave us policies for prosperity – and ag-scientists gave us the tools to achieve it"*** (Maotang, 2010).

PARAGUAY

Paraguay has successfully grown RR®soybean for eight years since 2004. In 2011, Paraguay grew a total of 2.9 million hectares of soybean, of which a record 2.8 million hectares (97% adoption) were biotech herbicide tolerant soybean; this compares with 2.6 million hectares of biotech soybean in 2010 out of a total of 2.7 million hectares. The increase in 2011 was due to more total plantings of soybean. Economic gains over the period 2004 to 2010 is estimated at US$655 million and the benefits for 2010 alone at US$90.3 million In October 2011, Paraguay approved a second biotech crop, Bt cotton for commercial production in 2012.

Paraguay is the world's number four exporters of soybeans and grew biotech soybean unofficially for several years until it approved four herbicide tolerant soybean varieties in 2004. In 2011, Paraguay was expected to grow a total of 2.9 million hectares of soybean of which a record 2.8 million hectares (approximately 95% adoption) was biotech herbicide tolerant soybean; this compares with 2.6 million hectares of biotech soybean in 2010 out of a total of 2.7 million hectares. The increase in 2011 was due to more total plantings of soybean. Paraguay is one of the 11 countries that have successfully grown biotech soybeans; the eleven countries, listed in order of biotech soybean hectarage are the USA, Argentina, Brazil, Paraguay, Canada, Bolivia, Uruguay, South Africa, Mexico, Chile and Costa Rica.

In October 2011, Paraguay approved its second biotech crop, Bt cotton for commercial production in 2012. Biotech maize has not been officially approved to-date in Paraguay but its neighboring countries Argentina and Brazil have been growing biotech maize successfully for many years. Paraguay was expected to grow approximately 600,000 hectares of maize in 2011, the same as 2010 and 2009, and up from 450,000 hectares in 2007. There is almost certainly a potential for utilizing biotech maize for economic, environmental and social benefits because its neighbors Argentina and Brazil are already benefiting from Bt and herbicide tolerant maize, as well as the stacked product. Paraguay was also expected to grow 80,000 hectares of cotton in 2011, which will benefit significantly from the recently approved biotech cotton also successfully grown in the neighboring countries of Argentina and Brazil.

PARAGUAY

Population: 6.3 million

GDP: US$14 billion

GDP per Capita: US$2,130

Agriculture as % GDP: 19%

Agricultural GDP: US$2.7 billion

% employed in agriculture: 26.8%

Arable Land (AL): 4.3 million hectares

Ratio of AL/Population*: 3.0

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

Commercialized Biotech Crop: HT Soybean

Total area under biotech crops and (%) increase in 2011:
2.8 Million Hectares (+8%)

Farm income gain from biotech, 2004-2010: US$655 million

*Ratio: % global arable land / % global population

Benefits from Biotech Crops in Paraguay

Paraguay is estimated to have enhanced farm income from biotech soybean by US$655 million in the period 2004 to 2010 and the benefits for 2010 alone is estimated at US$90.3 million (Brookes and Barfoot, 2012, Forthcoming).

Political Support to GM Crops in Latin America

The Consejo Agropecuario del Sur (CAS) – Southern Agricultural Council met in Santiago, Chile last October 21-22, 2010 and issued an important statement to endorse agricultural biotechnology development in their countries. CAS is a regional government network of the Ministers of Agriculture of the Southern Cone countries of Latin America, which include Argentina, Brazil, Chile, Uruguay and Paraguay, all important GM crop producers (Crop Biotech Update, 29 October 2010a).

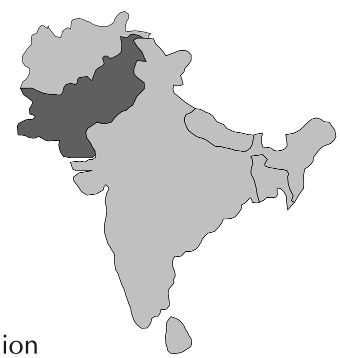
The statement said, there is a need to incorporate scientific and technological innovation to meet the challenge of global food production, and achieve competitive and sustainable development of agriculture. Specifically, the members agreed to:

- Deepen and strengthen the regulatory frameworks and instruments to ensure the use of genetically modified organisms.
- Request international organizations to provide technical and financial cooperation in a coordinated manner for the development of GMOs in accordance with the specific demands of the countries of the region.
- Instruct CAS to continue its coordination, harmonization and promotional efforts on activities related to GMOs.

PAKISTAN

In 2010, Pakistan officially approved, for the first time, the commercial release of 8 insect resistant Bt cotton varieties and 1 hybrid. In the second year of commercialization, 2011, Bt cotton was planted by ~650,000 farmers on 2.6 million hectares, occupying a substantial 81% of the total 3.2 million hectares of cotton area planted nationally in Pakistan; this compares with 2.4 million hectares of Bt cotton in 2010, equivalent to 75% of the 3.2 million hectares cotton area planted nationally. In 2011, Pakistan is estimated to have produced a record cotton harvest of 14.01 million bales, up by 2.32 million bales from the 11.69 million bales produced in 2010. The

PAKISTAN



Population: 167 million

GDP: US$165 billion

GDP per Capita: US$990

Agriculture as % GDP: 20%

Agricultural GDP: US$33 billion

% employed in agriculture: 44%

Arable Land (AL): 22.5 million hectares

Ratio of AL/Population*: 0.5

Major crops:
- Cotton
- Wheat
- Sugarcane
- Rice
- Maize

Commercialized Biotech Crop: Bt Cotton

Total area under biotech crops and (%) increase in 2011:
2.6 Million Hectares (+8)

*Ratio: % global arable land / % global population

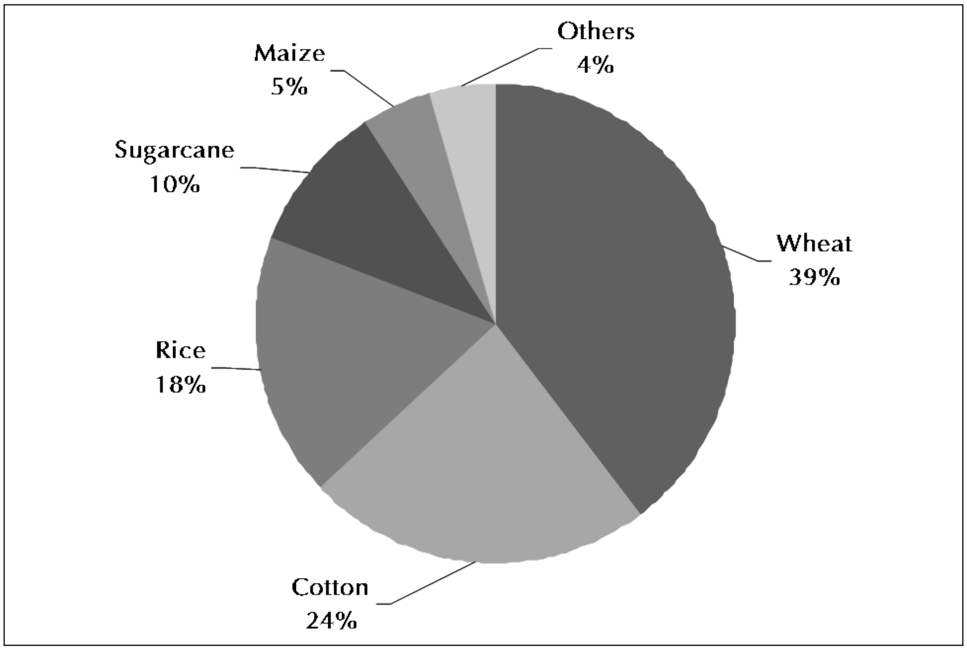
Pakistan Central Cotton Committee (PCCC), which is responsible for implementing the national "Cotton Vision 2015" aims to produce 19.1 million bales of cotton by 2015, up from the 11 million bales of cotton in 2010, a 74% increase over the five year period from 2010 to 2015. The Government of Pakistan and the PCCC places considerable reliance on improved germplasm and biotechnology to increase production by 40-60% in a national strategy to achieve the 19.1 million bales target by 2015.

Field experiments in Pakistan indicate that biotech cotton, with both Bt and herbicide tolerance traits in varietal and hybrid background, has the potential to increase yield, result in significant savings of insecticides, and deliver substantial net economic benefits of up to US$280 per hectare; this could contribute an additional US$800 million annually to the farm economy of Pakistan. Thus, the second generation biotech crops, conferring both insect resistance and herbicide tolerance in cotton and maize, which have been field tested in 2011, offer Pakistan new opportunities for boosting cotton yields which have been almost stagnant for the last two decades. Compared with other countries, like India, that have derived significant yield benefits from Bt cotton, Pakistan has to contend with the possibility that significant yield gains from Bt cotton can be eroded by cotton leaf curl virus (CLCuV). Food, feed and fiber crops are major contributors to Pakistan's GDP, and biotech crops could make a significant contribution at this critical time, when Pakistan is trying to desperately recover from the two worst consecutive floods in its history.

Pakistan is the fourth largest cotton producer in the world after China, India and USA. Cotton is a second major contributor and accounts for 9 percent of the value-added in agriculture and combined with textile industry, it makes up about 9% of the country's GDP (All Pakistan Textile Mills Association, 2007). At the national level, the performance of cotton crop is a significant influence on the national GDP growth with a +/- 10% change in production of cotton crop exerting a substantially disproportionate effect of 2% to 8% on the growth of GDP. Cotton is a multipurpose crop (fiber, oil and animal feed) and the single largest source of raw material for the textile industry in Pakistan that comprises over 400 textile mills, 1000 ginneries and 300 oil expellers (USDA, 2011). Cotton has been the main driver of the textile sector and the national economy for the last 50 years, in terms of foreign currency earnings and job creation (Figure 37).

Cotton is the most important cash crop of a legion of farmers who grow cotton, mainly in Punjab and Sindh provinces which are divided into zones on the basis of rainfall and temperature (Soomro, 1996). Farmers plant cotton on 2.8 to 3.2 million hectares with an average farm holding of approximately 4 hectares (Rao, 2010 Personal Communication and Table 23). Thus there are around 750,000 cotton farmers in the country. Both Punjab and Sindh farmers mainly grow open pollinated varieties (OPVs)

Figure 37. Composition of Value of Major Crops, 2009-10



Source: Economic Survey, 2010.

of cotton with almost 100% assured irrigation facility throughout the cotton season. A small area of cotton is also grown in the province of Balochistan and the North West Frontier Province (NWFP). Kharif (Monsoon season) is the major season for cotton cultivation which begins in April-June and harvested in October-December. An overview of cotton cultivation and its distribution in Pakistan in 2011-12 is detailed in Table 23.

It is important to note that the area under cotton has not increased substantially over the last two decades – 2.7 million hectares in 1990-91 to 3.2 million hectares in 2011-12. During the same period, cotton yields remained almost stagnant at 550 kg to 750 kg of lint per hectare which is a major cause of concern for the growing textile industry (Figure 38). As a result, annual cotton production has stalled at between 10 to 12 million bales whilst demand for cotton doubled from 6.6 million bales in 1990-91 to 14.05 million bales in 2010-11 (Figure 39). In the past, the country has witnessed a dismal growth in cotton production, which remained at less than 10 million bales from 1995 to 99, and around 12 million bales from 2000 to 2011. These low yields are attributed to various factors including floods, outbreak of severe cotton leaf curl virus (CLCuV) and the emergence of different bollworms like American, spotted and pink which caused the worst damage in the Sindh and Punjab provinces (Hussain & Awan, 2011).

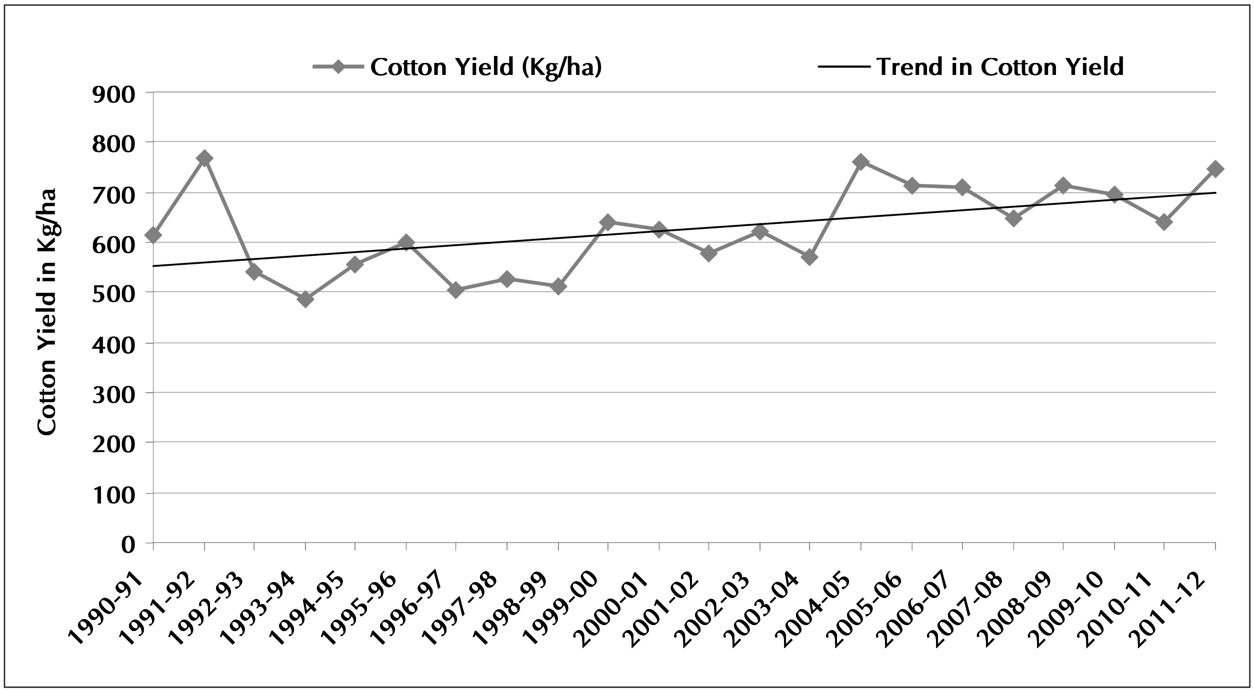
Table 23. Distribution of Cotton in Pakistan, by Province, 2011-12

Province	Punjab	Sindh	Balochistan/NWFP (North West Frontier Province)
Area	2.5 M ha	0.65 M ha	<50,000 ha
Production	10 M bales	3.25 M Bales	<50,000 Bales
Productivity	680 Kg/ha	1098 kg/ha	425 kg/ha
Condition	Irrigated	Irrigated	Irrigated
Nature of Genotype	Varieties	Varieties	Varieties
Popular Varieties/Hybrids	**Popular non-Bt varieties:** BH-160, CIM-473, CIM-496, CIM-506, CIM-534, MNH-786, NIAB-111 **Bt Varieties:** IR-3701, Ali Akbar-703, MG-6, Sitara-008, IR-1524, FH-113, Ali Akbar-802, Neelum-121 and GM-2085	**Popular non-Bt varieties:** NIAB-78, CRIS-134, FH-1000, FH-901 **Bt Varieties:** IR-3701, Ali Akbar-703, MG-6, Sitara-008, IR-1524, FH-113, Ali Akbar-802, Neelum-121 and GM-2085	Bt-121, CRIS-134, MN-496, MN-506
Species	*G. hirsutum* (>99%) *G. arboreum* (<1%)	*G. hirsutum* (>99%) *G. arboreum* (<1%)	*G. hirsutum*
Insect/Pests	Bollworm complex, Mealy Bug, Thrips, Jassids, Mites	Bollworm complex, Mealy Bug, Thrips, Jassids, Mites	Bollworm complex, Mealy Bug, Thrips, Jassids, Mites
Diseases	Leaf Curl Virus	Leaf Curl Virus in upper Sindh only	Nil
Time of Sowing (Month)	March to May	March to May	May
Time of Harvest (Month)	Start after 130 days of sowing	Start after 130 days of sowing	Start after 130 days of sowing

Source: Personal Communication with Mr. Ijaz Ahmad Rao and PCCC 2011; Compiled by ISAAA, 2011.

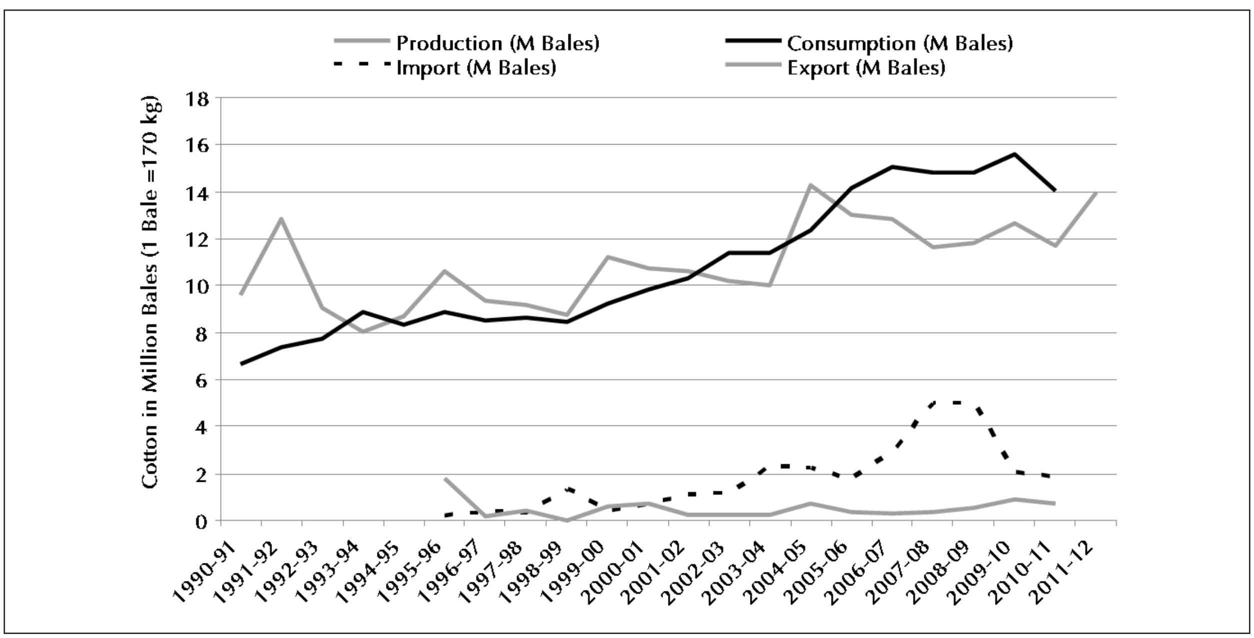
In 2004-05 the country produced a record cotton crop of 14.5 million bales as a result of favorable climatic conditions. Pakistan was a net cotton exporter in the early 1990s but is now a major importer to meet the growing demand of the domestic cotton based industry. Over the last five years, Pakistan has been importing 3 to 5 million bales of cotton per year which costs the national exchequer between US$3 to US$5 million per year, which further widens the trade deficit to record levels. In 2010-11, a record cotton production of 14 million bales was expected, however, 2 to 2.5 million bales of cotton were lost due to severe floods, which destroyed 0.7 million hectares of cotton in the major cotton growing provinces of Punjab and Sindh, resulting in a significantly lowered production of only 12 million bales. However, it is projected that the country could produce a record cotton production of 14.1 million bales in 2011-12 due to the high adoption of Bt cotton,

Figure 38. Trend in Annual Cotton Yields in Pakistan, 1990 to 2011



Source: Economic Survey, 2010.

Figure 39. Cotton Production, Consumption, Export and Import in Pakistan, 1990 to 2012

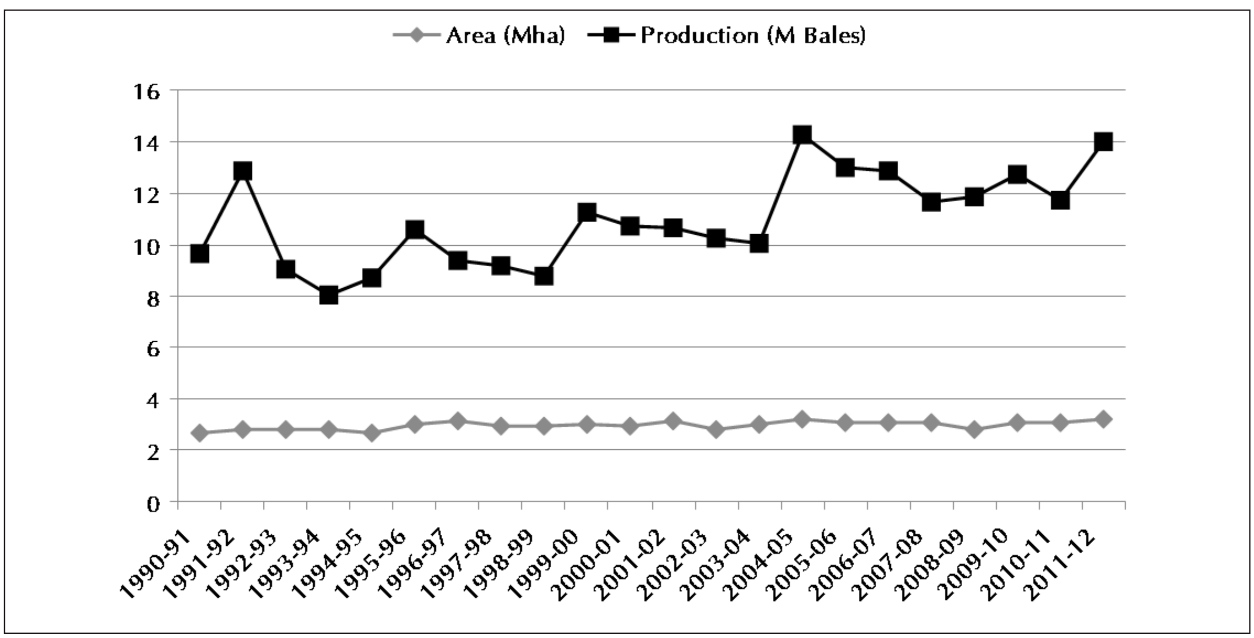


Source: PCCC, 2011.

low incidence of CLCuV and favorable climatic conditions. In 2011-12, the cotton area has been increased slightly from 3.1 million hectares in 2010-11 to 3.2 million bales in 2011-12 while the production is expected to increase to 14.1 million bales, up by 2.32 million bales from 11.69 million bales produced in 2010 (Figure 40). In contrast to the situation in Pakistan, over the last 10 years the top three cotton producers in the world, China, India and USA have substantially increased cotton yield over the same period, outcompeting others, including Pakistan, in the world cotton market. For instance, India has doubled its cotton production from 13 million bales in 2001 to 31.2 million bales in 2010-11. It is noteworthy that all three lead cotton countries have successfully deployed biotech cotton varieties and hybrids which confer resistance to major insect pests and tolerance to herbicides thus benefiting from cost effective and efficient management of insect pest and weed control. Consequently, farmers in these countries have generated substantial additional income by reducing losses caused by insect pests and weeds, significantly reduced insecticide applications and reaped bumper harvests of competitively priced cotton for the international market.

Insect pests and diseases of cotton cause substantial losses in Pakistan. There are mainly two types of insect pests; chewing and sucking pests which significantly damage the standing crop in the major cotton growing provinces of Punjab and Sindh. The major pests are the chewing insects – the bollworm complex including the American bollworm (*Helicoverpa armigera*), spotted bollworm (*Erias vitella*), pink bollworm (*Pectinophora gosspiella*) and army worms (*Spodoptera sps*). The

Figure 40. Area and Production of Cotton in Pakistan, 2011



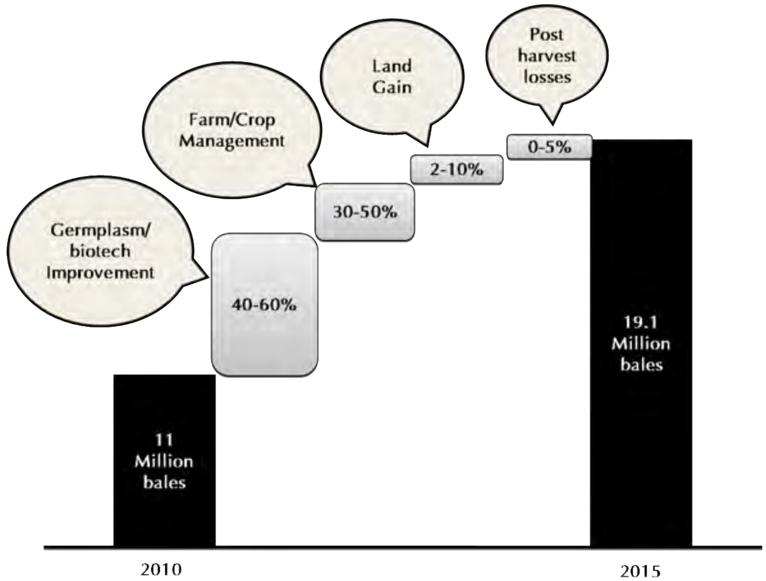
Source: PCCC, 2011.

second group is the sucking pests which comprise whitefly, cotton jassids, thrips, mites and aphids (Table 23). A timely and sufficient number of insecticide sprays can effectively control sucking pests, however bollworms can devastate the cotton crop resulting in significant losses and lower production of cotton, as well as deteriorating cotton quality. In recent years, cotton leaf diseases particularly cotton leaf curl virus (CLCuV) has become a major threat to cotton production, and it has spread rapidly in the Punjab and Sindh provinces. The epidemic of cotton leaf curl virus (CLCuV) has significantly decreased cotton production in 1994-95 and again in 2003-04, with moderate damage in other years.

Cotton farmers have to resort to frequent insecticide applications to control insect pests and diseases. On average, 5-8 insecticide applications are required to control the bollworm complex, depending on the infestation levels. At the national level, cotton farmers spend approximately US$250 million annually on insecticides, of which US$190 million is for bollworm control alone (Pakistan Industry Estimates, 2010). Research studies by the National Institute of Biotechnology and Genetic Engineering (NIBGE) suggest that the constant increase in application of pesticides has escalated production costs and contributed to environmental and public health problems as well as the development of resistance in insect pests to frequently used insecticides (Zafar, 2007).

The All Pakistan Textile Mills Association (APTMA) estimated that the textile industry's raw cotton requirements would be 20.1 million bales by 2015 comprising 66% of medium staple, 26% long staple and 8% extra long staple cotton. To meet these demands, Pakistan's "Cotton Vision 2015" concluded that this would require an increase of 5% in cotton hectarage in Balochistan and in the North West Frontier Province (NWFP), an annual average of 5% increase in yield, introduction of CLCuV resistant Bt cotton varieties and hybrids, and a strengthening of R&D and infrastructure of cotton institutes in Pakistan. Accordingly, the Pakistan Central Cotton Committee (PCCC), that is responsible for implementing the national "Cotton Vision 2015", aims to produce 19.1 million bales of cotton by 2015, up from the 11 million bales of cotton in 2010, and equivalent to a 74% increase in the five year period 2010 to 2015. The Government of Pakistan and the PCCC places considerable emphasis on improved germplasm and biotechnology to increase cotton production by 40-60% which is a key component of the national strategy to achieve a target of 19.1 million bales by 2015. The other important elements that are expected to contribute to enhanced cotton production include farm and crop management practices, an increase in cotton area, and a reduction of post-harvest losses (Figure 41). In 2005-06, Pakistan's federal government launched an ambitious plan to enhance cotton production to 20.7 million bales by 2015 – a 60% increase over 2005-06 production. However, actual production has dropped from 14 million bales in 2005/6 to a low of 11 million bales in 2009-10.

Figure 41. Pakistan's Roadmap to Cotton Vision 2015



Source: Adopted from PCCC, 2011.

Commercial Approval of Bt Cotton in Pakistan

In concurrence with the federal government national biosafety framework, the Punjab Seed Council (PSC) under the Ministry of Agriculture of the Punjab province decided to officially approve the commercial cultivation of 8 insect resistant Bt cotton varieties and one Bt cotton hybrid at their 39th meeting held on 31 March 2010. This decision of the Punjab Seed Council was considered very important particularly because a decision had not been declared at that time by the National Biosafety Committee (NBC) of the Federal Ministry of Environment.

Punjab is the largest cotton growing region occupying almost 80% of total cotton in Pakistan with the balance of cotton hectarage in the Sindh with less in Balochistan and North West NWFP (Table 23). The Federal Ministry of Food and Agriculture (MinFA) endorsed the PSC's decision for commercial release of Bt cotton in the meeting held on 15 April 2010. Accordingly, the Punjab Seed Council (PSC) approved the release of two events of Bt cotton namely MON531 (*cry1Ac* gene) and the GFM event expressing the fusion gene *cry1Ac* and *cry1Ab*. A total of 8 cotton varieties expressing MON531 and one hybrid expressing the fusion gene *cry1Ac* and *cry1Ab* received approval for commercial cultivation in 2010 (Punjab Seed Council, 2010; NBC, 2010). In 2011, the Punjab Seed Council approved the renewal of four Bt cotton varieties including IR-1524, FH-113, Ali Akbar-802 and Neelam-121, which was conditionally approved in 2010 for one year with the condition to reconsider approval subsequent to improving fibre characteristics (Pakistan Today, 2011).

Consistent with past experience in many other countries there was speculation that cotton farmers in Punjab and Sindh had been planting unofficial and unauthorized Bt cotton varieties on a large scale for sometime prior to the official release in 2010. This posed a potential serious threat that in the absence of a resistance management strategy, insects would develop resistance against these varieties and lead to the destruction of cotton crops and socio-economic and financial losses to a cotton economy that was already fragile (Rao, 2006; NBC, 2010). The Planning Commission of Pakistan in its annual plan 2010-11 reported that unauthorized cultivation of Bt cotton was on a significant scale and exacerbated pest infestation problems which may have negatively affected productivity in 2008 and 2009 (Planning Commission, 2010). Accordingly, the decision of the Punjab Seed Council (PSC) to officially approve cultivation of the 8 Bt cotton varieties and 1 hybrid in 2010 assumes great significance for Pakistan and could pave the way for improved and sustained cotton production in the country.

It is important to note that all approved Bt cotton varieties and hybrids have undergone more than 5 to 6 years of field trials complying with the field trial procedures laid down by the Pakistan Central Cotton Committee (PCCC). All eight Bt cotton varieties expressing *cry1Ac* gene (MON531 event) namely IR-3701, Ali Akbar-703, MG-6, Sitara-008, IR-1524, FH-113, Ali Akbar-802 and Neelum-121 have been developed by public and private sector institutes whereas the one Bt cotton hybrid GM-2085, expressing fusion gene *cry1Ac* and *cry1A*, has been developed by an indigenous private seed company. Out of the eight approved Bt cotton varieties, four received unconditional approval, and four varieties received one year approval with the condition that developers must submit fiber characteristics duly certified by the designated laboratory. In addition, Bt cotton hybrid GM-2085 received approval for two years with the condition that hybrid would be reconsidered by the PSC after fulfilling the requirement of the Federal Seed Certification and Registration Department (FSC&RD) in the Distinctness, Uniformity and Stability (DUS) trials. The details of each Bt cotton variety/hybrid, gene and event and its developer and date of approval are summarized in Table 24.

In 2010, Pakistan became the thirteenth country globally to officially plant Bt cotton. Thus, the Bt cotton farmers of Pakistan, for the first time, joined the exclusive club of biotech cotton growing farmers from the USA, China, India, Australia, South Africa, Brazil, Argentina, Columbia, Mexico, Costa Rica, Myanmar and Burkina Faso which control a very large proportion of global cotton production and trade. In the second year of commercialization in 2011, Bt cotton was planted by approximately 650,000 farmers on 2.6 million hectares, occupying a substantial 81% of the total of 3.2 million hectares of cotton area planted nationally in Pakistan, up from 2.4 million hectares equivalent to 75% of the 3.1 million hectares cotton area planted in 2010 (Table 25). In 2011, Pakistan planted 2.6 million hectares of biotech cotton which is over 10% of total biotech cotton area of the world in 2011.

Table 24. Commercial Release of Different Bt Cotton Varieties and Hybrid in Pakistan, 2011-12

Crop	Event	Variety (*hybrid)	Developer	Status	Date of Approval
Cotton	*cry1Ac* gene (MON531 event)	IR-3701	Nuclear Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad	Approved	Punjab Seed Council (PSC) approved it on 31 March 2010 Federal Ministry for Food and Agriculture approval on 15 April 2010
Cotton	*cry1Ac* gene (MON531 event)	Ali Akbar-703	M/s Ali Akbar Seeds, Multan	Approved	As Above
Cotton	*cry1Ac* gene (MON531 event)	MG-6	M/s Nawab Gurmani Foundation	Approved	As Above
Cotton	*cry1Ac* gene (MON531 event)	Sitara-008	M/s Nawab Gurmani Foundation	Approved	As Above
Cotton	*cry1Ac* gene (MON531 event)	IR-1524	NIBGE, Faisalabad	One year Approval 2010, Renewal of the approval in 2011	As Above
Cotton	*cry1Ac* gene (MON531 event)	FH-113	Cotton Research Institute, AARI, Faisalabad	One year Approval 2010, Renewal of the approval in 2011	As Above
Cotton	*cry1Ac* gene (MON531 event)	Ali Akbar-802	M/s. Ali Akbar Seeds, Multan	One year Approval in 2010, Renewal of the approval in 2011	As Above
Cotton	*cry1Ac* gene (MON531 event)	Neelum-121	M/s. Neelum Seeds, Multan	One year Approval in 2010, Renewal of the approval in 2011	As Above
Cotton	fusion gene (*cry1Ac* and *cry1Ab*)/GFM event	GM-2085 (*hybrid)	M/s. Guard Agricultural Research Services, Lahore	Approved (two year approval, DUS trial data to be submitted to FSC&RD)	As Above

Source: Punjab Seed Council (PSC), 2010; Pakistan Today, 2011.

Table 25. Adoption of Bt Cotton in Pakistan, 2011

Year	Adoption of Bt Cotton (Mha)	Total Cotton (Mha)	% Adoption
2010 - 11	2.4	3.1	75%
2011 - 12	2.6	3.2	81%

Source: Compiled by ISAAA, 2011.

After the establishment of the Bt cotton crop in 2010-11, the country expected to harvest a record 14 million bales of cotton as compared to 12.7 million bales in 2009-10. However, an estimated 2 to 2.5 million bales of cotton were destroyed when an estimated 0.7 million hectares was devastated by the worst floods in the history of Pakistan. As a result, Pakistan produced 11.69 million bales of cotton in 2010-11, and is projected to produce a bountiful harvest of 14.1 million bales in 2011-12 (PCGA, 2010; Daily Times, 2010; PCCC, 2011; Daily Times 2011).

Monitoring of Bt cotton fields prior to the floods in 2010 indicated that the approved 8 Bt cotton varieties and 1 hybrid performed well and seemed relatively tolerant to cotton leaf curl virus (CLCuV) and out-yielded their non-Bt counterparts, and saved 3-5 insecticide sprays. Based on preliminary field trials, and assuming deployment of biotech cotton at 90% with both insect and herbicide tolerance, there is a potential to substantially increase farmer income by approximately up to US$280 per hectare (Pakistan Textile Journal, 2010; Kakakhel, 2010). In order to optimize the benefits from the new technologies, the province of Punjab organized a vigorous campaign in 2010 and 2011 to implement insect resistant management and effectively control whitefly which is the vector of the lethal cotton leaf curl virus (CLCuV). Guidelines for marketing of Bt cotton seeds were issued by the Directorate General of Agriculture Extension of Punjab to ensure genetic purity, germination, refuge and product labelling of Bt cotton packets for optimizing the full potential of Bt cotton seeds in farmers field (Directorate General of Agriculture, 2010).

Advanced Field Trials of Biotech Crops in Pakistan

In the early 1970s, Pakistan was the first country to adopt and popularize the semi-dwarf high yielding wheat varieties that subsequently facilitated the implementation of the Green Revolution in the country. In recent years, Pakistan's leadership had reiterated that technology, especially ***"biotechnology can play the critical role in meeting agricultural targets during this century, leading to higher production, better resistance, and lower costs of production. Major investments in public sector have been made over the years in agricultural biotechnology, and a few research centres have attained international recognition. There is a need to establish more such centres especially on agro-genomics to act as the supplier of all basic***

information for developing desirable transgenic crops and animals. Investments in this area will have high rates of return" (Planning Commission, 2007).

Over the years, Pakistan has developed a well established infrastructure and R&D programs for crop improvement particularly in major crops like wheat, cotton, rice, maize and sugarcane, both at the federal and provincial levels. In recent years, the Pakistan Atomic Energy Centre (PAEC) and the Pakistan Agricultural Research Council (PARC) have invested US$17 million by establishing four biotech institutes namely: National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad: Centre of Excellence in Molecular Biology (CEMB), Lahore: National Institute of Genomics and Advanced Biotechnology (NIGAB), Islamabad; and the Agricultural Biotechnology Research Institute (ABRI), Faisalabad. In addition, 26 centres at various agricultural crop institutes and universities have been modernized to undertake tissue culture related activities, crop improvement using marker-assisted selection techniques, DNA testing and GMO detection in Pakistan (Khalid, 2009).

With the official release of eight Bt cotton varieties and one Bt cotton hybrid in 2010, there has been a definitive thrust at both public and private sector institutes to advance applications of biotechnology for crop improvement. In 2010, the National Biosafety Committee (NBC) approved the large scale field trials of various events of cotton including stacked traits of insect resistance and herbicide tolerance which, subject to regulatory approval facilitated release in the near term. It is expected that the country would continue to grow only the officially approved Bt cotton hybrid and varieties until the new generation of stacked Bt cotton varieties and hybrids (Bollgard®II) are made available in 2012-13 (USDA, 2011).

In addition, there are various biotech crops, including cotton, maize, sugarcane, potato and tomato, under development at the laboratory and field trial stages of the regulatory approval system in Pakistan. Notably, there has been a significant development on different biotech maize events field tested in Pakistan over the last couple of years. Maize is a major feed crop in Pakistan grown on over 1 million hectares, and after cotton, is an important crop. Biotech maize is the second most important biotech crop which can help maize farmers to substantially improve their yield and its competitiveness in the international maize market. Based on the extensive field data generated from 2009 to 2010, the Technical Advisory Committee (TAC) has concluded that the stacked maize event MON89034 × NK603 presents no biosafety risks as compared to conventional and recommended its commercial approval release to the National Biosafety Committee (NBC) in 2011 (Table 26). The commercialization of biotech maize is expected in the near term (Pakistan Observer, 2011; The News, 2011). The development of improved biotech varieties and hybrids of cotton, maize and other important crops would require enabling legislative frameworks including the Seed Act Amendment and the Plant Breeder's Right Bill, which are under consideration by Pakistan's parliament since 2009. The timely enactment of these legislations is vital to improve the investment climate for the

Table 26. Status of Advanced Field Trials of Biotech Crops in Pakistan, 2010

Crop	Organization	Transgene/Biotech Trait	Event
Cotton	NIBGE, Pakistan	*cry1Ac*/IR	–
	Monsanto Pakistan	*cry1Ac* and *cry2Ab*/IR	MON15985
	Ali Akbar Seeds	*cry1Ac*/IR	Event-1
	CEMB, Pakistan	*cry1Ac* and *cry2A*/IR	–
Maize	Monsanto, Pakistan	*cry2Ab2* & *cryA.105* and *CP4EPSPS/IR&HT*	MON89034 × NK603
	Pioneer, Pakistan	*cry1F, cry1Ab* and *CP4EPSPS*/ IR&HT	HX1 × MON810 × NK603

Source: National Biosafety Committee Pakistan, 2010; compiled by ISAAA, 2011.

introduction of new seed technology, streamline regulation of the development of transgenic crops and establishment of infrastructure for maintaining standards and quality control (USDA, 2011).

It is estimated that with the official release of first generation insect resistant cotton varieties and hybrids in 2010, along with expected release of stacked traits of biotech cotton in the near term, Pakistan could accrue significant benefits of approximately US$800 million per year to its farm economy, assuming a 90% adoption of biotech cotton (Industry Estimates, 2010). Additionally, it is expected that a widespread adoption of biotech cotton would substantially reduce insecticides sprays, result in less exposure of farmers and farm laborers to insecticides, a higher quality of cotton and higher return to cotton farmers and overall gains to the farm economy at the national level. Compared with other countries, like neighboring India, which has derived significant yield benefits from Bt cotton, Pakistan has to contend with the possibility that the significant yield gains from Bt cotton can be eroded by cotton leaf curl virus (CLCuV).

Benefits of Bt Cotton in Pakistan

Various researchers from Pakistan have observed that the country was growing Bt cotton varieties unofficially since 2002. It is estimated that by 2007, 60-80% of the cotton area was planted with Bt cotton in the Punjab and Sindh (Ahsan, 2009, Nazli, 2010; Ali, 2010; USDA, 2011). The Bt cotton varieties contained *cry1Ac* gene event MON531 which was not officially sourced from the developer. The Bt cotton varieties, of poor seed and fiber quality did not contribute significantly to cotton production because most of them were susceptible to cotton leaf curl virus (CLCuV), requiring high inputs (Ahsan, 2009). The situation changed in 2010 when the Punjab Seed Corporation (PSB) officially approved 8 Bt cotton varieties and one hybrid containing event MON531. In 2011, Pakistan planted 2.6 million hectares of officially approved Bt cotton varieties and a hybrid, equivalent, to an 81% adoption rate on the 3.2 million hectares of cotton hectarage; this compares with 2.4 million hectares of Bt cotton at an adoption rate of 75% on the 3.1 million hectares of national cotton crop in 2010.

The official approval of Bt cotton in 2010 was spurred by the demand for genuine good quality Bt cotton in the country with following specifications: resistant to CLCuV; well adapted for the different ecologies; meet required fiber quality standards; other desirable features required for the release of a normal commercial variety (Ahsan, 2009). Another milestone achievement in 2010 was the signing of the memorandum of understanding (MOU) between the Ministry of Food and Agriculture (MINFA) of the Government of Pakistan and Monsanto for introducing advanced Bt cotton and hybrid seed technology for the development of the agriculture sector. The MOU allows Pakistan to harness the benefits of the new generation stacked technology in cotton including the double gene Bt cotton (Bollgard®II), herbicide tolerant cotton (BGII-RRFlex) in cotton and other technologies developed for maize in the country (The Nation, 2010).

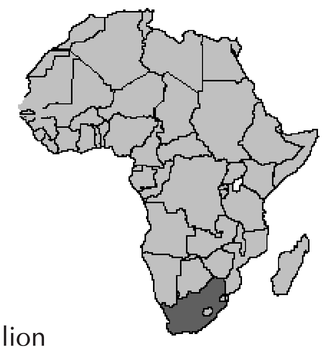
In anticipation of approved Bt cotton seeds, researchers in Pakistan have been attempting to assess the benefits and impact of Bt cotton in the country. The preliminary data from the field experiments in Pakistan indicate that biotech cotton, with both Bt and herbicide tolerance traits in varietal and hybrid background, has the potential to increase yield, result in significant savings of insecticides, and deliver substantial net economic benefits of up to US$280 per hectare; this could contribute an additional US$800 million annually to the farm economy of Pakistan. Thus, the second generation biotech crops, conferring both insect resistance and herbicide tolerance in cotton and maize, which have been field tested in 2011, offer Pakistan new opportunities for boosting cotton yields which have been almost stagnant for the last two decades. Compared with other countries, like India, that has derived significant yield benefits from Bt cotton, Pakistan has to contend with the possibility that significant yield gains from Bt cotton can be eroded by cotton leaf curl virus (CLCuV). Food, feed and fiber crops are major contributors to Pakistan's GDP, and biotech crops could make a significant contribution at this critical time, when Pakistan is trying to desperately recover from the two worst consecutive floods in its history.

SOUTH AFRICA

Following a wet summer season in 2010/2011 and reasonably good spring rains, planting was well underway when this Brief went to press. The hectarage occupied by biotech crops in 2011 continued to increase for the 14th consecutive season. The estimated total biotech crop area in 2011 was 2.3 million hectares, compared with 2.2 million hectares in 2010/2011. The total maize area increased by 5%, mainly

due to a successful export drive that depleted carry-over of grain stocks, while soybean planting increased by 20%. Approximately 12 million hectares of biotech maize (white and yellow) were planted in the period 2000 to 2011. The total area planted to soybeans increased from 390,000 hectares in 2010 to an estimated 450,000 hectares in 2011, due to higher demand, while the adoption rate of herbicide tolerant soybeans remained at 85% (382,000 hectares). Total cotton area is expected to remain at 15,000 hectares, due to competition from maize and soybeans, and its biotech adoption rate remained at 100%, of which 95% were stacked traits; herbicide tolerant cotton is used as a mandatory refuge for biotech cotton fields. Various biotech traits are being field tested for maize and cotton, and new biotech crops.

SOUTH AFRICA



Population: 49.5 million

GDP: US$491 billion

GDP per Capita: US$5,680

Agriculture as % GDP: 3.3%

Agricultural GDP: US$16.2 billion

% employed in agriculture: 9%

Arable Land (AL): 14.8 million hectares

Ratio of AL/Population*: 1.3

Major crops:

• Sugarcane	• Maize	• Wheat
• Grapes	• Potato	• Sunflower

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

Total area under biotech crops and (%) increase in 2011:
2.3 Million Hectares (+5%)

Farm income gain from biotech, 1998-2010: US$809 million

*Ratio: % global arable land / % global population

The temporary regulatory moratorium on importing of commodity grain containing events not yet approved in South Africa, has recently been lifted but importers need to comply with national standards to minimize spillage and conditions set in the import permit. The mandatory labeling of GM/GMO "goods", ingredients or components, as prescribed in Regulation 7 of the Consumer Protection Act of 2008 that has entered into force in 2011, has elicited ongoing criticism from stakeholders in the food chain due to its ambiguity and complexity. It now appears that government is reconsidering this provision. The GMO Executive Council is continuing its study on assessing stacked traits, adventitious presence and low level presence of novel genes. The National Strategy on Biotechnology of 2001 is being updated and redrafted by the Department Science & Technology.

It is estimated that 2.60 million commercial hectares of all maize will be planted in 2011, up 9.6% from 2010, in the ratio of 60% white or 1.564 million hectares and 40% yellow grain or 1.038 million hectares. Of the total maize area, 72% or 1.873 million hectares will be biotech. Of the 1.873 million hectares of biotech maize, 45.2% or 847,000 hectares were the single Bt gene, 14.4% or 270,000 hectares herbicide tolerant, and 40.4% or 756,000 hectares stacked Bt and herbicide tolerant genes. Approximately 12 million hectares of biotech maize (white and yellow) were planted in the 12 year period 2000 to 2010, producing a grain crop of over 40 million metric tons (MT) up to 2011 harvest without a single report of negative effects on humans, animals or the environment (Table 27).

The white maize crop of 1.564 million hectares comprised 72% biotech or 1.126 million hectares with the single Bt gene accounting for 518,000, hectares (46%), herbicide tolerance at 113,000 hectares (10%) and Bt-herbicide tolerance stacks at 495,000 hectares (44%). The supplies of stack gene seed again fell short of demand. The yellow maize planting of 1.038 million hectares comprised 72% or 747,000 hectares of biotech. The biotech breakdown by trait for yellow maize is 44% or 392,000 hectares for the single Bt trait, 21% or 157,000 hectares for herbicide tolerance, and 35% or 261,390 hectares for the stacked Bt and herbicide tolerant product. Similar data on small farmer usage for 2011 were not available when this Brief went to press.

Table 27. Adoption of Biotech Crops in South Africa, 2001 to 2011 (Thousand Hectares)

Year	Total Area of			
	Biotech crops*	Biotech maize	Biotech White Maize	% of Total White Maize
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
2008	1,813	1,617	891	56
2009	2,116	1,878	1,212	79
2010	2,229	1,898	1,139	75
2011	2,270	1,873	1,126	72
Total	**13,697**	**11,714**	**6,750**	

Source: Compiled by ISAAA, 2011.
*Composed of maize, soybean and cotton

Three trends emerged from these data: first, that adoption of biotech is very similar for white and yellow maize; second, that adoption of traits (insect resistance, herbicide tolerance and stacked for both) is similar for white and yellow; and, third, that adoption is reaching saturation as not all plantings require Bt insect resistance due to cost savings when fungicide and insecticide can be applied simultaneously through overhead irrigation when needed, plus some scheduled plantings not being subject to severe stalk borer pressure.

Total soybean plantings are estimated to grow by 15% in 2011, compared with 2010, to reach a record 390,000 hectares. HT soybean is estimated at 383,000 hectares or 85% of the total area planted. Of the 66 soybean varieties listed for 2010, 18 or 27% were biotech.

Cotton production has continued to decline in recent years due to a movement away from risky dryland to irrigation where it has to compete with maize or soybeans. Some 15,000 hectares is expected to be planted in 2011. All of the cotton is expected to be biotech with 95% stacked (Bt/HT) and 5% RR used in refugia. The stacked BtRR®(BollgardII®RR) will be entirely replaced with BtRR® (BollgardII®RR) Flex by 2011. Virtually no conventional cotton is being grown.

The GMO regulatory framework is based on a permit system. There were 348 GMO permits granted in 2010 and 173 from January to 31 July 2011. Maize seed import permits for 2010 for commercial planting covered 1,707 MT and exports for 8,763MT, while for the first six months in 2011 maize seed import permits were for 429MT and 11,470 MT for exports. South Africa has shifted its commodity GM maize grain exports from Africa to new markets with export permits granted in 2010 for 2.5 million MT and January to July for 2.1 million MT.

A number of biotech crops have been given approvals for field testing as indicated in 2010 (Table 28) and 2011 (Table 29).

The several incidences of African maize stalk borer tolerance/resistance to Bt bio-toxin are being monitored and studied by research teams. The first stacked two Bt traits had been approved for commercial use in 2010 and are being planted, while various other stacked insect resistance genes are being field tested, some also stacked with herbicide tolerance and others with stacked insect resistance plus stacked herbicide tolerance. At the same time, mandatory use of refugia is being strictly enforced and monitored. To date, cotton bollworm resistance to Bt has been minor but is being monitored as a precaution.

Table 28. Field Trial Permits Approved in 2010

Crop	Trait	Event Name
Maize	Drought tolerance	MON87460
	Insect resistance (IR)	MON89034
	IR + Herbicide tolerance (HT)	MON89034 x NK603
	IT + HT	TC1507 x MON810 x MIR162
	IR	TC1507 x MIR162
	IR + HT	TC1507 x MIR162 x NK603
	IR	MON810 x MIR162
	IR + HT	TC1507 x MON810 x NK603
	IR	51922
	IR	TC1507
	IR	TC1507 x MON810
	IR + HT	PHP38827
	IR + HT	PHP37046
	IR + HT	PHP36824
	IR + HT	PHP37048
	IR + HT	PHP37049
	IR + HT	PHP36826
	IR + HT	PHP37047
Cotton	IR + HT	Bollgard II x LLCOTT25
	IR + HT	GlyTol x LLCOTT25
	IR + HT	Bollgard II x GlyTol x LLCOTT25
Bulb flower *(Ornithogalum x thyrsoide)*	Virus Resistance	Rolou 2.1
		Rolou 2.4
Cassava	Enhanced Starch	TMS 60444 lines 3.1
		TMS 60444 lines 3.2
Sugarcane	Altered Sugar	NCo 310

Source: Compiled by ISAAA, 2011.

Table 29. Field Trial Permits Approved from January to July 2011

Crop	Trait	Event Name
Maize	Drought tolerance	MON87460
	IR + HT	PHP37050
	IR	59122
	IR	TC1507
	IR	TC1507 x MON810
	IR + HT	TC1507 x MON810 x NK603
	IR	PHP36826
	IR	PHP36827
	IR	PHP37046
	IR	PHP37047
	IR + HT	TC1507 x 59122 x MON810 x NK603
	IR + HT	TC1507 x 59122 x NK603
Cotton	HT	GlyTol x LLCOTT25
	IR + HT	TwinLink x GlyTol
	IR + HT	Bollgard II x LLCOTT25
	IR + HT	Bollgard II x GlyTol x LLCOTT 25
Bulb flower *(Ornithogalum x thyrsoide)*	Virus Resistance	Rolou 2.1
		Rolou 2.4
Sugarcane	Alternate sugar (ratoon)	NCo310
	Increased yield and sugars	PihUMPS
	increased cellulose	pCel
	increased yield and starch	pihADK
	decreased starch.	piAGPase

Source: Compiled by ISAAA, 2011.

Economic Benefits

It estimated that the economic gains from biotech crops for South Africa for the period 1998 to 2010 was US$809 million and US$133 million for 2010 alone (Brookes and Barfoot, 2012, Forthcoming).

Farmer Testimonies

Samuel Moloi grows 156 acres of corn on land that he rents in the Free State province, a vast region of prairies in South Africa's interior. He uses GM seeds that are both insect-resistant and tolerant to Roundup herbicide. He says he spends less on diesel by using his tractor, and less and less on labor, because he doesn't have to hire workers to cut the weeds, a common practice in Africa. ***"The GM seed is a little bit higher (in cost), but it does a fantastic, a wonderful job for me,"*** he said. ***"The benefits at the end of the day outweigh the cost of the seed itself"*** (Moloi, 2010).

Evan Enslyn of Klipfontein Farm near Witbank, South Africa acknowledges that new technologies sometimes cost more upfront but he says, ***"Making use of the new technology lowers the total costs and results in better profits that can be ploughed back into the farm to buy new technologies or improve business and marketing skills."*** New biotech seed varieties, such as Bt maize with built-in pest protection, are a great example of new technologies that are helping Klipfontein Farm to expand. ***"It definitely pays to buy new seed technologies,"*** says Enslyn. Although buying new seed is more expensive, the added benefits help him save money in the long run because he uses less crop protection products to control unwanted pests (Enslyn, 2009).

URUGUAY

Uruguay increased its biotech plantings of soybean and maize to a record 1.3 million hectares in 2011, a significant increase of about 150,000 hectares from 2010. A gain of approximately 100,000 hectares was recorded for herbicide tolerant soybean which now occupies 100% of the national soybean hectarage of the record 1.1 million hectares. Biotech maize also increased in area to ~150,000 hectares in 2011. 2011 was also the first year for Uruguay to plant a significant 50,000 hectares of the stacked Bt/HT maize and small area of HT maize. Uruguay approved five events

on the same day in early 2011 and for the first time deployed stacked Bt/HT maize. Uruguay has enhanced farm income from biotech soybean and maize of US$84 million in the period 2000 to 2010 and for 2010 alone at US$20 million.

URUGUAY

Population: 3.3 million

GDP: US$31.5 billion

GDP per Capita: US$ 9,010

Agriculture as % GDP: 10%

Agricultural GDP: US$3.2 billion

% employed in agriculture: 11.1%

Arable Land (AL): 1.35 million hectares

Ratio of AL/Population*: 1.6

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

Commercialized Biotech Crops:
- HT Soybean
- Bt Maize

Total area under biotech crops and (%) increase in 2011:
1.3 Million Hectares (+9%)

Farm income gain from biotech, 2000 to 2010: US$84 million

*Ratio: % global arable land / % global population

Uruguay, which introduced biotech soybean in 2000, followed by Bt maize in 2003 increased its total biotech crop area once again in 2011 to reach a record 1.3 million hectares. A significant increase of ~100,000 was recorded in the hectarage of herbicide tolerant soybean which now occupies 100% of the national soybean hectarage of 1.1 million hectares, compared with 1.0 million hectares in 2010. Biotech maize also increased in area to ~150,000 hectares in 2011. 2011 was also the first year for Uruguay to plant biotech maize other than Bt (~100,000 hectares), with a significant 50,000 hectares of stacked Bt/HT maize and small area of HT maize. Biotech maize, which Uruguay first approved in 2003, occupying ~150,000 hectares, equivalent to 93% of the total maize plantings of ~170,000 hectares in 2011.

Importantly, the moratorium for consideration of new events, in place since 2005, was lifted in 2009 and a government Commission was established to consider approval of new events Table 30. There are two maize stacked events and three soybean events currently being field trialed (Table 31).

Table 30. List of Approved Biotech Crops in Uruguay

Crop	Trait	Event Name
Soybean	Herbicide Resistant (HT)/GTS40-3-2	1996
Maize	Insect Resistant (IR)/ MON 810	2003
Maize	Insect Resistant/ Bt 11	2004
Maize	Insect Resistant/TC1507	2011
Maize	Herbicide Tolerant/GA21	2011
Maize	Herbicide Tolerant/NK603	2011
Maize	HT/IR//GA21 x Bt11	2011
Maize	HT/IR// NK603 x MON 810	2011

Table 31. List of Biotech Crops in Field Trials, 2011

Crop	Trait
Maize	Bt/HT// BT11 X MIR162 X GA21
Maize	Bt/HT//MON89034 X MON88017
Soybean	HT/A2704-12 (LL)
Soybean	HT/A5547-127
Soybean	Bt/HT//MON89788 X MON87701 (RR2YBt)

Benefits from Biotech Crops in Uruguay

Uruguay is estimated to have enhanced farm income from biotech soybean and maize of US$84 million in the period 2000 to 2010 and the benefits for 2010 alone is estimated at US$20 million (Brookes and Barfoot, 2012, Forthcoming).

BOLIVIA

RR®soybean was grown on an estimated 910,000 hectares in 2011 – this is slightly higher, 7%, than the 850,000 hectares in Bolivia in 2010. The adoption rate of RR®soybean in 2011 was estimated at 92% of the 990,000 hectares, compared with 85% in 2010. In 2008, Bolivia became the tenth country to officially grow RR®soybean with 600,000 hectares – thus, the growth rate between 2008 and 2011 has been significant at ~50%.

Bolivia is a small country in the Andean region of Latin America with a population of 10 million and a GDP of approximately US$20 billion. Agriculture contributes approximately 14% to GDP and employs just over 43% of the total labor force. Agriculture in the eastern Amazon region of Bolivia benefits from rich soils and modern agriculture which is in contrast to the traditional subsistence farming in the mountainous west of the country. There are approximately 2 million hectares of cropland in Bolivia, and soybean is a major crop in the eastern region. In 2007, Bolivia grew approximately 1 million hectares of soybean (960,000 hectares) with an average yield of 1.97 tons per hectare to generate an annual production of 2 million tons. Bolivia is a major exporter of soybeans (~5% of total exports) in the form of beans, oil, and cake. Current yields are estimated at an average of 2.3 tons per hectare according to the National Association of Oil Seed producers (Anapao) which reports that 51 varieties were available on the market in 2011, six of which were introduced as new varieties in 2011.

BOLIVIA

Population: 10.1 million

GDP: US$17.4 billion

GDP per Capita: US$1,630

Agriculture as % GDP: 14%

Agricultural GDP: US$2.4 billion

% employed in agriculture: 43%

Arable Land (AL): 3.6 million hectares

Ratio of AL/Population*: 2.0

Major crops:
- Soybean
- Maize
- Coffee
- Cocoa
- Sugarcane
- Cotton
- Potato

Commercialized Biotech Crop: HT Soybean

Total area under biotech crops and (%) increase in 2011:
910,000 Hectares (+7%)

Farm income gain from biotech, 2011: US$175 million

*Ratio: % global arable land / % global population

Certified Seed in Bolivia

It is not a well recognized fact that the seed industry business in Bolivia is exemplary in the organization and use of certified seeds. In 2008, the percentage of certified soybeans in Bolivia reached a high of 75% despite the fact that in Bolivia there is a tradition, which is constantly changing, for smaller farmers to save their own soybean seed. However, smaller farmers are becoming increasingly aware of the benefits associated with certified seed and are adopting it within their traditional farming systems, resulting in a high level of adoption of 75% in 2008. At the national level and at the Santa Cruz State level, Bolivia has well organized extension programs that provide technical assistance to seed producers regarding the value of high quality certified seed with a focus on the significant benefits it offers smaller low-income farmers. The presence of an effective and efficient certified seed industry in Bolivia greatly facilitates access and adoption of certified RR®soybean seed which is used not only by the larger farmers but increasingly by smaller subsistence farmers.

IFPRI reports that 97% of the soybeans are grown in Santa Cruz where most of the producers are relatively small farmers (classified as less than 50 hectares), although the majority of the production is by larger farms. A separate report estimates that RR®soybean was grown on 92% or 910,000 – hectares of the estimated total hectarage of approximately 1 million hectares (990,000 hectares) of soybean planted in Bolivia in 2011.

According to the most recent estimates of global hectarage of soybean (FAO, 2009 data), Bolivia ranks eighth in the world with 979,678 hectares, after the USA (30.9 million hectares), Brazil (21.8), Argentina (16.8), India (9.6), China (8.8), Paraguay (2.6), and Canada (1.4). Of the top eight soybean countries, five (USA, Argentina, Brazil, Paraguay and Canada) grow RR®soybean. Exports of soybean from Bolivia in 2011 were worth US$309 million – they were the most important agricultural export and the third largest of all Bolivian exports

In 2008, Bolivia became the tenth soybean country to officially grow RR®soybean. In 2008, 600,000 hectares of RR®soybean were planted in Bolivia, equivalent to 63% of the total national hectarage of 960,000 hectares. RR®soybean has been adopted on extensive hectarages in Bolivia's two neighboring countries of Brazil (currently at 20.6 million hectares) and Paraguay (currently at 2.8 million hectares) for many years. It is not clear at this stage what the potential impact of the Bill "Law of the Productive Revolution" introduced on 26 June 2011 will have on future production of RR®soybean. The law prohibits the introduction of modified organisms into Bolivia, if the country is the centre of origin and diversity. This leaves open the option of introducing transgenic crops for which Bolivia is not the center of origin. Farmers are encouraging Government to introduce biotech varieties of crops such as cotton, rice, sugarcane, of interest to Bolivian farmers.

Benefits from RR®soybean in Bolivia

Paz et al. (2008) noted that Bolivia is one of the few countries in Latin America where there is a significant number of small farmers producing soybeans. In Bolivia, soybeans are important, contributing 4.6% of GDP and 10% of total exports. Paz et al. (2008) noted that despite the lack of government incentive, RR®soybeans continue to expand because cost-benefit analysis favors RR®soybean over conventional. More specifically, the partial budget analysis (Table 32) indicates that the net benefits favor RR®soybean over conventional, which is approximately US$200 (US$196) per hectare. The principal benefits, include a 30% increase in yield, a 22% savings on herbicides and more modest savings in labor and other variable costs; in some cases, cost of RR® seed was lower than conventional seed. Based on a net return of US$196 per hectare with 910,000 hectares of RR®soybeans, the 2011 benefits at the national level could be of the order of approximately US$175 million, which is a significant benefit for a small poor country such as Bolivia.

Table 32. Partial Budget for Production of RR®soybean and its Conventional Equivalent in Bolivia

Variable	Non-RR	RR
Yield (t/ha)*	1.47	1.91
Price (US$/t)*	409.32	398.59
Gross Benefit (US$/ha)*	600.26	780.83
Costs (US$/ha)		
Seed	23.46	26.78
Herbicides	41.53	32.25
Insecticides	21.34	24.12
Fungicides	37.93	37.86
Labor cost for chemical input application	4.98	5.03
Machinery	55.02	52.13
All other labor costs*	3.50	2.25
Other variable costs	161.74	146.67
Net Benefits (US$/ha)*	436.53	632.54
Difference RR – non RR (US$/ha)		196.01

Source: IPFRI Annual Report, Paz et al, 2008.

AUSTRALIA

Australia grew 736,000 hectares of biotech crops in 2011, comprising 597,000 hectares of biotech cotton, (up from 520,000 hectares in 2010 and 190,000 hectares in 2009), plus 139,000 hectares of biotech canola (up marginally from 133,000 in 2010 compared with more than a three- fold increase from the 41,200 biotech canola hectares in 2009). The increase in biotech cotton between 2010 and 2011 was ~10% making the cotton crop the largest ever that Australia has ever produced. A remarkable 99.5% of all the cotton grown in Australia in 2011 was biotech and 95% of it featured the stacked genes for insect resistance and herbicide tolerance. The total biotech crop hectarage in 2011 represents a ~15-fold increase over the 48,000 hectares of biotech crops in 2007 during which Australia suffered a very severe drought which continued in 2008 and to a lesser degree in 2009 when the country was still recovering from the multi-year drought which is the worse on record in Australia. Enhanced farm income from biotech crops is estimated at US$408 million for the period 1996 to 2010 and the benefits for 2010 alone at US$141 million.

AUSTRALIA

Population: 21.0 million

GDP: US$1,015 billion

GDP per Capita: US$47,370

Agriculture as % GDP: 3%

Agricultural GDP: US$30.6 billion

% employed in agriculture: 3%

Arable Land (AL): 46.1 million hectares

Ratio of AL/Population*: 10.0

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

Commercialized Biotech Crops:
- Bt/Bt-HT Cotton
- FC Carnation
- HT Canola

Total area under biotech crops and (%) increase in 2011:
736,000 Hectares (+13)

Farm income gain from biotech, 1996-2010: US$408 million

*Ratio: % global arable land / % global population

In 2011, Australia grew 736,000 hectares of biotech crops, (up 13% from 653,000 hectares planted in 2010) comprising 597,000 hectares of biotech cotton, (up from 520,000 hectares in 2010 and 190,000 hectares in 2009), plus 139,000 hectares of biotech canola (up marginally from 133,000 in 2010). This compares with more than a three-fold increase from the 41,200 biotech canola hectares in 2009 to 133,000 hectares in 2010. The increase in biotech cotton between 2010 and 2011 was

~10% making the cotton crop the largest ever biotech cotton that Australia has ever produced. A remarkable 99.5% of all the cotton grown in Australia in 2011 was biotech and 95% of it featured the stacked genes for insect resistance and herbicide tolerance. Biotech cotton hectares in 2011 comprised, 567,000 hectares of Bt/HT, and 30,00 hectares of HT.

The total biotech crop hectarage of 736,000 hectares in 2011 represents a ~15-fold increase over the 48,000 hectares of biotech crops in 2007 during which Australia suffered a very severe drought which continued in 2008 and to a lesser degree in 2009 when the country was still recovering from the multi-year drought which is the worse on record in Australia. In 2011, Australia, for the fourth year, grew herbicide tolerant RR®canola in three states: New South Wales (NSW), Victoria and with Western Australia joining for the second time. According to the Australian Oilseeds Federation, an estimated 1.8 million hectares of canola were grown in Australia in 2011 of which 139,150 hectares, equivalent to 8% of the national total, were grown in the three states of Western Australia, NSW and Victoria (Table 33). Western Australia grew an estimated 800,000 hectares of canola in 2011 of which 90,850 or 11% were RR®canola. Victoria grew an estimated 390,000 hectares of canola in 2011 of which 18,550 hectares or 5% were RR®canola. Nationally, this is a modest increase of 4% over the 133,330 hectares grown in 2010 which represented an 8% adoption rate, the same as in 2010. A significant increase of 18,060 hectares of biotech canola occurred in Western Australia, where almost half of the total canola in Australia is grown.

Drought tolerant wheat

The Victorian Department of Primary Industries has field tested biotech wheat expressing candidate genes for drought tolerance over the 2007-09 period. The trials were planted in Northern Victoria in a drought prone area that suffered significant crop losses due to severe drought in recent years. Lines

Table 33. Hectares of Canola, Conventional and RR Biotech, Planted in Australia, by State, 2010 and 2011

State	Total Canola (ha)		Biotech Canola (ha)		Biotech Canola %	
	2010	2011	2010	2011	2010	2011
NSW	300,000	395,000	24,040	29,750	8	8
Victoria	260,000	390,000	36,500	18,550	14	5
South Australia	190,000	245,000	-	-	-	-
Western Australia	860,000	800,000	72,790	90,850	9	11
Total	**1,610,000**	**1,830,000**	**133,330**	**139,150**	**8**	**8**

Source: Compiled by Clive James, 2011 from Industry sources.

of biotech wheat were identified in the field trials that yielded over 20% more than the controls under water stress. The stated goal of this important research effort is to develop and commercialize the world's first biotech wheat within the next 5 to 10 years. Given that water constraints is by far the most important constraint globally to increased productivity, the encouraging results from this research effort is extremely important (German Spangenberg, 2009. Personal Communication).

Panama disease of bananas

The Panama disease of bananas called "*Verticillium* wilt" caused by the fungus *Fusarium* is an extremely important disease of bananas in the South East, which threatens the northern territories of Australia, and Queensland is also at risk. A team of scientists from Queensland, led by Dr. Jim Dale has developed a transgenic biotech banana which has proven resistance to the disease when challenged with severe epidemics of the disease under greenhouse conditions. The resistance is conferred by a single gene in both Cavendish and lady finger bananas; field tests were executed to study the resistance under field conditions. Coincidentally, efforts are underway to increase the nutrition of bananas as well as resistance to Panama disease which is an endemic and important disease of bananas worldwide and is particularly important in developing countries where bananas are a staple food (ABC News, 2007). In summary, bananas with a range of traits including, disease resistance and improved nutrition are under development and expected to result in a commercialized product in the near to mid-term.

GM perennial pasture grasses, rye grass and fescues

The first field trials of biotech/GM perennial pasture grasses, rye grass and fescues, were approved by the Federal Gene Regulator in October 2008. The trials featured biotech varieties which are more nutritious, have a reduced non-digestible content, could reduce the amount of feed required and could also help farmers survive drought (The Age, 2008).

Improving crop yield

At the University of Newcastle, Australia, Yong Ling Ruan discovered that deleting a gene from tomatoes allows the plant to produce sweeter tomatoes and longer-lasting leaves, which can boost crop yield and shelf life (University of Newcastle, Australia, 2009). Scientists found genes that can potentially feed millions. It is estimated that at least five more years are required to verify the value of the technology at the field level. The research is at a preliminary stage and further work needs to be completed to explore whether the technique could be applied to important commercial food, feed and fiber crops. The research is a collaborative effort between the University of Newcastle and the Zhejiang Academy of Sciences in Hangzhou, China.

Biotech Sugarcane

In November 2009, The Bureau of Sugar Experiment Stations (BSES) announced a A$25 million partnership with DuPont to field test biotech sugarcane over the next 5 years on approximately

2 hectares of land in Queensland; preliminary approval was granted by the Office of the Gene Regulator for these trials. The trials will feature unspecified new biotechnology applications which can contribute to increased productivity and efficiency of sugarcane production which is used for both food and biofuel. Commercial biotech sugarcane is not expected to be available until about 6 years from now, around 2017. Australia produces about 33 million tons of sugar annually of which about 85% is exported, making it the second most important crop export after wheat. In 2009, Australian farmers reaped about A$1.5 billion from sugarcane (Australian Financial Review, 2009).

Benefits from Biotech Crops in Australia

Biotech Cotton in Australia

Australia is estimated to have enhanced farm income from biotech cotton by US$408 million in the period 1996 to 2010 and the benefits for 2010 alone is estimated at US$141 million (Brookes and Barfoot 2012, Forthcoming). 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 10 years could have cost Australian farmers US$3 billion.

Biotech Canola in Australia

Biotech canola offers Australia a way to increase yield in a sustainable manner 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 (Australian Ministry of Agriculture, Fisheries and Forestry Press Release, 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 in the longer term – wheat is Australia's most important crop and significant export.

Scientists and Farmers Support Biotech Crops in Australia

Delegates at the 2008 ABARE conference learned that the introduction of GM crops in Australia were creating both opportunities and challenges for farmers:

Australia's former Chief Scientist, Dr. Jim Peacock, said biotechnology will play an important role in addressing global issues of food security. ***"We lose 12 percent of yields around the world to disease pathogens, and GM technologies offer a means to increase global food supply,"*** Dr. Peacock said.

ABARE Principal **Research Economist Max Foster** said that evidence of separate markets for GM and non-GM grains is already present in world markets. **"World trade in soybeans, corn, canola and cotton is dominated by GM varieties, but non-GM crop varieties coexist as niche markets,"** Mr. Foster said.

Victorian canola grower Andrew Broad told the conference that biotechnology will play a significant role in the Australian grain industry remaining competitive, with declining yields and profitability from canola becoming significant issues. ***"Without biotechnology, the Australian canola industry will not remain viable,"*** Mr. Broad said.

GM canola grower Reuben Cheesman from St. Arnaud in Victoria grew 56 hectares of Roundup Ready canola last year and is increasing this to 180 hectares this year. ***"Lower herbicide costs and the ease of use of the system were true benefits. Together with higher yields, oil content and superior weed control in comparison to Clearfield® varieties, Roundup Ready has a distinct advantage over other systems,"*** he said.

Views on Biotech Crops in Australia

The motion to disallow GM Crops by the Green Parties in Western Australia (WA) was voted down by the Nationals and Liberals in the State Parliament in May 2010. On this, **Mike Norton, the WA president** was not surprised that this move was defeated in the upper house of the Parliament. He said that the use of GM technology is well and truly warranted. ***"I think the bulk of farmers would certainly hope that GM technology is well and truly here to stay. It's certainly another tool that Western Australian farmers need to manage their operations without increasing costs"*** (Norton, 2010).

Mr. Roy Hamilton is a founding member of the Riverine Plains Grower Group, and a regular participant in Grain Research and Development Corporation (GRDC) Southern Grower Updates. Mr. Hamilton also sits on the SE Regional Advisory Committee and enjoys reflecting local farmer issues and priorities through to the GRDC Southern Panel. ***"I like looking at new ways of doing things. I was in Canada in 2001 and did some research and talked to a lot of farmers and became quite comfortable with the science and technology, and the rigour involved in the safety of the GM system,"*** Mr. Hamilton said (Hamilton, 2010).

Dr. Jason Clay, senior vice president at the World Wildlife Fund (WWF) said of the increase in world's population, ***"we need to address this because the 'impacts' to people and food production/consumption have on the land and water that are acceptable today with 6.8 billion people will not be acceptable with 9.1 billion people. We will have to get better at producing more food with fewer resources."*** Agriculture/food producers need to become increasingly more efficient and producers must adopt advanced genetics, management practices and technology and emphasized that ***"we cannot abandon modern genetics and technology,"*** he added (Clay, 2010).

PHILIPPINES

In 2011, the area planted to biotech maize in the Philippines is projected to increase to 644,000 hectares, up 19% from the estimated hectares of biotech maize in 2010. Notably, the area occupied in 2011 by the stacked traits of Bt/HT maize is 545,000 hectares, compared with only 411,000 hectares in 2010, with the stacked trait maize occupying 85% of total biotech maize hectares in 2011, reflecting the preference of farmers for stacked traits and the superior benefits they offer over a single trait. Farm level economic gains from biotech maize in the Philippines in the period 2003 to 2010 is estimated at US$170 million and for 2010 alone at US$63 million.

The adoption of biotech maize in the Philippines has increased consistently

PHILIPPINES

Population: 89.7 million

GDP: US$167 billion

GDP per Capita: US$1,850

Agriculture as % GDP: 15%

Agricultural GDP: US$25 billion

% employed in agriculture: 37%

Arable Land (AL): 5.1 million hectares

Ratio of AL/Population*: 0.3

Major crops:
- Sugarcane
- Coconut
- Rice
- Maize
- Banana
- Cassava
- Pineapple
- Mango

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

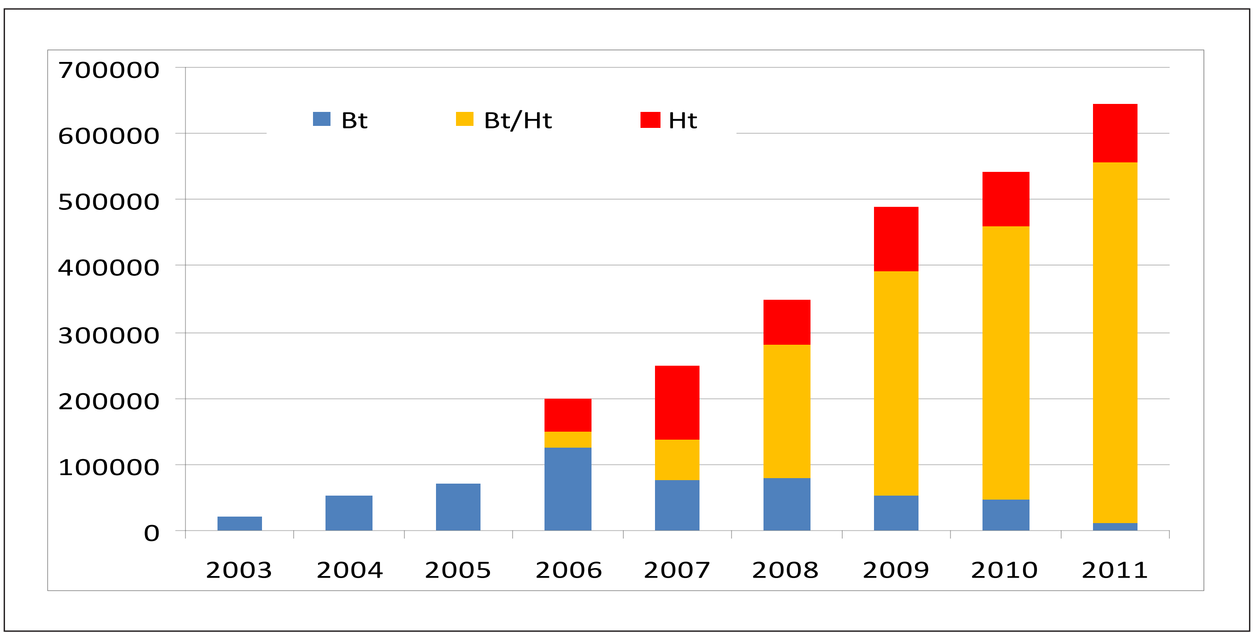
Total area under biotech crops and (%) increase in 2011:
644,000 Hectares (+19)

Increased farm income for 2003-2010: US$170 million

*Ratio: % global arable land / % global population

every year since it was first commercialized in 2003. The area planted to biotech maize was projected to significantly increase in the wet and dry seasons in 2011 to reach 644,000 hectares, up 19% from the 541,000 hectares of biotech maize in 2011 (Figure 42). Notably, the area occupied by the stacked traits of Bt/HT maize has continuously increased every year reaching 545,000 hectares in 2011, compared with only 411,000 hectares in 2010, up by a substantial 33%, reflecting the preference of farmers for stacked traits and the superior benefits they offer over single trait. This shift in farmers' preference from single trait maize to those with combined traits has been observed since the introduction of stacked-traits in 2006. The total hectarage planted to the single trait Bt maize, after experiencing a 32% decline between 2008 to 2009 and a 12% decline between 2009 and 2010, has further decreased by 77% in 2011, with a total of only 12,300 hectares compared to last year's 54,000 hectares. Single trait herbicide tolerant (HT) maize was planted on 86,500 hectares in 2011, which is only 13.4% of the total biotech maize hectarage compared to last year's 15%. On a percentage basis, biotech yellow maize has consistently increased by about 5% of the total yellow maize hectarage every single year from the first year of commercialization in 2003, reaching the highest ever level of 64% in 2011 (up from 42% in 2010). Consistent with the experience of other biotech maize growing countries the year-by-year steady increase in adoption of biotech maize reflects the significant and consistent benefits generated by biotech maize to farmers in the Philippines.

Figure 42. Increase in Hectarage of Biotech Maize in the Philippines and Proportion of Commercialized Traits, 2003 to 2011



Source: Compiled by ISAAA, 2011.

The number of small resource-poor farmers, growing on average 2 hectares of biotech maize in the Philippines in 2011, was estimated at 322,000, up significantly by 52,000 from 270,000 in 2010.

A total of eight events of biotech maize are approved for commercial planting in the Philippines: MON810 for insect resistance (first approved in 2002 and the approval was renewed in 2007), NK603 for herbicide tolerance (first approved in 2005 and renewed in 2010), Bt11 for insect resistance (first approved in 2005 and renewed in 2010), GA21 for herbicide tolerance approved in 2009, the stacked gene product of MON810/NK603 (first approved in 2005 and renewed in 2010), the stacked trait Bt11/GA21 for insect resistance and herbicide tolerance approved in 2010, MON89034 which contains two Bt genes for resistance to fall armyworm, black cutworm, the ECB and the corn worm, and the stacked trait IR/HT, MON89034 x NK603 (Table 34). In addition, a total of 27 stacked trait maize and cotton products have been approved for importation for direct use as food, feed and for processing, from among a total of 68 biotech crops and products currently approved for direct use as food, feed and for processing.

The future acceptance prospects for biotech crops in the Philippines continue to look promising with new biotech crop products also being developed by national and international institutes. Among these are Golden Rice (GR), a biofortified rice being developed by the Philippine Rice Research Institute (PhilRice) and the International Rice Research Institute (IRRI). The first generation Golden Rice was first tested in advanced field trials in IRRI in 2008, and second generation of Golden Rice (GR2) introgressed into selected mega varieties were field tested in the wet season of 2010. At PhilRice, field trial of GR2 introgressed lines was conducted in 2011 dry season. It is expected that succeeding field

Table 34. Approval of Biotech Maize Events in the Philippines, 2002 to 2011

Crop	Event	Trait	Year of Approval/Renewal
Maize	MON810	IR	2002/2007
Maize	NK603	HT	2005/2010
Maize	Bt11	IR	2005/2010
Maize	MON810 x NK603	IR/HT	2005/2010
Maize	GA21	HT	2009
Maize	Bt11/GA21	IR/HT	2010
Maize	MON89034	IR/HT	2010
Maize	MON89034 x NK603	IR/HT	2011

IR: Insect resistance, HT: Herbicide Tolerance
Source: Compiled by ISAAA, 2011.

trials of the GR2 being developed by IRRI and PhilRice will be undertaken in 2012 and can generate the required data for possible full regulatory submission in 2013. In addition to the trait for pro-Vitamin A, the biotech rice being developed by PhilRice, also dubbed as a '3-in-1' rice, incorporates resistance to tungro virus and to bacterial blight diseases (Pablico, 2008; Icamina, 2008).

The fruit and shoot borer resistant eggplant being developed by the Institute of Plant Breeding (IPB), University of the Philippines Los Baños (IPB-UPLB) already completed in 2011 the first two seasons of multi-location field trials in the island of Luzon. Additional trials are to be conducted starting late 2011 and continue in 2012 to generate additional regulatory data. Biotech papaya with delayed ripening and papaya ring spot virus (PRSV) resistance, also being developed by IPB-UPLB, has already been tested in confined field trials. Bt cotton for the first time was tested in a confined field trial in 2010 and will start with multi-location trials in late 2011/early 2012. 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 and the initial efforts to generate transgenic lines of virus resistant abaca (*Musa textilis*) by the Fiber Industry Development Authority (FIDA) in collaboration with the University of the Philippines. The Philippine Department of Agriculture Biotechnology Program Office and the Department of Science and Technology have been very supportive of research and development activities on biotech crops and have been eager to support the products that will emerge from the R&D pipeline for commercialization in the near term.

It is important to note that the Philippines is the first country in the ASEAN region to implement a regulatory system for transgenic crops; the system has also served as a model for other countries in the region and other developing countries outside of Asia. The Philippine biotechnology regulatory system was formalized with the issuance of Executive Order No. 430 in 1990 establishing the National Committee on Biosafety of the Philippines (NCBP). In 2002, the Department of Agriculture (DA) issued Administrative Order No. 8, which provided the basis for commercial release of biotech crops. Subsequently, in 2006 Executive Order 514 was issued further strengthening the NCBP and establishing the National Biosafety Framework. In 2008, the country launched its national biosafety clearinghouse, BCH Pilipinas, to serve as the Philippine node of the Biosafety Clearing House (BCH) mechanism established under the Cartagena Protocol on Biosafety (CPB). The Philippines, which grows approximately 2.5 million hectares of maize is still the only country in Asia to approve and grow a major biotech feed crop; moreover, the Philippines achieved a biotech mega-country status with biotech maize in 2004, i.e. 50,000 hectares or more. Asia grows 32% of the global 158 million hectares of maize with China itself growing 29 million hectares, plus significant production in India (7.8 million hectares), Indonesia (3.6 million hectares), Philippines (2.7 million hectares), and Vietnam, Pakistan and Thailand (each with about 1 million hectares) (FAO, 2009).

Benefits from Biotech Crops in the Philippines

The benefits of biotech maize to Filipino farmers' livelihood, income, the environment and health have been well studied and documented. Farms planted with Bt maize in the Northern Philippine provinces 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 farm level economic benefit of planting biotech maize in the Philippines in the period 2003 to 2010 is estimated to have reached US$170 million. For 2010 alone, the net national impact of biotech maize on farm income was estimated at US$63 million (Brookes and Barfoot, 2012, Forthcoming).

Other studies report that gain in profit at the farmer level was computed at 10,132 pesos (about US$180) per hectare for farmers planting Bt maize with a corresponding savings of 168 pesos (about US$3) per hectare in insecticide costs (Yorobe and Quicoy, 2006). 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$135) per hectare during the dry season and 7,080 pesos (about US$125) 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). In a more recent study covering crop year 2007-2008, biotech maize increased average net profitability in 9 provinces by between 4 to 7% during the wet season and between 3 to 9% during the dry season (Gonzales, 2009). Overall, the four studies that examined net farm income, as well as other indicators, consistently confirmed the positive impact of Bt maize on small and resource-poor farmers and maize producers generally in the Philippines.

The projected benefits from other biotech crops nearing commercialization, such as the Golden Rice could be higher than maize at US$88 million per year (Zimmermann and Qaim, 2004), while benefits from Bt eggplant are projected at almost nine million pesos (about US$200,000, Francisco, 2007). The benefits from Golden Rice are derived from gains due to reduced mortality and reduced disability. Benefits from Bt eggplant include higher income from higher marketable yields, reduction in insecticide use by as much as 48%, and environmental benefits associated with less insecticide residue in soil and water and the protection of beneficial insects and avian species. Bt eggplant adoption could result to savings of about 2.5 million pesos (about US$44,414) in human health costs, and 6.8 million pesos (about US$120,805) in aggregated projected benefits for farm animals, beneficial insects, and avian species (Francisco, 2009). For the virus resistant papaya, a substantial increase in the farmer's net income is projected, with expected returns of up to 275% more than conventional papaya (Yorobe, 2006).

Other recently completed ex-ante studies in Bt cotton and abaca (*Musa textilis*) indicate significant potential social and economic benefits. These studies were conducted to assist Philippine policy makers decide whether the development and commercialization of these biotech crops in the country is a sound investment. Chupungco et al. (2008) has concluded that Bt cotton commercialization in the Philippines will improve yield by about 20% with a return on investment (ROI) of between 60-80%, compared to 7-21% when using conventional varieties. The biotech abaca resistant to abaca bunchy top virus (ABTV), abaca mosaic virus (AbaMV) and bract mosaic virus (BrMV), were estimated to be able to provide an additional increase in yield of 2.5 tons per hectare and 49.36% ROI after 10 years (Dumayas et al. 2008).

In summary, the Philippines has already gained US$108 million from biotech maize in a short span of seven years, 2003 to 2010, and is advancing the adoption of the maize stacked traits, IR/HT. In 2011, stacked traits in maize represented around 85% of the total biotech maize area in the Philippines. Future prospects look encouraging, with "home grown" biotech products likely to be commercialized in the next 3 years including Bt eggplant in 2012/13 and with a reasonable possibility that the Philippines might also be the first country to commercialize Golden Rice around 2012-13 (IRRI, 2010).

Stakeholder Experiences

Emil Q. Javier, President of the National Academy of Science and Technology (NAST), former President of the University of the Philippines, and Minister of Science and Technology, says ***"Much of this was made possible through collective leadership, a strong group of scientists who believed in transgenics for modern agriculture, and government support,"*** referring to the several Philippine biotech products in the pipeline such as Bt eggplant, virus-resistant and delayed ripening papaya, Golden Rice, blight resistant rice, and virus resistant abaca (Navarro, 2009).

Dr. Candida B. Adalla, the Director of the Department of Agriculture Biotechnology Program Office stressed in a farmers' forum that, ***"We are investing on the safe use of biotech and are committed to the safe and responsible use of biotech. Biotech products would benefit everyone, particularly the Filipino people."***

Dr. Emiliana Bernardo, an entomologist and retired professor of the University of the Philippines Los Baños, answering a query on "interfering with the act of God" in a researchers' workshop said, ***"I believe that nothing will succeed without the permission of God. The fact that God gave us the wisdom to develop the technology… then that means God gave us the permission... And so I am not afraid."***

Isidro Acosta, a maize farmer and Region 2 RAFC Chairman from Naguilian Isabela said, ***"You get savings from labor and spraying with biotech corn. It is also safe to the environment. When you spray an ordinary hybrid corn, you cannot immediately go in your farm within 24 hours – you have to let the chemicals pass. When we sprayed back then, many friendly insects disappeared. Now, with biotech corn, they are gradually coming back to the farm, because spraying has significantly lessened."***

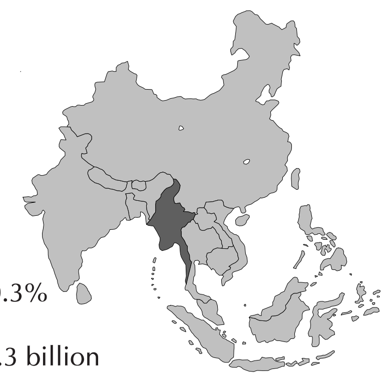
"With biotech corn, you don't have to weed, you don't have to spray pesticides, you have no problem with borer. You are not tired," said a lady farmer Lydia Lapastora of Benito Soliven, Isabela.

MYANMAR

2011 is the sixth consecutive year of cultivation of the insect resistant Bt cotton variety named "Silver Sixth" or "Ngwe chi 6" – approved for commercial cultivation in Myanmar in 2006-07. In 2011, the insect resistant Bt cotton variety silver sixth, a long staple was estimated to have been planted by 400,000 farmers on about 283,000 hectares (0.7 hectare per farm), equivalent to 79% of all the cotton grown in Myanmar, up by 3% from 275,000 hectares in 2010-11.

Myanmar with a population of 50 million is predominantly an agricultural based economy. Agriculture contributes more than half (50.3%) of the national Gross Domestic Product (GDP) of US$26.5

MYANMAR



Population: 50.5 million

GDP: US$26.5 billion

GDP per Capita: US$635

Agriculture as % GDP: 50.3%

Agricultural GDP: US$13.3 billion

% employed in agriculture: 70%

Arable Land (AL): 10.6 million hectares

Ratio of AL/Population*: 0.7

Major crops:

- Rice
- Pulses
- Beans
- Sesame
- Groundnuts
- Sugarcane
- Cotton

Commercialized Biotech Crop: Bt Cotton

Total area under biotech crops and (%) increase in 2011:
283,000 Hectares (+3)

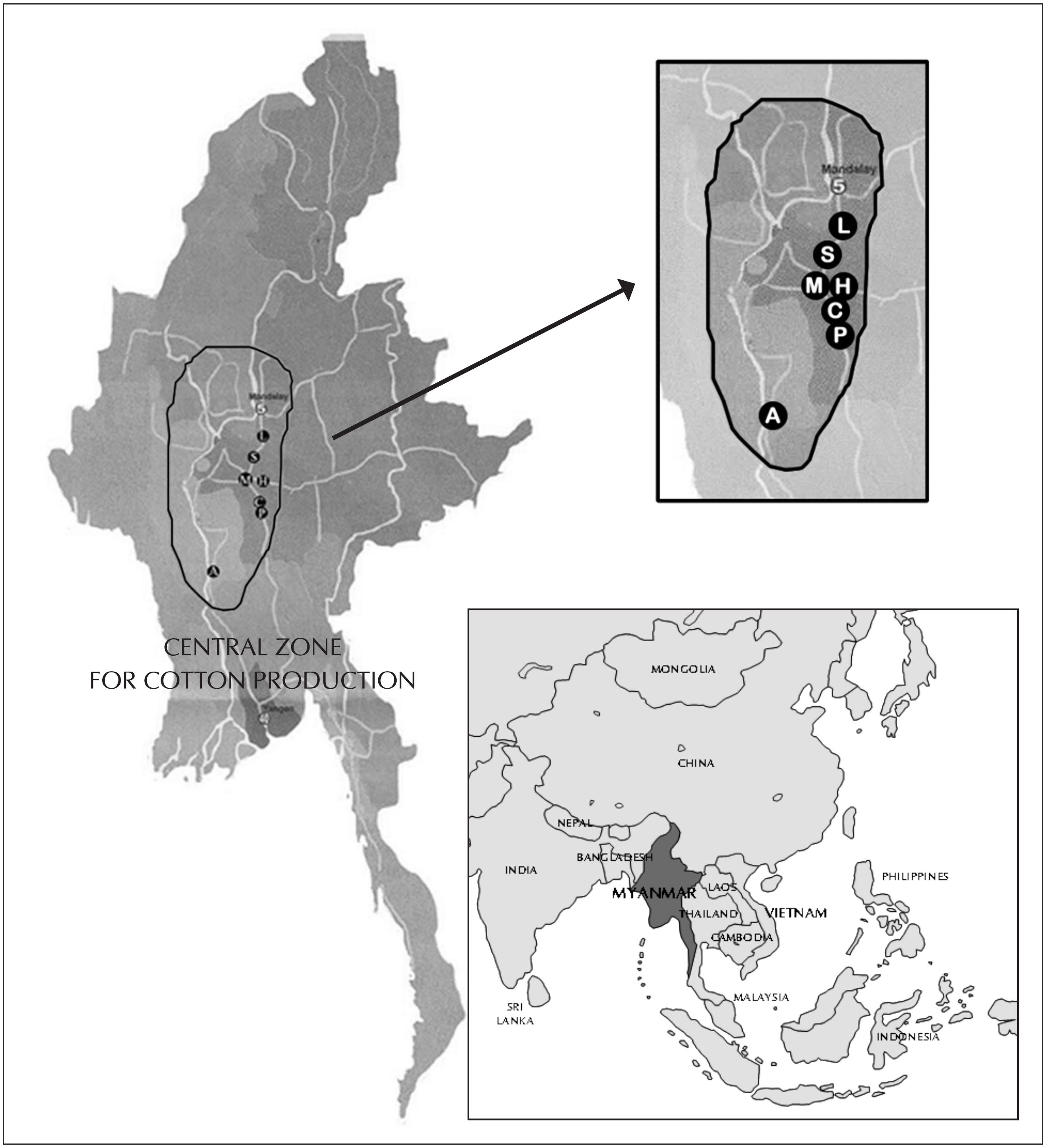
*Ratio: % global arable land / % global population

billion or equivalent to US$635 per capita. Agriculture employs 70% of total population of the country which has two distinct agro-eco climates – the temperate North and tropical South. This allows the country to cultivate different crops throughout the year that include rice, oilseed crops, pulses, and industrial crops such as cotton, vegetables, fruits and flowers under their respective cropping systems (MCSE, 2001; UNEP GEF, 2006). Approximately 4.5 million farm families cultivate various crops on an estimated arable land of 10.6 million hectares, with an average 2.35 hectare per farm family. It is estimated that around 3 million farms (two-thirds of all farms) cultivate less than an average 2 hectares. There are four principal crops – rice, pulses, cotton and sugarcane that ensure food self sufficiency and earn significant foreign exchange. Rice occupies 47% or 5.5 million hectares of the cultivated area and cotton occupies about 350,000 hectares. Most of the crops are rainfed with a noticeable increase in area under irrigation in recent years. Intensive multiple cropping system allows farmers to reap significant returns throughout the year. India relies heavily on the supply of beans and pulses from Myanmar and imports more than one billion dollars worth of agricultural produce annually.

Cotton in Myanmar

Cotton is a traditional crop grown in Myanmar and is the principal fiber crop of the country. It occupies about 350,000 hectares, primarily in the central zone of the country which receives 600 mm to 1000 mm rainfall. Approximately half a million farmers (an estimated 503,566) farming 368,000 hectares in 2007, cultivate an average 0.7 hectares of cotton per farm in the regions of Western Bago, Mandalay, Magwe and Sagaing (Tun, 2008). Traditionally, cotton farmers grew indigenously developed varieties of *Gossypium arboreum* (short staple) until the large scale commercial adoption of upland cotton varieties of *Gossypium hirsutum* (long staple) in the 1960s. The Ministry of Agriculture and Irrigation (MOAI) conducts all activities related to research, development and seed multiplication on their own research farms, located in the central part of the country. In addition, there is a cotton fiber and miniature spinning laboratory, established in the 1980s designed to ensure compliance with quality parameters (Tun Win, 2008). Most of the cotton produced in the country is used by the textile industry with 0.3 million spindles and a large number of spinning units to meet the growing demand for quality yarn and fabric in the country. The Cotton and Sericulture Department (CSD) of the Ministry of Agriculture and Irrigation conducts all the R&D and extension activities in seven cotton research farms located in all the major cotton producing zones that are also responsible for seed multiplication of improved varieties (Figure 43). Notably, the government agencies undertake the multiplication of foundation and registered seed in the production section of research farm whereas the certified cotton seed are produced in farmers' fields under the supervision of cotton researchers (Nu, 2011). Yezin Agricultural University (YAU) and the Department of Agricultural Research (DAR) also conduct research on cotton.

Figure 43. Cotton Research & Development Farms in Myanmar



Caption: L= Lungyaw farm; S= Shwedaung farm; A= Aunglan farm; H= Hlaing det farm; C= Chaung Magyi farm; M= Padawzet farm; M= Fibre quality lab; P= Pyaw bwe farm.

Source: Adopted from Tun Win, 2008.

Bt Cotton in Myanmar

In 2010, for the first time, it was reported that Bt cotton was being widely grown in Myanmar (Gain Report BM0025 USDA/FAS 3 Nov 2010; Myanmar Times, 2010). The reports confirmed that a long staple variety named 'Silver Sixth' popularly known as "Ngwe chi 6" Bt cotton variety was developed in Myanmar in 2001. Following field trials at Mandalay's research facilities the first release was in 2006-07. In the interim, cotton farmers have quickly switched to Ngwe chi 6 Bt cotton variety with adoption increasing significantly from 8,300 hectares in 2007-08 to 140,000 ha in 2008-09. In 2009-10, the adoption of Ngwe chi 6 Bt cotton variety doubled with an estimated 270,000 hectares farmed by 375,000 farmers or 75% of the cotton area planted in all major cotton growing regions including Western Bago, Mandalay, Magwe and Sagaing in Myanmar. In 2010, it is estimated that the Ngwe chi 6 Bt cotton variety was grown by 375,000 farmers (based on an estimated 503,566 farmers growing all cotton in Myanmar in 2007) (ICAC, 2010. Personal Communication), on approximately the same area of 270,000 hectares (an average of 0.7 hectares of Bt cotton per farm). In 2011, the insect resistant Bt cotton variety "Silver Sixth" was estimated to have been planted by 400,000 farmers on about 283,000 hectares, equivalent to 79% of all the cotton grown in Myanmar, up by 3% from 275,000 hectares in 2010-11. Bt cotton now occupies the entire long staple hectarage in the country (Table 35).

In 2010-11, the only cotton area that was planted with conventional non-Bt cotton variety was the area with short staple cotton variety, for which Bt cotton varieties are not available; "Ngwe chi 6" is the only long staple Bt cotton variety released to date in Myanmar. According to the Ministry of Agriculture's Extension Department approximately 75% of the cotton grown in Myanmar is long staple cotton whilst the balance of 25% is short staple. In 2009, Myanmar grew 360,000 hectares of cotton of which 270,000 hectares were long staple cotton producing 524,000 MT or 93 percent of total cotton production, whilst 68,000 hectares were short staple cotton producing only 38,000

Table 35. Adoption of Bt Cotton in Myanmar, 2006 to 2011

Year	Adoption of Bt Cotton (ha)	Total Cotton (ha)	% Adoption
2006-07	<500	300,000	<1%
2007-08	8,300	368,000	2%
2008-09	140,000	360,000	39%
2009-10	270,000	360,000	75%
2010-11	270,000	360,000	75%
2011-12	283,000	360,000	79%

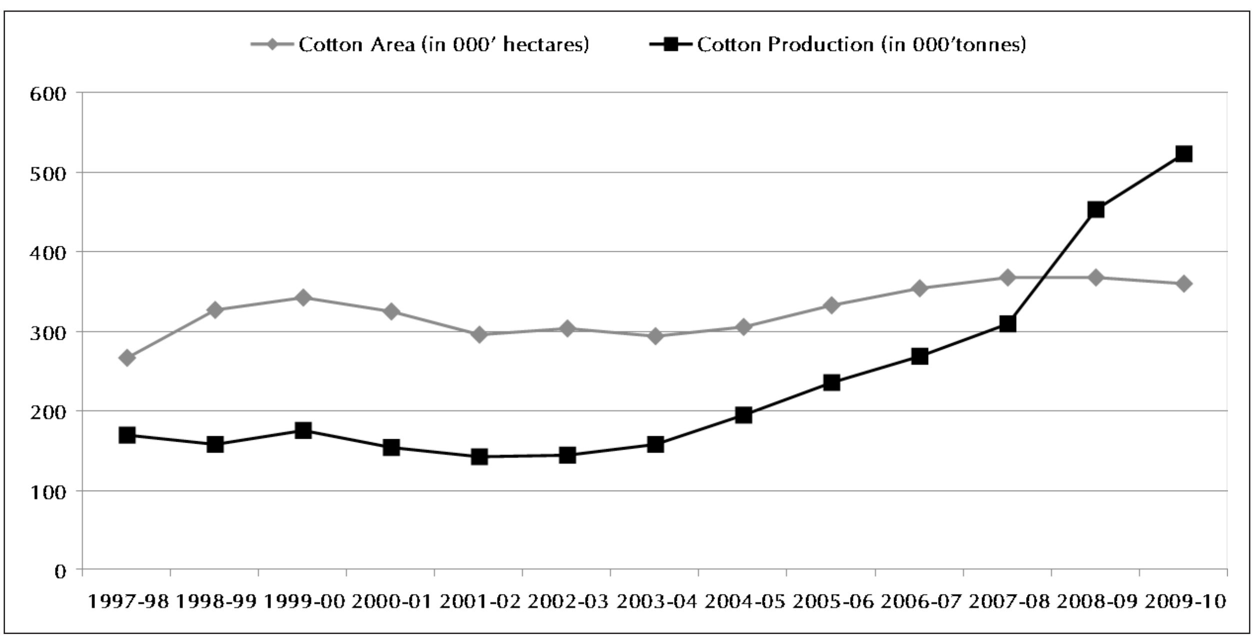
Source: Compiled by ISAAA, 2011.

MT or 7 percent of total cotton production (Figure 44). The yield of short staple cotton has grown at only 2.5% per year whilst the yield of long staple cotton has doubled since the introduction of Ngwe chi 6 in 2006-07.

R&D in Cotton Research

The cotton and sericulture department of the Ministry of Agriculture and Irrigation focuses exclusively on R&D programs to develop long staple cotton varieties and hybrids especially for better fibre quality and improved ginning percentage. In addition to the five commercially grown varieties (Ngwe chi 1, Ngwe chi 2, Ngwe chi 3, Ngwe chi 4 and Ngwe chi 5), four promising new cotton varieties namely SDG 1, SDG 4, SDG 6 and SDG 8, which posses greater ginning percentages, have been developed through conventional breeding. The introduction of Ngwe chi 6 – the long staple insect resistant Bt cotton variety developed using genetic modification technology was a landmark achievement of the Cotton and Sericulture department (CSD) of the Ministry of Agriculture and Irrigation in 2006 (USDA FAS, 2010; Myanmar Times, 2010; Nu 2011). In 2010, Myanmar became the 13th cotton growing country in the world to commercially deploy biotech cotton and now joins the group of 29 biotech crop growing countries in the world in 2011.

Figure 44. Cotton Area and Production in Myanmar, 1997 to 2010



Source: Cotton and Sericulture Department, 2011; Nu, 2011

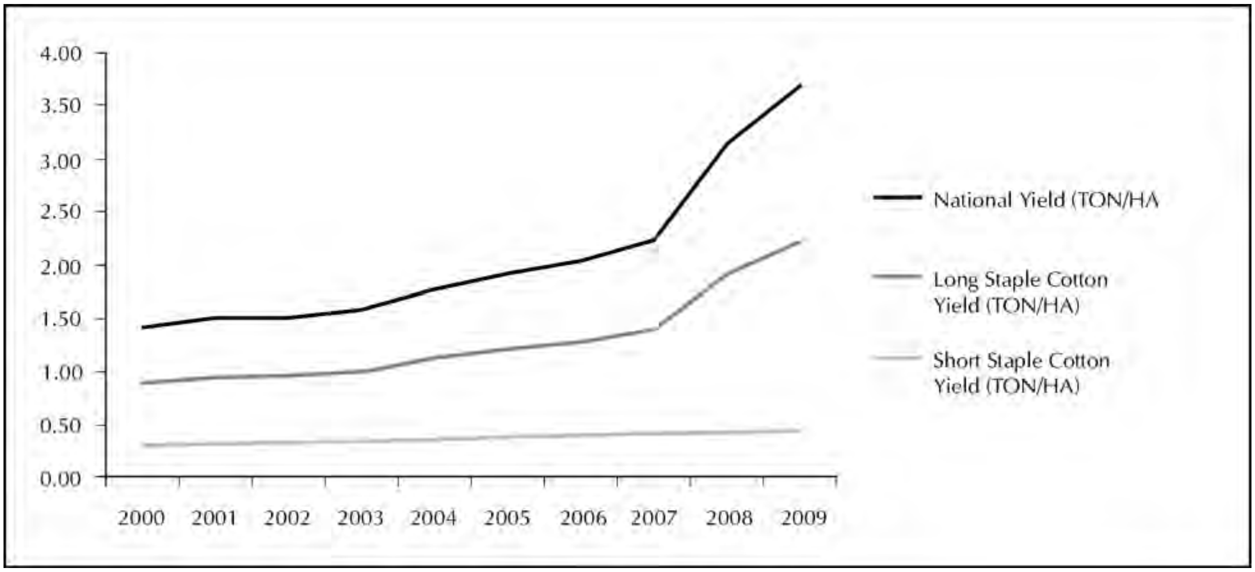
Myanmar was involved in a project in the mid 2000s to establish a National Development Policy with the assistance of the United Nations; the project was supported by the Global Environment Facility (GEF) in 2004 and terminated in 2005. Current laws that may facilitate the introduction of regulatory biotech and biosafety laws include the Essential Supplies and Services Act, the Pesticide Law, the Plant Pest Quarantine Law, the Seed Law, the National Food Law, and the Animal Health and Development Law. The National Biosafety Framework (NBF) was developed in accordance with the Cartagena Protocol on Biosafety (CPB) that was signed by Myanmar on 11 May 2001. Under the National Biosafety Framework (NBF), the Ministry of Agriculture and Irrigation drafted the Law of Biosafety with the help of UNEP GEF and this is pending approval by the legislature of the Union of Myanmar (UNEP GEF, 2006).

It is noteworthy that as long ago as in 2005, Myanmar had already completed four years (2001 to 2005) of field trials of Bt cotton in the Mandalay division of Myanmar (GAIN Report BM5018, 2005). These field trials were reported to have shown that the Bt cotton was well adapted to Myanmar's soil and climate. At the same time, efforts were made to strengthen the human resources and trained manpower in biotechnology areas including agriculture, pharmaceuticals, fermentation and industrial biotechnology in the country. In this regard, the Department of Biotechnology which was newly established in Yangon Technological University (YTU) under the Ministry of Science & Technology (MoST) has been conducting some programs in biotechnology since 1998. In 2001, a National Biotechnology Development Center was established at Pathein University, Irrawaddy Division in collaboration with the National Institute of Technology and Evaluation of Japan.

Benefits of Bt Cotton

It is estimated that more than 90% of long staple cotton producers in Myanmar have adopted Bt cotton. Compared to conventional long staple cotton, the best Bt cotton growers are estimated to have doubled or tripled yield using Ngwe chi 6 which requires one third less insecticides, resulting in a net significant increase in income (GAIN, USDA/FAS, 2010). The increase in income can be up to three times the income of competing crops such as beans, pulse and sesame, and can even be higher than the income from rice. Yield of long staple cotton has risen steeply from 2007 (coincides with introduction of Bt cotton Ngwe chi 6) to 2009 whilst the yield of the short staple cotton has remained stagnant (Figure 45).

Figure 45. Comparing Yield of Long Staple Bt Cotton, Short Staple Cotton and National Average, 2000 to 2009



Source: Adopted from GAIN, USDA FAS, 2010.

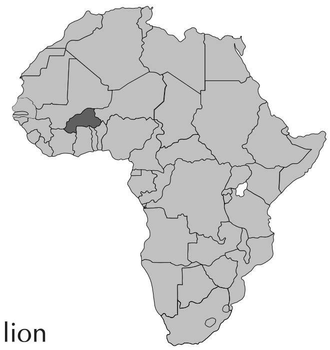
BURKINA FASO

2011 was the fourth year for farmers in Burkina Faso to benefit significantly from Bt cotton. Out of a total of 424,810 hectares planted to cotton in the country, 247,000 hectares or 58% were planted to Bt cotton. While there was a slight decrease of 5% or 13,433 hectares from 2010 (260,000 hectares and 65% adoption), Bt cotton still occupied more than half of total hectarage on cotton grown in 2011 and planted by 76,000 farmers. A combination of factors contributed to the marginal decline, key among them, was farmers' dissatisfaction with the purchase price offered for their 2010 cotton and rising input costs. Some farmers contested for an improvement of payment from the 245 CFA Francs (~US$0.5) set by the cotton companies to a minimum of at least 500 CFA Francs (US$1.1) per kilogram (2.2 pounds) of cotton. In the protracted and at times acrimonious negotiations that followed, some farmers were discouraged while plantings were delayed. Furthermore, two months before the onset of planting season that runs from June to mid-July, the price of fertilizer increased from 13,200 CFA Francs (~US$30) per 50-kilogram bag to 16,000 CFA Francs (~US$36),

to the disappointment of many farmers. Finally, in the central parts of the country, the rains stopped just after the farmers, cotton companies and the government had amicably resolved the disputes and resumed the planting.

In other areas, farmers did not adhere to the recommended field management practices despite provision of extension services. Coupled with mixed messages from diverse extension service providers, some of whom turned out to be unauthorized and/or unskilled, led to low grade quality of cotton in some areas. Key lessons from this experience are that successful and sustained adoption of Bt cotton and indeed other biotech crops must be supported by favorable market prices, affordable inputs and adherence to good stewardship and appropriate agronomic practices.

<u>BURKINA FASO</u>



Population: 15.8 million

GDP: US$8.1 billion

GDP per Capita: US$510

Agriculture as % GDP: 28%

Agricultural GDP: US$2.3 billion

% employed in agriculture: 93%

Arable Land (AL): 5.2 million hectares

Ratio of AL/Population*: 1.5

Major crops:
- Cotton
- Millet
- Peanuts
- Maize
- Sorghum
- Rice
- Shea nuts

Commercialized Biotech Crops: Bt Maize

Total area under biotech crops and (%) increase in 2011:
247,000 Hectares (0)

Farm income gain from biotech, 2009-2011: US$70 million

*Ratio: % global arable land / % global population

Nonetheless, the more than 50% plantings of biotech cotton despite the aforementioned challenges is a demonstration that Bt cotton in Burkina Faso continues to offer substantial benefits to farmers. With average cotton holding at 3.25 hectares per farm, there were approximately a total of 76,000 Bt cotton farmers in Burkina Faso in 2011. Benefits from Bt cotton include an average yield increase of almost 20%, plus labor and insecticide savings (2 rather than 6 sprays), which resulted in a net gain of about US$66 per hectare compared with conventional cotton.

It is estimated that Bt cotton has the potential to generate an economic benefit of up to US$100 million per year for Burkina Faso. National benefits to Bt cotton farmers

in 2009 were estimated at US$35 million representing 53% of total benefits with the balance accruing to the technology developers. Extrapolating for 2010, when the adoption rate was 65%, compared with 29% in 2009, the national benefit from Bt cotton in 2010 was about US$80 million. By inference, 58% adoption achieved in 2011 would accrue annual national benefits in the range of US$70 million. This is no mean achievement for a country with per capita GDP of US$510 per year. In 2008, for the first time ever, approximately 4,500 Burkina Faso farmers successfully produced 1,600 tonnes of Bt cotton seed on a total of 6,800 farmer fields. In 2009, approximately 115,000 hectares of Bt cotton were planted. Compared with 2008, when 8,500 hectares were planted, this was an unprecedented year-to-year increase of approximately 14-fold (1,353% increase), to 115,000 hectares, the fastest proportional increase in hectarage of any biotech crop in any country in 2009. Thus, the adoption rate of Bt cotton in Burkina Faso has increased from 2% of 475,000 hectares in 2008 to 29% of 400,000 hectares in 2009, a record 65% or 260,000 hectares in 2010 and 58% or 247,000 hectares of 424,810 hectares of total cotton in 2011.

Cotton remains Burkina Faso's principal cash crop generating over US$300 million in annual revenues. This represents over 60% of the country's export earnings (ICAC, 2006). Exports of cotton have ranged from 775,000 bales per year to 1.4 million bales. Some 2.2 million people depend directly or indirectly on cotton, often referred to locally as "white gold" (Vognan et al. 2002), "the king" (CARITAS, 2004; Elbehri and MacDonald, 2004) and "the foundation" of rural economies. Increasing productivity in cotton would therefore directly translate into a significant boost in GDP. Other commercial crops for exportation include fruits, vegetables, French beans and tomatoes.

2011 was the fourth year for Burkina Faso to benefit significantly from Bt cotton. Out of a total of 424,810 hectares planted to cotton, remarkably 247,000 hectares or 58%, were planted to Bt cotton by 76,000 farmers. In 2011, Bt cotton occupied more than half of total hectarage on cotton in the country. Indeed, had it not been for the late planting due to the protracted disputes over the increasing rise of inputs and dissatisfaction with prices offered, the adoption rate would have exceeded 75% or 300,000 hectares in 2011. This unprecedented high adoption rate speaks for itself in terms of the success of Bt cotton in Burkina Faso, the benefits it offers and the trust of up to 100,000 resource-poor farmers in the new technology. In 2008, the first 8,500 hectares of commercial Bt cotton was planted in the country by approximately 4,500 Burkinabe farmers. This hectarage successfully produced 1,600 tons of Bt cotton seed on a total of 6,800 farmer fields. In 2009, approximately 115,000 hectares of Bt cotton were planted. Compared with 2008, when 8,500 hectares were planted, this was an unprecedented year-to-year increase of approximately 14-fold (1,353% increase), to 115,000 hectares, the fastest proportional increase in hectarage of any biotech crop in any country in 2009. Thus, the adoption rate of Bt cotton in Burkina Faso has increased from 2% of 475,000 hectares in 2008 to a substantial 29% of 400,000 hectares in 2009 and a record 65% adoption or 260,000 hectares in 2010. In 2011, approximately 247,000 hectares of Bt cotton or 58% were sown out of the 424,810 hectares on cotton nationally. There was a slight decline of 13,433 hectares due to a combination of pricing, institutional and management issues as well as a spell of sporadic rains.

It is estimated that Bt cotton has the potential to generate an economic benefit of up to US$100 million per year for Burkina Faso, based on yield increases of up to 30%, plus a two-thirds reduction in insecticides sprays, from a total of 6 sprays required for conventional cotton, to only 2 for Bt cotton.

The potential economic impacts of insect resistant (Bollgard®II) cotton in Burkina Faso are significant. Even with the application of recommended insecticides, crop losses of 30% or more due to insect pests of cotton have been recorded (Goze et al. 2003; Vaissayre and Cauquil, 2000). On average, at the national level, the annual cost for insecticides for the control of cotton bollworms and related pests is US$60 million per year (Toe, 2003). However, insecticides are proving ineffective with losses due to bollworm as high as 40% even with the full treatment of insecticides (Traoré et al. 2006). Moreover, Bt cotton may prove to be the only option in areas where pest infestations are so high that growing conventional cotton with insecticides is unprofitable. Adoption of Bt cotton is thus inspired by the need to improve productivity, raise farmers' incomes and reduce pesticide use. In 2009 alone, 650,000 tonnes were harvested depending on climatic conditions.

Insect pests and drought are the two significant constraints to increased productivity in the country. All the cotton is produced by small resource-poor subsistence farmers, similar to the situation in countries like China and India. Yield is however low at approximately 367 kg per hectare, compared with 985 kg per hectare in the USA (Korves, 2008). In an effort to address the challenge posed by insect pests, the national research institute, Institut de l'Environnement et de Recherches Agricoles (INERA), field tested Bt cotton over a four-year period (2003 to 2007) with excellent results. INERA scientists in collaboration with Monsanto incorporated the Bt gene (Bollgard®II) into selected popular cotton varieties that are well adapted to the local environment. After rigorous risk assessment and stakeholder consultations, the National Bio-Security Agency approved two varieties of Bt cotton for seed production and commercialization.

A well-conducted survey in 2009 (Vitale et al. 2010), has provided a detailed analysis of the impact of Bollgard®ll in Burkina Faso, and is summarized below:

- The yield advantage of Bollgard®ll over conventional was 18.9%.
- Yield increase plus labor and insecticide savings (2 rather than 6 sprays) resulted in a gain of US$65.57 per hectare compared with conventional cotton; this translated to a 206% increase in cotton income.

- For the average cotton farm with 3.16 hectares of cotton, Bollgard®II increased farm income by US$207.20; INERA surveys indicated that the average cotton farm income of US$657.11 increased by 31% with the use of Bollgard®II.
- The main benefit of Bollgard®II derives from the increase in yield whereas the reduction of production costs associated with four or less insecticide sprays is offset by the higher cost of the seed.

Elsewhere, Falck-Zepeda et al. (2008) studied potential payoffs and economic risks of adopting biotech cotton in 5 countries in West Africa namely; Benin, Burkina Faso, Mali, Senegal and Togo. The study concluded that Bt technology needs to be adopted, in order to 'catch up' with major cotton-producing countries in the rest of the world. Under the assumptions of the model, all of the studied countries would be worse off economically by not adopting Bt cotton. Referencing the cotton initiative in the WTO's Doha Round of discussions, a paper from the World Bank (WPS3197, Anderson et al. 2006) concluded that cotton-growing developing countries in Africa and elsewhere do not have to wait until the Doha Round is completed before benefiting from increased income from cotton.

The higher yield of Bt cotton compared with conventional cotton results in a more competitive product for the international cotton market and higher profits for small resource-poor subsistence farmers, thus making a contribution to the alleviation of their poverty. The scientific work to evaluate performance and selection of the two approved varieties was done by local scientists under authority of Burkina Faso's National Bio-Security Agency. The capability of local researchers to produce Bt cotton seed locally counters the long-held perception of dependency on foreign firms for seed. The State is co-owner of the genetically modified varieties with Monsanto. The price of the seed and the distribution of value added were determined by mutual agreement. Royalties have been negotiated in such a way that the technology fee accruing to Monsanto will be dependent on the farmer's income. The general formula is that the value of increased yield plus savings in insecticide sprays will be considered as gross income which will be divided into three parts. Two-thirds will remain at the farm gate, thus, most of the gain goes to the farmers with the remaining one-third to be shared between Monsanto and the seed companies that provide the seeds for planting.

The cotton sector is well organized into village associations and cotton companies that have exclusive rights to buy seed cotton from producers and provide them with inputs, including seed. The main cotton producing regions are in the west which is covered by the Textile Fiber Company of Burkina Faso SOFITEX. Another company, the Cotton Society of Gourma (SOCOMA) takes care of production in six provinces in the east (SOCOMA, 2007). FASO COTON situated in central Burkina Faso is the smallest company. It covers 11 provinces grouped into 5 regions. Table 36 presents a summary of the area planted on cotton, which also includes the area set aside for seed for 2012. Total area planted to Bt cotton is 247,000 hectares out of 424,810 hectares of the total area planted

Table 36. Summary of Area Sown to Conventional and Bt Cotton in Burkina Faso, 2011

Region	Area planted (Hectares)			Area for Seed Production (Hectares)		
	Total Cotton	Bt cotton	%	FK95 R2	FK96 R2	TOTAL
FASO COTON						
Zorgho	3,765	1,235	33			
Tenkodogo	3,813	3,371	88			
Manga	5,281	2,712	51			
Pô	5,343	5,062	95	2,200		2,200
Kombissiri	2,319	1,570	68			
SOCOMA						
Fada	26,681	24,100	90	2,669	0	2,669
Diapaga	29,146	25,264	87	2,880	0	2,880
SOFITEX						
Banfora	55,675	26,004	47	4,500	0	4,500
Bobo	63,079	31,270	50	4,000	0	4,000
Dedougou	69,185	43,543	63	11,000	1,000	12,000
Diebougou	28,963	14,285	49	4,500	0	4,500
Hounde	62,250	30,724	49	3,757	3	3,760
Ndorola	38,806	21,238	55	7,500	0	7,500
Koudougou	30,505	16,188	53	3,000	2,500	5,500
TOTAL	424,810	246,566	58%	46,006	3,503	49,509

Source: Compiled by ISAAA, 2011.

to cotton in 2011. This covers fifty eight percent (58%) of total cotton area planted to biotech cotton by 76,000 farmers.

Burkina Faso serves as an example within the Economic Community of West African States (ECOWAS) for its development capabilities in biotechnology with Bt cotton in a legal context. The Bt cotton program, initiated and expedited by the Government of Burkina Faso can serve as a model for many other developing countries growing cotton as well. It is also consistent with the recommendation of the 2008 G8 Hokkaido meeting which recommended the utilization of biotech crops acknowledging the significant and multiple benefits they offer. Burkina Faso, as the leader of the group of four cotton growing countries in West Africa (Burkina Faso, Benin, Chad and Mali) is now in a position to share its important knowledge and experience on Bt cotton with its neighboring countries, so that they, if they so wish, can expedite the commercialization of Bt cotton in their respective countries. This would ultimately expedite the commercialization process in those countries for the benefit of their cotton farmers. It is noteworthy that these countries are beginning to put regulatory mechanisms in place as a first step towards preparing themselves for the safe and responsible uptake of the technology. The National Assemblies of Mali and Togo for example, passed national biosafety laws in 2008 (James, 2008). In 2011, two other West African countries Ghana and Nigeria also passed their biosafety laws, an indication that the Burkina Faso experience is inspiring more and more countries into putting governance mechanisms for safe use of modern biotechnology.

Political Will and Support

President of Burkina Faso, Honorable Blaise Compaore's statement on GMOs during the National Peasants Day 2010 ***"In a continent that is hungry, the GM debate should be very different. The technology provides one of the best ways to substantially increase agricultural productivity and thus ensure food security to the people. In the cotton sector, for example, Burkina Faso has succeeded in increasing its production under current conditions, but it will be difficult to exceed one million tonnes. But with falling prices, we have no choice but to produce in quantity. And biotechnology may allow us to reach 2 to 3 million tons."***

Farmer Testimonials

Interview with Mahama Ilboudo, Cotton Farmer from Douaba Village – September 2011

Mr. Mahama Ilboudo is a small scale farmer from Douaba village in the southern central part of the country, about 80 km from Burkina Faso's capital city of Ouagadougou. The year 2011 was his 3rd consecutive year of growing transgenic cotton but has 13 years experience in cotton farming. He also grows millet, maize, groundnuts and eggplants in his 0.5 hectare of land. He has 2 wives and 10 children and therefore enough people to assist in the farm.

Asked to comment which of the two is more motivating to grow, Bt cotton and conventional cotton, given his long experience in cotton farming, he said, ***"Sincerely, there is no comparison between the two. I have grown Bt cotton since 3 years ago and I have realized that Bt cotton is far more beneficial than conventional cotton. Among other advantages, for Bt cotton, we have less spraying to do, which makes farming less strenuous compared to the work involved in growing conventional cotton. What is certain is that we save on time, which can be used to do other things. There is also a significance increase in terms of harvest."***

Unfortunately, he had problems with land ownership and could only plant 0.5 hectares of Bt cotton.

He has tried to maximize on use of organic fertilizer to enrich the soil and give more nutrients to the cotton. His hope, like that of many Burkinabe farmers in his neighbourhood is that they will get enough yields from their small farms to feed the many mouths in the family. Challenges encountered include water scarcity, increased prices of farm inputs and equipment, and low prices for their cotton.

Interview with Tasséré Ilboudo, Bt cotton farmer, Bensboumbou village – September 2011

Fifty seven year old Mr. Tasséré Ilboudo is a resident of Bensboumbou village in Toécé section of Bazèga province, 80 km from the capital city of Ouagadougou. He is the chairman of the Bazèga Provincial Union of cotton farmers (UPPC). He has 4 wives and 16 children, and says everyone among those who are old enough works on the farm. He has been growing cotton for14 years. He also grows maize, millet and groundnuts. The year 2011 was his 3rd year of growing Bt cotton. He belongs to the Bensboumbou GPC (cotton farming group) composed of 100 farmers all of whom grew biotech cotton in 2011.

Asked why he and his group chose to grow Bt cotton, he laughs and says, ***"You know, every human being would like to improve his or her farm enterprise, in order to get enough funds to provide for his/her family. Our decision is clear; we have decided to grow GM cotton because we are satisfied in terms of its yield, and it gives us increased profitability. In addition to that, we do less spraying with Bt cotton. There were moments when our colleagues paid dearly for using pesticide. One day, one of our colleagues collapsed. We had to carry him to an emergency clinic. Fortunately he did not die. This means that by using too many pesticides, our health is threatened and even deteriorates."***

He has planted 4 hectares and says if the rains continued till 15 October 2011, the harvest would be very good. Generally he gets 1.1 tonnes per hectare on average. Therefore, he expects to harvest about 4.4 tonnes of Bt cotton. His advice to others: ***"It is the person inside the house who would know that its roof has holes or not and in our case, only a Bt cotton farmer would be able to testify on the benefits of Bt cotton. To my knowledge, nobody forced me or the farmers in my group to grow Bt cotton. We cannot do something which will not yield much interest, just for the purpose of satisfying somebody. Therefore, skeptical farmers should stop harming their business, especially now that we have an opportunity to get more money."*** Like other farmers in Burkina Faso, Tasséré expects better purchasing price for their cotton and reduced price for seed.

Interview with Mrs. Rakiéta Sawadogo, lady cotton farmer, Balavé village – October 2011

Mrs. Sawadogo Rakiéta comes from Mouhoun region in the Western part of the country, also known as the bread basket of Burkina Faso, which is 170 km from Bobo-Dioulasso, the second town of Burkina Faso and 535 km from the capital city of Ouagadougou. She belongs to the Wendsongdo cotton women farmer association. She is married with five children. They joined together as a group after realizing that cotton gives many benefits, which could help them deal with some of their problems. In her farmer group, twelve of them grow Bt cotton. They also grow ground nuts and sesame.

The year 2011 was their 2nd year to grow Bt cotton. Asked why they choose to grow Bt cotton, she said, ***"We chose to grow Bt cotton because we are women. The maintenance of conventional cotton is difficult. The labor involved in it is enormous for a woman. For example, it is really hard for a woman to carry the spraying machine and walk about a one hectare field, spraying. On the other hand, taking care of Bt cotton does not require much effort. It only requires two sprays instead of the six for conventional cotton."***

The association has 12 hectares of Bt cotton with some of the women having 0.5 hectares; others 1 hectare and larger ones having 2 hectares. Rakiéta has one hectare. She expects to harvest 1 tonne but with the lack of rains, she wouldn't make any prediction since at the flowering stage, the crop became weak. According to her, the most challenging thing was the delay in acquiring Bt cotton seeds. The other problem was the scarcity of rains. Due to lack of rains, some of the seeds rot and they were obliged to buy fresh Bt cotton seeds, which are expensive.

Asked why their group was not doing the 3rd year of growing Bt cotton like many others in the province she says, ***"Initially, people were saying that Bt cotton leaves can kill animals and Bt cotton causes bareness. This scared us but afterward, we realized that those were lies. So far, no animal has died of grazing on Bt cotton and some of our group members have given birth this year,"*** she proudly concludes the interview.

MEXICO

In 2011, Mexico planted 161,500 hectares of biotech cotton, equivalent to 87% of the 185,000 hectares of the national cotton hectarage and approximately 14,000 hectares of biotech RR®soybean for a country total of 175,500 hectares of biotech crops, compared to 71,000 hectares in 2010; this is an impressive performance by any standard. Plans are in place to make Mexico self sufficient in cotton. Following productive discussions between the private, social and public sectors to develop a "best practices regulatory system" that would facilitate predictable access to biotech

cotton for farmers in Mexico, approval has been granted to commercialize up to ~340,000 hectares of specific biotech cotton (BollgardII®/Flex and RR Flex) to be planted annually in specific northern states of Mexico. The most significant development in Mexico in recent years was the planting of the first biotech maize trials in the country in 2009. After an 11 year moratorium, the Mexican government approved 21 experimental field trials of GM maize; Mexico plants just over 7 million hectares of maize and imports about 10 million tons per annum at a foreign exchange cost of US$2.5 billion. Mexico is estimated to have enhanced farm income from biotech cotton and soybean by US$121 million in the period 1996 to 2010 and the benefits for 2010 alone is US$19 million.

MEXICO

Population: 107.8 million

GDP: US$1,088 billion

GDP per Capita: US$10,230

Agriculture as % GDP: 4%

Agricultural GDP: US$43.5 billion

% employed in agriculture: 14%

Arable Land (AL): 25.6 million hectares

Ratio of AL/Population*: 1.0

Major crops:
- Maize
- Soybeans
- Cotton
- Wheat
- Rice
- Coffee

Commercialized Biotech Crops:
- Bt Cotton
- HT Soybean

Total area under biotech crops and (%) increase in 2011:
175,500 Hectares (+100%)

Farm income gain from biotech, 1996-2010: US$121 million

*Ratio: % global arable land / % global population

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 2011, Mexico increased its biotech crop area substantially by approximately 150% to 175,500 hectares from 71,000 hectares in 2010. The increase was all due to the increase in biotech cotton with biotech soybean occupying the same area as 2010 at 14,000 hectares. Between 2010 and 2011, Mexico increased its biotech cotton area from 58,000 hectares to 161,500 an impressive 178% increase. About half of this increase was due to an increase in total cotton plantings in Mexico which increased by 73% to 185,000 hectares from 107,000 hectares in 2010. In 2011, 87% of all the cotton in Mexico, equivalent to 161,500 hectares was biotech compared with a 73% adoption rate in 2010. Thus, biotech cotton hectares in Mexico increased due to both an adoption increase and a hectare increase. Of the 161,500 hectares of biotech cotton in Mexico in 2011, 155,000 hectares or 95% were the stacked product Bt/HT and 6,500 hectares or 5% were herbicide tolerant HT. Mexico plants just over 7 million hectares of maize and imports about 10 million tons per annum at a foreign exchange cost of US$2.5 billion The substantial gain in biotech cotton in Mexico is impressive. In addition, there were 4,180 hectares of herbicide tolerant soybean in Mexico with a 17% adoption rate; they were planted in three states in Mexico in 2011: Peninsula (9,042 hectares), Tamaulipas (1,647 hectares) and Chiapas (3,491 hectares). The distribution between states is shown in Table 37 with the highest hectarage and percent adoption rate in Tamaulipas at 9,042 hectares and a 50% adoption rate.

Table 37. Total and Biotech Soybean Hectares Planted in Mexico in 2011, by State

Regions	Total Hectares	Biotech soybean (% adoption)	
Tamaulipas	55,000	1.647	(3%)
Peninsula	18,000	9,042	(50%)
Chiapas	12,500	3,491	(28%)
TOTAL	**85,500**	**14,180**	(17%)

Source: AgroBIO, Mexico, 2011.

After being subject to an experimental regulatory system for the last 13 years, and in the framework of the Biosafety Law, in 2011 the private sector, through AgroBIO Mexico, the Agriculture and Environment Ministries and key agricultural sector representatives together evolved a cotton regulatory framework that incorporated the best practices for the advancement of experimental trials to a pre-commercial and commercial phase. This new Best Practice Regulatory Framework now provides an appropriate cost/time-effective system that is responsible, rigorous and more transparent, and has the resources to operate effectively. It has facilitated the increase of cotton production to a total of 185,000 in 2011 (87% biotech) and this is expected to climb to 280,000 hectares by 2012, reducing imports from 66 to 45% in 2011 with significant positive impacts on the Mexican economy, including the creation of 7,000 additional direct jobs which will improve the income of more than 4,500 families.

Mexico is now positioned on a clear path to achieve in the midterm, cotton self-sufficiency and has the ability to become a key global exporter of this important crop. This success story is a good example of the benefits that can result from building alliances between Government authorities, farmer representatives and the private sector to support the ambitious expectations of Mexico to move forward to solidify its agricultural goals.

Mexico grows just over 8 million hectares of maize annually. The most significant development in Mexico in 2009/10 was the planting of the first biotech maize trials in the country. After an 11 year moratorium, the Mexican government approved 21 experimental field trials of GM maize.

Following several years of debate, the Mexican Congress approved the GMO Biosafety Law on 15 February 2005 that permitted the introduction of biotech crops despite the debate regarding gene flow in maize. Under this law, authorization for the sale, planting and utilization of biotech crops and products is on a case-by-case basis, under the control of the Ministry of Agriculture and Ministry of Environment and policy coordination by the "Comision Intersecretarial de Bioseguridad de los Organismos Genéticamente Modificados" (CIBIOGEM), an inter-ministerial body. Increasing trade in biotech crops made this *ad-hoc* law necessary, and Mexican policy makers believe it was a major step forward in dealing with an issue that required urgent attention.

The Mexican government issued more than 20 permits for field trials in 2010/11 and further permits for 2011 in the northern states of Mexico in Sonora, Sinaloa, Tamaulipas, Chihuahua and Coahuila. The trials were approved following the passage of the GMO Biosafety Law (2005), its By Laws (2008) and the Special Protection Regime for Corn, which was concluded in March 2009. All the trials were conducted by independent scientists from recognized local Universities and Public Research Institutions. The evaluation was focused on three fundamental aspects: agronomic attributes of biotech maize versus its conventional counterpart; the biological effectiveness of insect resistant maize and the impact on non-targeted organisms; and the biological effectiveness of herbicide tolerance maize. The field trials of biotech maize featured the technologies listed in Table 38.

The field trials of biotech maize in Mexico in 2010 and 2011 demonstrated that biotech maize is as safe as conventional maize, and effective; this is consistent with international experience with commercializing biotech maize in around 20 countries around the world for more than 15 years. Further trials, planned shortly, will evaluate biotech maize pre-commercially (pilot phase); these trials will generate valuable information regarding the use of adequate biosafety measures that will allow coexistence of biotech and conventional maize to be practiced on a realistic and pragmatic basis, as well as to provide accurate cost-benefit data regarding economic benefits for farmers. The granting of the first pilot permit approvals for biotech maize trials is expected by the end of 2011.

Table 38. GM Technologies Featured in the Field Trials

Characteristic	Event
Insect Resistance (IR)	DAS 01507-1
Herbicide Tolerance (IR)	MON 00603-6
Insect Resistance + Herbicide Tolerance (IR/HT)	MON 89034-3 × MON 00603-6 DAS 01507-1 × MON 00603-6 MON 89034-3 × MON88017-3

Source: AgroBIO, Mexico, 2011.

Benefits from Biotech Crops in Mexico

Mexico is estimated to have enhanced farm income from biotech cotton and soybean by US$120.5 million in the period 1996 to 2010 and the benefits for 2010 alone is estimated at US$19 million (Brookes and Barfoot, 2012, Forthcoming).

SPAIN

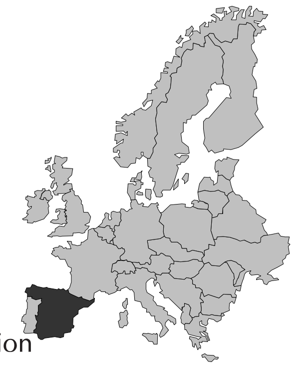
> **Spain is the lead biotech crop country in Europe, with 85% of all the Bt maize hectares planted in Europe in 2011. Spain has successfully grown Bt maize for fourteen years and grew an all time record 97,326 hectares of Bt maize hybrids approved in Spain and the EU in 2011, compared with 76,575 hectares in 2010; this is a substantial 27% increase from 2010. Total plantings of maize were 10% more in 2011 at 351,141 hectares compared with 320,289 hectares in 2010, leading to an adoption rate in 2011 of 28% compared with 24% in 2010. Enhanced farm income from biotech Bt maize is estimated at US$113.9 million for the period 1998 to 2010 and for 2010 alone at US$20.4 million.**

Spain is the only country in the European Union to grow a substantial area of a biotech crop. In 2011, Spain grew 85% of all the 14,490 hectares of biotech maize in the EU. Note that the 2011 estimates by the Government of Spain include, Bt maize hybrids approved in other EU countries. Spain has successfully grown Bt maize for fourteen years since 1998 when it first planted approximately 22,000 hectares out of a national maize hectarage of 350,000 hectares. Since 1998, the area of Bt maize has grown consistently reaching a peak of over 50,000 in the last four years, qualifying Spain as one of the 16 biotech mega-countries globally growing 50,000 hectares or more of biotech crops. In 2011, the Bt maize area in Spain reached a record 97,326 hectares compared with 76,575 hectares in 2010 and the adoption rate in 2011 was 28%. In 2011, total maize plantings at 351,141 hectares were 10% more than 2010 when the adoption rate was 24% and total maize plantings were 320,289 hectares. This is despite the fact that in 2011 the factor used by Government for calculating hectares of Bt maize was 85,000 seed per hectare compared with 80,000 seed /hectare in 2010 – this has the effect of underestimating the Bt maize hectares for 2011. It should be noted that the adjustment of seed rate was necessary for 2011 because regions such as Extremadura and Andalusia, where seeding rates are high, increased maize hectares substantially in 2011. Thus, both absolute Bt maize hectares increased in 2011 by 2,075 hectares or 27%, as well as an increase in the adoption rate to 28% from

24%. The principal areas of Bt maize in Spain in 2011 were in the provinces of Aragon (41,368 hectares) where the adoption rate for Bt maize was 64% compared with 51% in 2010, followed by Cataluña (29,632 hectares) with the highest adoption rate of 83%, similar to last year's 84%, with significantly more area of Bt maize in Extremadura (10,567 hectares), with an adoption rate of 20%; the balance of Bt maize was grown in eight other provinces in Spain in 2011 (Tables 39 and 40).

Currently, varieties of nine seed companies, including event MON810 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



Population: 44.6 million

GDP: US$1,604 billion

GDP per Capita: US$35,220

Agriculture as % GDP: 3%

Agricultural GDP: US$48.12 billion

% employed in agriculture: 4%

Arable Land (AL): 12.6 million hectares

Ratio of AL/Population*: 1.1

Major crops:
- Grape
- Maize
- Wheat
- Sugarbeet
- Potato

Commercialized Biotech Crops: Bt maize

Total area under biotech crops and (%) increase in 2011:
97,326 Hectares (+27%)

Farm income gain from biotech, 1996-2010: US$114 million

*Ratio: % global arable land / % global population

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 the area planted to Bt maize, the approval of NK603, and particularly, a progressive and tolerant government policy especially in relation to coexistence.

Spain is the leader in biotech crops in the EU and conducts 42% of all the biotech field trials planted in the EU. In Spain, field trials of biotech crops are very carefully controlled and must be reviewed and recommended for approval by the National Biosafety Committee and are then subject to final approval by the Federal Government.

Table 39. Hectares of Biotech Bt Maize in the Autonomous Communities of Spain, 1998 to 2011

Provinces	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aragon	11,500	7,300	9,000	4,250	9,200	12,592	25,547	21,259	23,734	35,860	31,857	29,540	28,652	41,368
Cataluña	1,700	3,000	4,500	3,250	5,300	5,430	15,699	16,830	20,365	23,013	25,298	28,260	28,258	29,632
Extremadura	1,000	2,500	2,500	600	1,500	1,899	2,026	1,171	2,071	6,460	10,416	8,308	7,770	10,567
Castilla-La Mancha	4,500	6,800	5,650	870	4,150	7,682	8,197	7,957	4,176	3,659	4,739	3,128	3,187	5,817
Andalucia	780	2,800	1,500	450	1,800	2,067	2,770	2,875	298	592	1,372	2,175	3,773	5,244
Navarra	1,760	300	220	80	500	1,387	2,446	2,604	2,821	5,327	5,150	4,397	4,477	4,096
Madrid	660	1,560	1,970	1,940	780	1,034	1,385	155	80	193	381	130	340	418
Valencia	190	300	150	100	20	72	73	293	0	0	14	0	23	107
Islas Baleares	2	2	26	0	30	6	29	29	0	3	3	92	75	52
La Rioja	25	30	30	0	0	0	35	41	122	4	11	8	5	21
Castilla Y Leon	200	360	270	0	0	74	0	12	0	13	28	19	0	6
Murcia	0	0	0	0	0	0	12	0	0	24	0	0	0	0
Asturias	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cantabria	0	0	0	0	0	0	0	0	0	0	0	0	15	0
Total	**22,317**	**24,952**	**25,816**	**11,540**	**23,280**	**32,243**	**58,219**	**53,226**	**53,667**	**75,148**	**79,269**	**76,057**	**76,575**	**97,326**

Source: Ministry of Agriculture, Spain, 2011.

Table 40. Total Hectares of Maize Planted in Spain by Province, 2011 and Percent Adoption of Bt Maize

Province	Total Hectares	Percent Bt Adoption
Castilla y Leon	101,528	6
Aragon	64,989	64
Extremadura	52,000	20
Catalunia	35,350	834
Castilla-Mancha	31,475	18
Andalucia	26,851	20
Galicia	17,700	0
Navarra	12,500	33
Madrid	5,450	7
Canarias	670	0
La Rioja	600	4
C. Valenciana	559	19
Pais Vasco	437	0
Cantabria	325	0
Pais de Asturias	300	0
Balearas	285	18
R de Murcia	122	0
Total	**351,141**	**28%**

Source: Ministry of Environment Rural Development and Fisheries, Spain, 2011. Avances Suopefices y Producciones Agricolas, September 2011.

Benefits from Biotech Crops in Spain

Spain is estimated to have enhanced farm income from biotech Bt maize by US$114 million in the period 1998 to 2010 and the benefits for 2010 alone is estimated at US$20 million (Brookes and Barfoot, 2012, Forthcoming).

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. Data from the Institute of Agro-Food Research and Technology (IRTA, 2008), a 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.

Farmers' Views on Biotech Crops

Farmers from Spain, Romania and Portugal presented to the members of the European parliament (MPs) and representatives of the European Commission in Brussels a manifesto stating that ***"Biotechnology, a tool for agro-food cannot be ignored. The text in the rejection of positions and decisions against GMOs are not based in science. The safety of GM crops is guaranteed by the strictest and independent scientific assessment."***

The farmers stressed the inequality of the European Union in making decisions re. agricultural production and called for scientifically-based decisions so as not to discriminate against EU farmers who want to grow GM crops. Spanish farmers have also attested their experiences in planting GM crops saying that the cultivation of transgenic maize leads to higher yields in a more cost-effective way with higher quality grain and using less resources. The farmers noted that biotech crops which are available in other parts of the world, should also be enjoyed by farmers in the EU (Crop Biotech Update, 16 July 2010).

COLOMBIA

Colombia grew 49,333 hectares of biotech cotton in 2011, compared with 37,000 hectares in 2010, a 33% year-to-year increase. Eighty-six percent of the biotech cotton was the stacked product Bt/HT. Biotech maize was also grown on 59,239 hectares in a "controlled program", but this hectarage is not included in the global data base. Colombia is estimated to have enhanced farm income from biotech cotton by US$45 million in the period 2002 to 2010 and the benefits for 2010 alone is estimated at US$16 million.

Colombia grew biotech cotton in two semesters. In 2011, Colombia grew 49,333 hectares made up of 42,247 hectares of the stacked Bt /HT (86%) and 7,084 hectares of HT cotton (14%). Colombia first introduced Bt cotton in 2002 on approximately 2,000 hectares and in the interim, this has increased to 49,333 hectares.

Biotech maize is not approved for commercialization in Colombia. However in 2011, Colombia, for the sixth year, planted biotech maize in two seasons in a "controlled planting program" in two regions, one on the Coast and Llanos region and the other in the interior of the country. Thus, in total for the first and second semesters Colombia grew 59,239 hectares of biotech maize, compared with 35,000 hectares in 2010. Of the 59,239 hectares, over 42%, equivalent to about 24,975 hectares were the stacked traits Bt and herbicide tolerance (Bt/HT), 24,350 hectares were Bt maize (41%) and about 9,912 hectares were herbicide tolerant (HT, 17%). The biotech maize hectarage grown in Colombia is not included in the global biotech data for 2011 because it has not been approved for commercialization, and is only grown in a "controlled planting program."

Colombia has approximately 600,000 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 2010 planted 4 hectares in greenhouses near Bogota which, although commercial, are not included in the global biotech hectarage.

Benefits from Biotech Crops in Colombia

A preliminary IFPRI study (Zambrano et al. 2011) on the benefits of biotech cotton for women indicates that it saved them time and money. This resulted from spending less time on weeding (an onerous back-breaking task) and on hiring men to spray insecticides, and generally freeing up their time for other important family activities. Importantly, a major unmet need for women growing biotech cotton, that needs to be remedied, is the lack of information from the various agencies involved, from the various public and private sector agencies involved in providing various services related to biotech cotton. The study confirmed that the gender focus on women is an important aspect and needs more detailed study in Colombia, where women, as is also the case in Africa, play a key role as practitioners in biotech cotton production.

Colombia is estimated to have enhanced farm income from biotech cotton by ~US$46 million in the period 2002 to 2010 and the benefits for 2010 alone is estimated at ~US$16 million (Brookes and Barfoot, 2012, Forthcoming).

Farmer Testimonies

Sergio Valencia, has farmed corn, soybeans, coffee, citrus, tomatoes, passion fruit, banana, and African palm in Llanos Orienta les (Eastern Plains), Colombia for 20 years. He heard about the benefits of planting biotech maize in 2009 and has since then planted a 60 hectare field of biotech maize. Valencia believes that although the biotech maize seeds are slightly more expensive than conventional seeds, the extra expense translates into overall savings because planting biotech maize reduces the application of inputs. He explains that, ***"In a conventional maize crops, he would spend about 500 thousand pesos (approximately US$250) per hectare during a farming season. However, by planting biotech seeds, he has been able to reduce that amount to just 70 thousand pesos (approximately, US$35) per hectare. The use of biotech seeds has enabled him to save 86 percent in costs per hectare."*** He added that, ***"which means I get to enjoy more free time! I can focus in other activities in my farm or… just rest!"***

For all these benefits, he said, today ***"I do prefer biotechnology!"*** From now on he will continue to grow biotech crops in this region of Colombia, which has been catalogued as one of the most promising territories on agricultural development and production (Valencia, 2010).

<u>CHILE</u>

In 2011, Chile grew an all time record of 42,300 hectares of biotech maize, canola and soybean, exclusively for seed exports – this is a 150% increase on 2010, when 16,678 hectares were planted.

In 2011, Chile was projected to plant 25,000 hectares of biotech maize, 15,000 hectares of biotech canola and 2,300 hectares of biotech soybean for a total of 42,300 hectares for seed export; this is approximately 150% more than the 16,678 hectares planted in 2010-11.

Chile has a population of 16.8 million and a GDP of US$169 billion, 4% 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 13% of the population is involved in agriculture and the export market requires that the products are of top quality to compete in the global market.

From a biotech crop standpoint, it is important to recognize that Chile is the fifth largest producer of export seed in the world, with a value of US$370 million (Table 1 in Appendix 3). Chile has been producing biotech seed for export since commercialization began in 1996 and this activity is fully covered by the current law. Chile has clearly demonstrated over the last fourteen years that like the other 28 countries that commercialized biotech crops, it has all the necessary management know-how 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. Commercialization and consumption of biotech crops produced in Chile are under consideration. 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 third 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. Chile also has 80,000 hectares of potatoes which could benefit from biotechnology. The most recent REDBIO regional meeting on biotechnology recognized this opportunity for Chile to grow biotech maize for domestic consumption.

The area of biotech crops grown for seed export in Chile has shown a growth trend and plateauing over the last eight years, increasing from 10,725 hectares in 2002/03 to an all time high of 42,300 hectares in 2011 (Table 41). Multiplication of biotech seed for export is a significant business activity that was valued at approximately US$400 million in 2009, of which the value of biotech seed alone was at least US$200 million. Maize has always been the most important biotech seed crop grown in Chile and was at 25,000 hectares in 2011/12. The number of biotech seed crops multiplied in Chile is now more than 10 crop/trait combinations. The country has broad and diversified experience in successfully managing all aspects related to the growing of biotech crops for over 10 years.

Table 41. Hectares of Major Biotech Seed Crops Grown for Export in Chile, 2002/03 to 2011/12*

Crop	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Maize	10,400	8,450	7,614	12,120	17,981	25,000	30,000	28,000	9,378	25,000
Canola	110	140	746	628	444	2,500	4,200	1,200	3,500	15,000
Soybean	215	128	273	166	250	500	1,800	3,000	3,800	2,300
Total	**10,725**	**8,718**	**8,633**	**12,914**	**18,675**	**28,000**	**36,000**	**32,200**	**16,678**	**42,300**

Source: Government of Chile statistics, SAG, 2011. *industry estimates

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).

HONDURAS

Honduras grew 18,000 hectares of biotech maize in 2011, almost 20% more than 2010 (15,000) comprising 16,000 hectares of Bt/HT maize and 1 hectare each of HT maize and Bt maize.

Honduras is a poor country in Central America with a GDP per capita of US$1,966 – one of the poorest in the region. Both large and small farmers cultivate maize which is the major staple in the country. The average yield is 1.6 tons per hectare which is one of the lowest in the region; this low yield is due to several factors, including lepidopteran pests which can cause significant losses, particularly on smallholdings.

Honduras was the first country to adopt biotech maize in Central America and introduced herbicide tolerant maize in 2002 with a pre-commercial introductory area of approximately 500 hectares. In the interim, the biotech maize area increased to 15,000 hectares in 2009, and a record 18,000 hectares in 2011. In 2011, the 18,000 hectares comprised 16,000 hectares of the stacked Bt/HT maize and 1,000 hectares each of HT maize and Bt maize. The national maize crop of Honduras is approximately 362,000 hectares.

Benefits from Biotech Maize in Honduras

Assuming a modest gain of US$75 per hectare from stacked biotech maize the national benefit from 15,000 hectares would be about US$1 million per year. Preliminary results from IFPRI studies, suggest that, not surprisingly, the larger farmers (over 2 hectares) have been the initial beneficiaries of biotech maize in Honduras and studies are underway to assess the impact of biotech maize in the country. The experience of Honduras, as a small country with very limited resources in implementing a successful biosafety program can serve as a useful model and learning experience for other small countries particularly those in the Central American region. Zamorano University in Honduras has activities in biotech crops, including a knowledge sharing initiative which should contribute to a better understanding of biotech crops and facilitate more informed decisions about biotech crops, their attributes and potential benefits.

PORTUGAL

In 2011, Portugal planted an all time record of 7,724 hectares of Bt maize, compared with 4,868 hectares in 2010, a substantial 59% increase equivalent to 2,856 hectares. The adoption rate in 2011 was 6% based on total maize plantings of 137,413 hectares, up 4% from 132,488 in 2010. In 2011, a total of 7,724 hectares of Bt maize, were grown in 5 regions by Portuguese farmers, who first grew Bt maize in 1999, resumed successful planting in 2005, and since then, they have elected to continue to plant Bt maize for seven years because of the benefits they offer.

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 2011, Portugal planted 7,724 hectares of Bt maize, compared with 4,868 hectares in 2010. The adoption rate in 2011 was 6% based on total maize plantings of 137,413 hectares, up 4% from 132,488 in 2010. The major regions for planting Bt maize in Portugal are listed in Table 42 in descending order of hectarage and percent contribution to the total Bt maize national hectarage of 7,724 hectares in 2011. The region of Alentejo had the

Table 42. Major Regions Planting Bt Maize in Portugal, 2011

Region	Hectares (has.)	Percentage of National Bt Maize has.
Alentejo	4,460	58
Lisbon/de Tejo	2,294	30
Central	758	10
North	209	2
Acores	3	<1
NATIONAL	**7,724**	**100**

Source: Ministry of Agriculture, Rural Development, and Fisheries, Lisbon, Portugal, www.dgadr.pt, 13 September, 2011.

largest hectarage of Bt maize at 4,460 hectares or 58% of the national hectarage. Alentejo was followed by the Lisbon and Tejo Valley regions with 2,294 hectares of Bt maize or 30% of the national hectarage. The central region was the third region with 758 hectares of Bt maize or 10% of the national hectarage. The Northern area was the fourth region with 209 hectares of Bt maize or 2% of the national hectarage of biotech maize and the Acores region was 5th with 3 hectares. All the Bt maize in Portugal is MON 810, resistant to European corn borer. As a member country of the EU, Portugal's continued cultivation of Bt maize is an important development, acknowledging that the national maize area is modest.

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 results in biotech maize being grown in the central and southern regions of Portugal where the farms are bigger, 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 the European corn borer (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."***

CZECH REPUBLIC (CZECHIA)

In 2011, the Czech Republic grew 5,091 hectares of Bt maize in 2011, compared with 4,680 hectares in 2010, an increase of 411 hectares equivalent to 9%. This increase is despite the onerous disincentives for farmers who are required to report intended biotech plantings to government authorities inconveniently early.

The Czech Republic, more familiarly known as Czechia, approved the commercial production of a biotech crop for the first time in 2005 when it grew 150 hectares of Bt maize. In 2011, the Czech Republic grew 5,091 hectares of Bt maize in 2011, compared with 4,680 hectares in 2010, an increase of 411 hectares equivalent to 9%. This increase was realized despite the onerous disincentives for farmers who are required to report intended biotech plantings to government authorities inconveniently early. Czechia grew 150 hectares of Amflora in 2010 with none reported in 2011 and commercialization expected to resume in 2012.

The latest information shows that Czechia grew up to 400,000 hectares of maize of which the majority was for silage, and hence there is less incentive than for maize for grain production where losses are higher than for silage. It is estimated that up to 30,000 to 50,000 hectares of maize are affected by the corn borer to a degree that would warrant the deployment of Bt maize planting, thus the potential for biotech maize expansion is significant. Coexistence rules apply with 70 meters between Bt maize and conventional maize (or alternatively 1 row of buffer is a substitute for every 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 estimated that up to 90,000 hectares were infested with European corn borer (ECB), and that up to 30,000 hectares were being sprayed with insecticide to control 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.

POLAND

The hectarage planted to Bt maize in Poland in 2011 was the same as in 2010, and estimated at 3,000 hectares.

Poland has a population of approximately 38.12 million and a GDP (nominal) of US$528 billion, 5% of which is generated from agriculture equivalent to US$26.4 billion per year. Agricultural products and food stuffs represent about 8% of total exports equivalent to US$6 billion per year. Agriculture provides employment for 15% of the population, the highest percentage in the EU of which Poland is a member.

The hectarage planted to Bt maize in Poland in 2011 was the same as in 2010, and estimated at approximately 3,000 hectares. The latest information indicates that there was an estimated total of 670,000 hectares of maize grown in Poland, of which 260,000 hectares, or 39%, was used for grain, and 61% or 410,000 hectares, used for silage. 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, cost about US$35 per hectare.

Some pre-commercial Bt maize was planted in Poland in 2006 on approximately 100 hectares. In 2007, Poland commercialized Bt maize for the first time when 327 hectares were planted. Based on the positive experience of farmers who planted the 327 hectares of Bt maize in 2007, the hectarage planted to Bt maize in 2008 increased more than 8-fold to 3,000 hectares and the hectarage remained the same from 2009 to 2011. In 2007, Poland had the distinction of becoming the eighth EU country to plant Bt maize. Bt yellow maize is being used in Poland for animal feed and/or for ethanol production.

Benefits from Bt Maize in Poland

In 2007, a report entitled "The benefits of adopting genetically modified maize in the European Union; first results from 1998 to 2006 plantings," Graham Brookes (Personal Communication, 2008) reported that gross margins from Bt maize, over conventional, based on trials conducted in 2006 were on average approximately 25% higher, and associated with an increase of 2.15 tons/ha. A significant advantage of Bt maize, not captured in the benefits associated with yield increase, is the substantial decrease in mycotoxin level with multi-fold 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 a range of 44 to 103 ppm in conventional maize to a range of 0 to 8 ppm in Bt maize.

EGYPT

In 2011, Egypt planted 2,800 hectares of Bt yellow maize (MON 810) known in Egypt as Ajeeb YG®, with a year-over-year increase of 40%, compared with the 2,000 hectares in 2010. Egypt was the first Arab country to adopt biotech crops when it planted Bt maize in 2008 on 700 hectares, which climbed to 1,000 hectares in 2009, and 2,000 hectares in 2010.

Egypt with a population of 80 million lies in the northeastern corner of Africa with a total land area of approximately 100 million hectares. It is bounded by the Mediterranean Sea to the North and the Red Sea to the East and Sudan to the South. The topography of Egypt is dominated by the river Nile, the longest river in the world, which provides the critical water supply to this arid country. Only 3% of the land, equivalent to approximately 2.5 million hectares is devoted to agriculture, making it one of the world's lowest levels of cultivable land per capita. However, agriculture is considered a principal sector in the economy contributing about 13% to GDP and providing close to 30% of employment. About 90% of the agricultural land is in the Nile Delta and the balance is within a narrow strip along the Nile between Aswan and Cairo. The rich cultivated land, irrigated by the Nile, is very fertile and allows double cropping. Nevertheless, the meager area of cultivable land as well as problems related to salinity and water, results in Egypt being dependent on imports for about half of its food supply. The principal crops are rice, wheat, sugarcane and maize. The government policy is to enhance agriculture as a major contributor to the national economy, by promoting privatization and decreasing government controls and subsidies. The new Minister for Agriculture and Land Reclamation Dr. Salah Farag, appointed in 2011, re-affirmed the use of biotech plants as one way of overcoming some of the serious problems facing the country. The major challenges for agricultural development in Egypt are the limited arable land base, erosion of land resources, loss of soil fertility and salinity and the high rate of population growth of 1.9%.

In 2011, Egypt continued to plant 2,800 hectares of Bt maize (MON 810: Ajeeb YG®). The country first planted Bt yellow maize in 2008, with 700 hectares, which increased to 1,000 hectares in 2009 and to 2,000 hectares in 2010. Egypt was the first country in the Arab world to commercialize biotech crops, by planting a hybrid Bt yellow maize, Ajeeb YG®. Egypt grew approximately 660,000 hectares of maize in 2010, and annually imports 4.5 million tons of yellow maize valued at US$1.3 billion. Of the 660,000 hectares of maize, 160,000 hectares (25%) are yellow maize and the balance of 500,000 hectares is white maize. The biotech maize hybrid is resistant to three maize insect pest borers (Massoud, 2005). Field trials were conducted from 2002 to 2007, which indicated that the yield of Bt yellow maize can be increased by up to a significant 30% over conventional yellow hybrid maize.

Egypt has a well established biotechnology institute, the Agricultural Genetic Engineering Research Institute (AGERI), which is the lead crop biotech institute in the Arab world, and the centre of excellence in biotechnology, molecular biology, and genetic engineering research focusing on product development. AGERI is within the Agricultural Research Centre (ARC) of the Egyptian Ministry of Agriculture and Land Reclamation. It is dedicated to the production of biotech crops and biotechnology-based products. AGERI's objective is to maximize production efficiencies with scarce water resources and arable land, reduce environmental degradation and minimize production risks for farmers. The institute is implementing a broad range of biotech crop activities, including the development of resistance to biotic stresses caused by viruses, insect, fungal pests and nematodes, and tolerance to the abiotic stresses of drought and salinity. Some basic research is also conducted on genome mapping, and protein and bio-molecular engineering. AGERI has several collaborative research programs with universities and institutions internationally. Several biotech crops are under development including wheat, barley and cotton tolerant to drought and salinity. Wheat is the most important crop in terms of crop value and increasing wheat production is considered a high priority in Egypt. Cultivated area of wheat crop is almost 1.23 million hectares with a total production of about 7.0 million tons/year. The total consumption of wheat is 14.0 million tons with a gap of 50% between production and consumption. A collaborative research team with AGERI has developed drought-tolerant transgenic wheat (with *hvaI* gene F13) which was cultivated in 2011. The event was evaluated under rainfed conditions at the North coast of Egypt with promising results. Some of the transgenic lines have 20% more grain yield than their non-transgenic parental genotype.

There is a suite of other projects incorporating resistance to various viruses in potato, squash and melons (zucchini yellow mosaic), tomato (tomato yellow leaf curl), and banana (bunchy top and cucumber mosaic). Similarly, there is also another set of projects incorporating resistance to insect pests, mainly featuring Bt genes, including projects on the *Gossypium barbadense* species of cotton (bollworm and other lepidopteran pests), potato (tuber moth), and maize (*Sesamia* stem borer), most of which are nearing commercialization.

Benefits from Bt Maize in Egypt

Developers of Ajeeb YG® have reported the following economic benefits in 2009. Increase in yield per hectare resulted in a gain of US$267, plus an insecticide saving equivalent to US$89 per hectare for a total gain of US$356 per hectare, minus the additional cost of seed per hectare at US$75 for a net benefit per hectare of US$281. Extrapolating from these data, the benefits from planting 2,800 hectares in 2011 is of the order of US$785,000. On a national basis the estimated annual opportunity cost to Egypt of not deploying Bt maize, based on a 33% and 66% adoption on the 160,000 hectares of yellow maize is US$15 million and US$30 million annually, respectively. Additionally, the use of Bt maize in Egypt would have an import substitution value, from increased self-sufficiency of maize plus savings of foreign exchange.

SLOVAKIA

In 2011, the hectarage of Bt maize in Slovakia was 761 compared with 1,248 hectares in 2010. The decrease is mainly due to the fact that maize in Slovakia is mostly for grain, (not silage) which has to be laboriously reported, which becomes an additional administrative chore and a disincentive for farmers seeking to plant Bt maize.

Slovakia grew its first commercial biotech crop, Bt maize in 2006 when 30 hectares of Bt maize were grown for commercial production by several farmers. In 2007, the area increased 30-fold to 900 hectares and in 2008 it again increased by over 111% to 1,931 hectares. In 2011, the hectarage of Bt maize in Slovakia was 761 compared with 1,248 hectares in 2010. The decrease is mainly due to the fact that maize in Slovakia is mostly for grain, (not silage) which has to be reported, and which becomes an additional administrative chore and a disincentive for farmers seeking to plant Bt maize. As a result of several factors associated with the economic recession and decreased plantings of hybrid maize, the Bt maize hectarage in 2009 decreased to 875 hectares but increased again in 2010 to 1,248 hectares, equivalent to a significant year-over-year increase of 43%.

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 is estimated to have grown 236,000 hectares of maize in 2008 comprising 157,000 for grain and 79,000 for silage.

Benefits from Biotech Crops in Slovakia

It is estimated that from a third to a half of the 240,000 hectares of maize in Slovakia is infested with European corn borer 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

Romania grew its first 350 hectares of Bt maize in 2007 which increased to 7,146 hectares in 2008. Following the severe economic recession, (particularly the restricted access to credit), the biotech maize area in 2009 declined to 3,243 hectares, to 822 hectares in 2010 and 588 hectares in 2011. There were three factors involved in the lower hectarage in 2011: a decrease in the domestic price of maize which in turn led to decrease total plantings of maize; onerous and bureaucratic reporting requirements for farmers regarding intended planting details, and a decreased infestation of the insect pest *Ostrinia* which Bt controls. Up until 2006, Romania successfully grew over 100,000 hectares of RR®soybean, but on entry to the EU in January 2007, was forced 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. It is noteworthy that because conventional soybeans yield substantially less (approximately up to 30%) than RR®soybean, the hectarage of soybeans has dropped precipitously in Romania from 177,000 hectares in 2006 to 48,000 hectares in 2009. 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. Romania is estimated to have enhanced farm income from RR®soybean of US$45 million in the period 2001 to 2008 after which it had to discontinue planting when Romania became an EU member state.

Romania grew its first 350 hectares of Bt maize in 2007 which increased to 7,146 hectares in 2008. Following the severe economic recession, (particularly restricted access to credit), the biotech maize area in 2009 declined to 3,243 hectares, to 822 hectares in 2010 and 588 hectares in 2011.

There were three factors involved in the lower hectarage in 2011: a decrease in the domestic price of maize which led to decrease total plantings of maize; onerous reporting requirements for farmers regarding intended planting details, and decreased infestation of the insect pest *Ostrinia* which Bt controls. In 2011, the major hectares of Bt maize were planted in the following counties in Romania; Braila County, 261 hectares, Arad County 224 hectares, Timis County 84 hectares, and Cluj county 19 hectares, for a total of 588 hectares.

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. It is noteworthy that because conventional soybeans yield substantially less than RR®soybean, the hectarage of soybeans has dropped precipitously in Romania from 177,000 hectares in 2006 to only 46,000 hectares in 2008. 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. Romania grew its first 350 hectares of Bt maize in 2007, and this increased more than 20-fold in 2008, to 7,146 hectares; this was the highest percent increase for any country in 2008, acknowledging that the base hectarage of 350 hectares in 2007 was very low. Following the severe economic recession in 2009, (particularly restricted access to credit), and decreased planting of hybrid maize, the biotech maize area in 2011 receded to 588 hectares. 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 if and when it is eventually approved for planting in the EU, thus it is appropriate to discuss the history of Romania and RR®soybean. Romania ranked equally with France as the third largest producers of soybean in Europe, after Italy and Serbia Montenegro, 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 million 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 ranged 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 was taken by the Romanian Government, required by the European Union, to discontinue cultivation of biotech soybean as of January 2007 to qualify for membership in the EU, where RR®soybean has not been approved for planting. Many independent observers support the very strong views of Romanian farmers who are very much opposed to the decision to discontinue RR®soybean cultivation and believe that there were 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 weed-control program, even with more expensive alternates, resulting in significant financial losses for farmers growing conventional soybeans, and less affordable soybeans for consumers. Second, given that use of RR®soybean also results in better weed control in the crops following it in the rotation, elimination of RR®soybean leads to higher cost of weed control and more use of herbicides for all other crops following it in the rotation. This will result in negative implications for the environment because of more applications of alternative herbicides, which will also erode profitability. Thirdly, preclusion of RR®soybean legal plantings in Romania has reduced national production of soybean by up to one third which illogically can only be compensated with imports of exactly the same product – RR®soybean that has been banned, which 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 was 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, 2008 and 2009. Romania was the largest grower of maize in Europe – 2.5 million hectares in 2008, 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, Slovakia, Portugal, Germany, and Poland successfully grew an increasing hectarage of Bt maize on approximately 110,000 hectares. Contrary to the findings of the European Food Safety Agency (EFSA) which declared that the event MON810 in Bt maize was safe to cultivate in Europe, France decided to discontinue Bt maize in 2008 and Germany in 2009. In both cases, the evidence submitted by the two countries to support their rejection was not considered valid by EFSA – thus the decisions by both France and Germany to discontinue cultivation of Bt maize are in the view of EFSA, as an EU independent scientific organization, cannot be supported by scientific evidence.

Benefits from Biotech Crop 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 of US$45 million in the period 2001 to 2008 (Brookes and Barfoot, 2010). Romania had to stop growing RR®soybean when it became an EU member country in January 2007, and since then, the hectarage of soybean in Romania has plummeted from 177,000 hectares in 2006 to only 46,000 hectares in 2008.

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*** accurately 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."

SWEDEN

It is noteworthy that in 2010, Sweden became the first Scandinavian country to commercially grow a biotech crop. In 2011, Sweden continued to grow 15 hectares of the biotech potato "Amflora" with high quality amylopectin starch for seed multiplication and commercial production.

Notably in 2010, Sweden became the first Scandinavian country to commercially grow a biotech crop. In 2011, Sweden was one of two countries in the EU (the other was Germany) which continued to grow the biotech potato "Amflora" approved for planting in the EU in March 2010. In 2011, Amflora was grown at two locations (5 hectares each), in Vastergotland in southern Sweden and two locations in northern Sweden, Unbyn (2 hectares) and Vojakkala (3 hectares). Amflora was approved for planting in the EU as a source of pure amylopectin for producing high quality glazed paper, adhesive and value added products for the textile industry. Amflora reduces production costs and optimizes processing, using less water energy and chemicals. Amflora was also approved for feed use by farmers. The product Amflora was developed by BASF from Germany which has a similar second generation product under development.

In addition to Sweden, the other three Scandinavian countries are Denmark, Norway and Finland. The Ministry of Agriculture from Denmark has already declared an interest in the biotech potato, Fortuna (currently under regulatory consideration in the EU) which is resistant to the devastating "late blight" disease, the cause of the devastating Irish famine in 1845. Around 250 Danish farmers have already been trained in the practical implementation of coexistence practices so that they are prepared for planting the first commercial biotech crop, such as "late blight" resistant potato determined to be appropriate, safe and beneficial to Denmark. **The former Danish Minister of Agriculture, Eva Kjer Hansen** has published a welcomed report entitled ***"Lets get rid of the myths of GMOs"*** (Ministry of Agriculture and Fisheries, Denmark 2009) and called for an evidence-based open-debate on genetically modified organisms and argues that there is nothing new in modifying plant genetic material. Late blight-resistant potatoes offer Denmark significant advantages, including substantial reduction in pesticides with positive implications for the environment (potatoes are sprayed up to 7 times a season for late-blight in Denmark) and biodiversity. Denmark's forward-looking policy on biotech crops has anticipated that the country will plant biotech crops that offer Danish farmers advantages and the hope is that these could become available soon. The biotech potato variety

"Fortuna", being developed by BASF, and resistant to late blight, has successfully completed its field trial phase, and could be commercialized in Europe as early as 2014/2015, subject to approval.

COSTA RICA

Costa Rica grew biotech cotton and soybean for seed export for the first time in 2009, and continued to grow them in 2010 and 2011. Like Chile, Costa Rica plants commercial biotech crops exclusively for the seed export trade. In 2011, it planted approximately 3.0 hectares of biotech cotton, as well as about 0.1 hectare of biotech soybean for a total of 3.1 hectares of biotech crops.

Costa Rica is a Spanish speaking country with a population of approximately 4.5 million situated in Central America. Costa Rica is bounded by Nicaragua to the north, Panama to the east and south, the Pacific Ocean to the south and east, and the Caribbean to the East. The major cash crops for domestic consumption and exports are coffee, bananas and pineapples. About a quarter of Costa Rica is designated as national parks and the country was one of the first in the world to develop ecotourism. Whereas Costa Rica has only about 0.1% of the world's landmass, it contains 5% of the world's biodiversity. Expressed as a percentage of its land area, Costa Rica has the largest area of land devoted to national parks and protected areas than any other country in the world.

Costa Rica was included for the first time in 2009 in the global list of countries officially planting biotech crops, because like Chile, it plants commercial biotech crops exclusively for the export seed trade. The only difference between Chile and Costa Rica, and the other twenty seven countries planting biotech crops in 2010, is that the current laws in Costa Rica and Chile allow only commercialization of biotech crops designated for seed export. The biosafety law was promulgated in Costa Rica in 1998 (www.cr.biosafetyclearinghouse.net). The volume of biotech seed production in Costa Rica is small compared with Chile but has potential for growth. In 2011, approximately 3.0 hectares of biotech cotton were planted commercially, as well as about 0.1 hectare of biotech soybean for total of 3.1 hectares. Cotton and soybean are planted in October and harvested in April/May of the following year.

Apart from the commercial production of biotech crops for seed export, Costa Rica is also continuing to field test biotech pineapples, featuring a nutritional quality trait and a disease resistant banana. These field tests were approved under the biosafety regulations of Costa Rica which conform to international standards.

GERMANY

In 2010, Germany resumed planting biotech crops commercially when it approved the commercial production of the 2010 EU- approved biotech potato "Amflora". In 2011, commercial planting of Amflora continued on 2 hectares. Germany discontinued the deployment of Bt maize after 2008 when it planted 3,173 hectares, up 18% from the 2,685 hectares planted in 2007.

In 2010, Germany resumed planting biotech crops when it allowed the commercial planting and production of the EU-approved biotech potato "Amflora". In 2011, commercial planting of Amflora continued on two hectares at Oplingen in Saxony – Anhalt, Germany. "Amflora" was developed by BASF and produces a high quality amylopectin starch suitable for high grade glazed paper production, adhesives and value added products in the textile industry. Amflora was the first biotech product to be approved for planting in the EU in thirteen years. The only other product that is approved for planting in the EU is Bt maize. The EU approval of "Amflora" is for both industrial and feed use. The biotech potato variety "Fortuna", being developed by BASF, and resistant to the fungal disease causing "late blight", has successfully completed its field trial phase, and could be commercialized in Europe as early as 2014/2015, subject to approval.

Germany officially grew a small hectarage of Bt maize, from 300 to 500 hectares for eight years, starting in 2000 to 2008; Bt176 was used until 2003 when MON810 was introduced. The area of officially approved commercial Bt maize in Germany in 2008 was 3,173 hectares, up 18% from the 2,685 hectares planted in 2007. 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. After 2008, Germany discontinued the deployment of Bt maize

Benefits from Biotech Crop in Germany

Benefits accrued to German farmers when they successfully planted Bt maize during the eight year period 2000 to 2008 when they were allowed to grow Bt maize officially. The areas infested by European corn borer (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 US$8.25 million per year.

THE EUROPEAN UNION (EU 27)

Eight EU countries continued to plant 114,507 hectares including 114,490 hectares of biotech Bt maize and 17 hectares of a new biotech potato named "Amflora" in 2011. Six countries, Spain, Portugal, Czechia, Poland, Slovakia and Romania continued to plant only Bt maize. Two countries, Sweden and Germany planted Amflora potato. The total Bt maize hectares in 2011 was 114,490 hectares compared with 91,193 hectares in 2010, a substantial 26% increase. For the 2010 EU-approved Amflora potato, the first approval for planting in 13 years, Czechia grew 150 hectares, Sweden grew 80 hectares and Germany 15 hectares for seed multiplication and commercial production, it is noteworthy that Sweden is the first EU Scandinavian country to grow biotech crops. Spain was by far the largest EU Bt maize grower with 85% of the total in the EU with a record adoption rate of 28% in 2011, compared with 24% in 2010. Bt maize hectarage increased in the three largest Bt maize countries Spain, Portugal and Czechia, remained the same in Poland, and decreased in Romania and Slovakia. The marginal decreases in Bt maize in Romania and Slovakia was associated with several factors, including disincentives for some farmers due to bureaucratic and onerous reporting of intended plantings of Bt maize. A Kenyan national criticized the EU's opposition to GM crops stating that this was *"robbing"* the developing countries of the *"chance to feed itself and could threaten food security."* Dr. Felix M'mboyi of the African Biotechnology Stakeholders Forum criticized the European Union of *"hypocrisy and arrogance"* and called for ***"development bodies within Europe to let African farmers make full use of GM crops to boost yields and feed a world population expected to reach 7 billion by the end of the year."***

The European Union comprises 27 states, a population of almost 500 million (7% of global) with a GDP in 2010 of US$17 trillion, equivalent to over 22% of global GDP. Less than 6% of the EU's workforce is employed in agriculture and the principal major crops occupy just over 90 million hectares (versus 1.5 billion hectares globally) of which maize is 13 million hectares, about 10% of global hectarage. There are approximately 15 million farms in the EU; Romania has the largest number of farms (almost a third of the EU total, followed by Poland, Italy and Spain). Table 43 summarizes the planting of Bt maize in the countries of the European Union from 2006 to 2011. Eight EU countries planted 114,507 hectares of biotech Bt maize and a new biotech crop "Amflora" potato in 2011. Six countries, Spain, Portugal, Czechia, Poland, Slovakia and Romania continued to plant only Bt maize; two countries, Sweden and Germany planted only Amflora potato. The total Bt maize hectares in 2011 was 114,490 compared with 91,193 hectares in 2010, a significant 26% increase of more than 23,000 hectares over 2010. For the 2010 EU approved Amflora potato, the first approval for planting in 13 years, Czechia grew 150 hectares, Sweden grew 80 hectares, and Germany 15 hectares for seed multiplication and commercial production; it is noteworthy that Sweden is the first EU Scandinavian country to grow biotech crops. In 2011, Sweden and Germany planted 15 hectares and 2 hectares Amflora potato, respectively. Spain was by far the largest EU Bt maize grower with 85% of the total in the EU with a record adoption rate of 28%. Bt maize hectarage increased in Spain, Portugal and Czechia, remained the same in Poland, and decreased in Romania and Slovakia. The marginal decrease in Bt maize in Romania and Slovakia was associated with

Table 43. Hectares of Bt Maize Planted in 2006 to 2011 in EU Countries and Hectares of Amflora Potato Grown in the EU Countries in 2010 and 2011

	Country	2006 Bt maize	2007 Bt maize	2008 Bt maize	2009 Bt maize	2010 Bt maize	2011 Bt maize	Change 2010/11 Bt maize	Amflora 2011
1	Spain	53,667	75,148	79,269	76,057	76,575	97,326	20,751	– –
2	Czechia	1,290	5,000	8,380	6,480	4,680	5,091	411	
3	Portugal	1,250	4,263	4,851	5,094	4,868	7,724	2,856	– –
4	Romania*	– –	350	7,146	3,244	822	588	-234	– –
5	Germany	950	2,685	3,173	– –	– –	– –		2
6	Poland	100	327	3,000	3,000	3,000	3,000	0	– –
7	Slovakia	30	900	1,900	875	1,248	761	-487	
8	Sweden	–	–	–	–	–	–	–	15
	Total	**57,287**	**88,673**	**107,719**	**94,750**	**91,193**	**114,490**	**+23,297**	**17**

* Germany discontinued planting Bt maize at the end of 2008 and grew 2 hectares of Amflora potato in 2011. Sweden grew 15 hectares of Amflora in 2011. Romania grew 145,000 hectares of RR®soybean in 2006 but had to cease growing it after becoming an EU member in January 2007.

Source: Compiled by Clive James, 2011.

several factors, including disincentives for some farmers due to bureaucratic reporting of intended plantings of Bt maize.

All six EU countries which grew Bt maize commercially in 2011 provided benefits to farmers, to the environment and a more affordable feed source for animals, which in turn benefited consumers who eat meat.

Details of the biotech field trials conducted in the UK are provided in http://www.defra.gov.uk/environment/quality/gm/. They include a field trial at Rothamsted Research to conduct a trial of a biotech wheat resistant to aphids. DEFRA also authorized two different field trials in 2010 on different types of biotech potato, one by Leeds University and the other by Sainsbury Laboratory.

The company BASF from Germany, confirmed that it had submitted the regulatory dossier to EFSA for its biotech potato "Fortuna", resistant to late blight disease: the BASF plan is to market Fortuna in Europe in 2014, subject to regulatory approval (http://www.basf.com/group/pressrelease/P-11-488).

Contrary to the findings of France and Germany, EFSA has clearly stated, that ***"No specific scientific evidence, in terms of risk to human and animal health and the environment, was provided that would justify the invocation of a safeguard clause"*** (EFSA, 2008). A report in September 2008 by the EU's Joint Research Council (EU-JRC, 2008) concluded that, ***"No demonstration of any health effects of GM food products submitted to the regulatory process that has been reported so far."*** This finding of the JRC endorsing the safety of biotech crops is consistent with many independent studies conducted over the last several years including the Nuffield Bioethics Council, the Royal Society and the EU's EFSA. The latest report (EU-JRC, 2008) suggested that, ***"Europe must 'move forward' and clear biotech crops amid increasing food prices."***

In October 2011, a Kenyan agri-economist criticized the EU's opposition to GM crops stating that this was ***"robbing"*** the developing countries of the ***"chance to feed itself and could threaten food security"*** (Derbyshire, 2011). Dr. Felix M'mboyi of the African Biotechnology Stakeholders Forum criticized the European Union of ***"hypocrisy and arrogance"*** and called for ***"development bodies within Europe to let African farmers make full use of GM crops to boost yields and feed a world population expected to reach 7 billion by the end of the year."*** Dr. M'mboyi, who formerly worked with the Kenyan Ministry of Agriculture, added that, ***"The affluent west has the luxury of choice in the type of technology they use to grow food crops, yet their influence and sensitivities are denying many in the developing world access to such technologies which could lead to a more plentiful supply of food. This kind of hypocrisy and arrogance comes with the luxury of a full stomach."*** In 2011, Kenyan government published its implementing regulations for environmental release as outlined in the Biosafety Act of 2009, allowing commercial cultivation of GM crops, becoming the fourth African country to explicitly legalize growing of GM crops.

Mr. Gilbert Arap Bor is a Kenyan framer who grows maize and vegetables and raises dairy cows on his 25-acre farm near Kapseret. He recently shared his views on biotech crops and the EU regulatory policy. ***"Thankfully, Kenya is beginning to take positive steps. Last year, our government approved the commercial planting of genetically modified crops, becoming the fourth African country to do so after Burkina Faso, Egypt and South Africa. This will give our farmers access to one of the world's most important hunger-fighting tools. We can also draw upon tremendous resources in human capital, from the scientific expertise at the Kenya Agricultural Research Institute to the business know-how of the Kenya Seed Company... the billions in aid that Europe sends to Africa every year do nothing to encourage the use of agricultural technology, and often discourage or prevent it. Africa's farmers and their would-be customers are being held hostage by scientific illiterates whose well-paid jobs involve raising money by frightening people about biotechnology"*** (Bor, 2011).

Political Support to Biotech Crops in the EU.

Whereas there is a great deal of ideological and political opposition to biotech crops in the EU, there is also some more progressive thinking.

In a very substantive report, published in October 2009, entitled ***"Reaping the Benefits – Science and the sustainable intensification of agriculture,"*** **The Royal Society,** the UK's most prestigious scientific academy, has recommended publicly-funded research of GM crop technologies. The report concludes that the application of both conventional and biotech technologies would allow northern Europe to become one of the ***'major bread baskets of the world'***. The UK Government's Chief Scientist, **Sir John Beddington** has endorsed biotech crops for the UK (Crop Biotech Update, 29 October 210).

The UK Government's Foresight Report concluded that Britain must embrace GM crops or face serious food shortages in the future. The Report has had unusually strong support from Government, ministers, leading scientists and is consistent with the recommendations of the recent substantive report from the UK's prestigious Royal Society, referenced in the following paragraph (Crop Biotech Update, 8 January, 2010).

Speaking at the Oxford Farming Conference, after the publication of the Food 2030 Report, Sir John Beddington, the UK's Chief Scientist said, ***"GM and nanotechnology should be part of modern agriculture. We need a greener revolution, improving production and efficiency through the food chain within environmental and other constraints. Techniques and technologies***

from many disciplines ranging from biotechnology and engineering to newer fields such as nanotechnology will be needed" (Gray, 2009). Sir David King, the UK Government's former Chief Scientific Adviser is a strong advocate of biotech crops and 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"*** (Cookson, 2008).

Petitions from biological scientists in Sweden and the UK

In October 2011, 41 leading Swedish biological scientists, in a strongly-worded open letter to politicians and environmentalists, spoke out about the need to revise European legislation to allow society to benefit from GM crops developed on science-based assessments of the technology. They stressed that current ***"European legislation in the field of genetic engineering is so narrow that it blocks the ability of researchers to take progress from publicly-funded basic research on plants through to practical applications."*** The scientists ***"urged politicians and environmental groups to take the necessary steps to change the relevant legislation so that all available knowledge can be used to develop sustainable agricultural and forest industries"…*** they declared that ***"the use of GM plants is both standard practice and necessary."*** Furthermore, they stated that ***"there is no scientific uncertainty on the issue of whether GM crops pose more risk to consumers or the environment than conventionally produced crops varieties. The legislation was formulated when there was not yet sufficient data on this but now we know better. Five hundred independent research groups have received 300 million Euros from the EU to study the risks. The conclusion in a summary of the results ("A decade of EU-funded GM research") is that <u>GMOs are not per se more risky than conventional plant breeding technologies.</u> We are basic research scientists and we know that the changes produced by genetic engineering are easier to control than those produced in other ways. The legislation argues the opposite, and imposes controls only on GM plants. The Swedish environmental movement has a proud tradition of working from a sound scientific basis. For many of us, an early involvement in the non-profit environmental movement was an essential element in choosing our current careers; we wanted to contribute to a better world. The environmental movement should view it as a warning that many of us, with sadness, abandoned it when we felt we could no longer belong to organizations that sided with anti-science and populist forces – without subverting our scientific principles. We urge the Swedish environmental movement to unite with science and act as a rational, informed voice to influence their more vocal foreign counterparts. Changing the genetic engineering legislation is not only a very important issue for Europe. Poorly funded plant breeding researchers and organizations in many third world countries are also being deprived of one of their best tools to provide better local crops because of the obvious risk of being excluded from the GM-hostile European market. We therefore urge our politicians to change this outdated law. Our desire is that the***

world's farmers will be offered seeds that have been developed to provide the most energy- and water-efficient and chemical-free agriculture and forestry as possible, but current genetic engineering legislation prevents this" (Tribe, D. 2011; EU Commission, 2010).

Scientists in the UK endorsed the Swedish initiative and gained support for the following petition ***"We, the undersigned, share the views of 41 leading Swedish plant scientists (that current legislation of GM crops is not based on science, ignores recent evidence, blocks opportunities to increase agricultural sustainability and stops the public sector and small companies from contributing to solutions. We call on pressure groups and organic trade associations to cease and desist from blocking genetic solutions to crop problems, and on Europe to change current laws and adopt science-based GM regulations"*** (Tribe, D. 2011).

In September 2011, the UK's Department for Environment, Food and Rural Affairs (DEFRA) approved a land mark field trial of biotech wheat which has been genetically modified to resist crop-damaging aphids. The 1.3 hectare trial will be conducted between March 2012 and September 2013 at Rothamsted Research Station UK, the oldest agricultural research station in the world. DEFRA indicated that the field trial is an essential stage of continuing research and that the trial had "tight controls and had to go through a complex and detailed clearance process." The biotech wheat will be surrounded by a wheat-pollen barrier of at least 2 meters wide of a different grain and no cereal plants will be grown within 20 meters. During the year following harvesting of the biotech wheat, the area will be left unseeded and any "volunteer" plants killed. DEFRA has approved seven similar trials in the UK since May 2008, including one on a potato variety resistant to cyst nematodes under development at Leeds University. The nematodes can cause significant damage estimated at over US$100 million in the EU annually. The National Farmers Union stated that more than 20 species of aphids attack U.K. crops, reducing yields and quality. The NFU chief science and regulatory affairs adviser, Helen Ferrier, said that ***"the approval of the wheat trial was an exciting development, genetic improvement, enabling the plants to be more resistant to aphid infestation, is one important way to reduce unsustainable crop losses and reliance on pesticides, …genetic modification is one highly effective breeding technology that can make crops resistant to pests"*** (DEFRA, 16 September 2011).

At Leeds University, research is focused on transgenic resistance to the most devastating nematode of potatoes, potato cyst nematode (PCN, *Globodera spp*) which is found in 50 to 80% of potato fields in the UK and estimated to cause annual losses worth over US$100 million per annum in Europe alone. The work is at the proof of concept stage and utilizes a plant based chicken egg white cystatin (CEWC) in conjunction with a CaMV35S promoter (www.fbs.leeds.ac.uk/nem/Potato.htm). Contained and field trials have already confirmed the usefulness of the transgenic technology for controlling potato cyst nematode. Some of the nematicides currently used in the UK include some of the most toxic of registered pesticides, and government policy is to replace them with more benign means of control which the new transgenic technology offers. These include: a promise of improved durability of resistance; a control method that is effective at all levels of infestation; and a control method that is easily and safely deployed by farmers. The major constraint, by far, is the herculean effort and the significant long term financial investment required of the University, to satisfy the demanding tasks and expense of gaining deregulation and approval to commercially deploy the technology.

A study by a group from the University of Leuven, Belgium (Demont et al. 2007) concluded that the potential annual value of biotech crops for an average 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.

The long debate about zero tolerance of unauthorized biotech crop events in imported feed has resulted in some progress with the approval of the following new EC Regulation 619/2011 on low level presence approved by the EU in 2011: ***"A feed material, feed additive or, in the case of compound feed each of the feed material and feed additive of which it is composed shall be considered as non-compliant with Regulation (EC) No 1829/2003 when the analytical result (x) for one measured transformation event minus the expanded measurement uncertainty (U) equals or exceeds the level of 0,1% related to mass fraction of GM material."*** The European Compound Feed Manufacturer's Federation (FEAC) was involved in this debate for a very long time, seeking a sensible concession similar to that granted to banned veterinary antibiotics, which are now allowed in the EU at trace levels. FEAC reasoned, quite rationally that the matter was of paramount importance given that soybean meal is the "lifeline" of Europe's livestock industry, and without it there would be "no" compound feed. The impractical zero tolerance policy had high risks because the EU is dependent for more than 80% on imports of vegetable proteins, for which there are no substitution possibilities in the short term (Crop Biotech Update, 5 November 2010).

In October 2011, European biotech industry warned the EU Commission that slow approval of biotech crop imports, critical as feed-stocks, pose a risk for the EU that could disrupt supply of animal feed-stocks. Consumers in the EU are highly dependent on a massive import of 30 million tonnes of biotech animal feed annually, equivalent to a significant 60 kg per person. The report highlighted the anomaly that as feed exporting countries in the world such as Brazil (8 products approved in 2010 alone and 6 in 2011) increases the pace of approval; the EU is slowing it down. On average, the EU's approval process is 15 to 20 months longer than the corresponding process in the three major feed exporters to the EU, the US, Brazil and Canada. The number of biotech crops pending approval in the EU has increased from 50 in 2007 to 72 in 2011– 51 for import and 21 for cultivation. It is projected that the number of products that will be pending approval in 2015 will increase to 90. Only two biotech crops are currently approved for cultivation in the EU (Bt maize and Amflora potato), compared to 90 in the US and 28 in Brazil. In addition to denying EU farmers the right to grow biotech crops, the lack of approvals contribute to price volatility and import disruptions when the presence of unapproved events is detected. The EU Commission drafted a proposal in 2010 to empower EU member countries to decide whether to cultivate biotech crops or not, which could accelerate the approval process, however the proposal was blocked (AllAboutFeed.net, 13 October, 2011).

A University of Reading study in 2011 (Park et al. 2011) on the *Impacts of the EU regulatory constraints of transgenic crops on farm income,* revealed that "if the areas of transgenic maize, cotton, soya, oilseed rape and sugarbeet were to be grown where there is agronomic need or benefit, then farmer margins would increase by between €443 and €929 million per year." It was also noted that "this margin of revenue foregone is likely to increase with the current level of approval and growth remains low, as new transgenic events come to market and are rapidly taken up by farmers in other parts of the world."

The former **Danish Minister of Agriculture, Eva Kjer Hansen** published a welcomed report entitled ***"Let's get rid of the myths of GMOs"*** (Ministry of Agriculture and Fisheries, Denmark 2009). She called for an evidence-based open-debate on genetically modified organisms and argued that there is nothing new in modifying plant genetic material. She pointed out that recombinant insulin was accepted and used daily around the world and that there are biotech crops such as blight-resistant potatoes that offer Denmark significant advantages, including substantial reduction in pesticides with positive implications for the environment (potatoes are sprayed up to 7 times a season for late-blight in Denmark) and biodiversity. She also cites benefits related to reductions in greenhouse gases. Denmark's forward-looking policy on biotech crops has anticipated that the country will plant biotech crops that offer Danish farmers advantages and that these could become available soon. Around 250 Danish farmers have already undertaken training in the practical implementation of coexistence practices so that they are prepared for planting the first commercial biotech crops determined to be safe and beneficial to Denmark.

In a 2011 survey commissioned by the UK's Crop Protection Agency (Crop Protection Agency UK Booklet, 2011), increased support for biotech crops was evident. More specifically, 35% supported placing GM foods on shelves in the UK: this figure increased to 37% if they were nutritious; to 44% if they helped to keep the price of food down; to 46% if biotech crops were also good for the environment, and to a high of 78% if biotech crops helped the UK become more self-sufficient in food.

An international group of scientists including some from the Scottish Crop Research Institute (2009) have sequenced the potato genome. This is an important achievement, given that potato is the third most important food crop in the world after rice and wheat, and will allow the development of biotech potatoes to be expedited in the EU in "speeding the breeding" initiatives. It is noteworthy that Bt biotech potato was one of the first successfully commercialized biotech crops in the USA and Canada in the 1990s. The approval of Amflora potato, developed in Europe, could well prove to be a very important development for the future of biotech crops in the EU. Both public and private institutions in the EU are now developing several new biotech potatoes with traits ranging from improved starch production, late blight disease resistance, bacterial disease resistance and nematode resistance. The potato resistant to late blight being developed by BASF is of particular significance. Russia is also involved in the development of Bt potatoes resistant to the devastating Colorado beetle pest. In summary, in the next five years biotech potatoes could present an attractive and appropriate biotech product for consideration by the EU, which produces 20% of global production in intensive cropping systems requiring heavy and expensive pesticide applications for diseases such as the devastating late blight fungal disease which was the cause of the Irish famine in 1845. Biotech potatoes could substantially reduce the need for pesticides on crops which is entirely consistent with EU policy. (See section in this Brief on the Future and in the Executive Summary.)

One of the first actions that **EU Commissioner for Health and Consumer Affairs, Mr. John Dalli,** took in 2010 was to approve the planting of the biotech potato "Amflora" developed by BASF from Germany; this was the first in 13 years following the approval of Bt maize MON 810 in 1998. Commissioner Dalli proceeded to present a proposal that would allow EU states to independently reject or approve products. His objective was to make EU approvals for biotech crops more efficient, more equitable, less bureaucratic and more transparent. However, there have been many objections from member states including questioning the legality of the proposal, despite it having been cleared at the outset by Mr. Dalli's lawyers. There are more than ten biotech crops waiting for EU approval to plant, including two varieties of biotech potato, one from BASF, another by Avebe from Holland, and a sugarbeet developed jointly by KWS from Germany and Monsanto. The EU member states of Austria, Greece and Italy have consistently denied approvals for planting or importing of biotech crops in the EU. Several of the countries exporting biotech crops, including the USA, Canada and Argentina won a 2006 WTO lawsuit that required the EU to ease approvals of biotech crops; under this WTO ruling these countries could require duties to be paid by the EU if the EU continues to block trade in biotech crops (New York Times, 11 November 2010).

On 8 Sept 2011, Europe's highest court, the European Court of Justice ruled against future unilateral decisions by EU countries to ban biotech crops, particularly France, without informing the EU commission and without evidence "of a situation which is likely to constitute a clear and serious risk to human health, animal health or the environment." The decision was precipitated by a 2008 ban by France on the planting of MON 810 Bt maize. Six other countries, Austria, Bulgaria, Germany, Greece, Hungary and Luxembourg also banned the same product. Whereas the ruling, is not legally binding, it will now be referred to France's highest administrative court for consideration and if the Council of State, ratifies the ruling, the government will have to abandon its "safeguard clause" against biotech crops. The ruling was welcomed by French farmers as a step towards pro-choice in Europe and that they would no longer be denied the opportunity to benefit from Bt maize which is planted in several countries in the EU led by Spain and Portugal. To-date the EU Commission has allowed individual EU states to impose the ban if compatible with World Trade Organization rules, and if the EU is notified first. In a separate ruling the European Court of Justice ruled that honey containing even tiny traces of pollen from biotech maize could not be sold in the EU without prior authorization (Expatica.com. 8 September 2011).

A crucial decision was made recently by the highest court of France, the Conseil d'Etat – it declared that the 2008 decision by the European Court of Justice to ban the cultivation of genetically modified crops in France was illegal (Seed Today, 28 November 2011). The French government was not able to present scientific evidence of any risk to health or the environment from these crops, thus, both the EU and the French high court overturned the national ban.

In a national referendum in 2005, Switzerland banned GM products with the most restrictive law which will expire and be reviewed again in 2013. As a result the Swiss have no direct experience with GM foods, except when they visit countries that market GM products, like Canada and the US in North America. A recent study in Switzerland offered three clearly labeled corn bread, organic, conventional, and GM to consumers at market stands. The authors concluded that consumers "treated the GM product like any other novel food and that consumers appreciated transparency and freedom of choice" and recommended that "retailers should allow consumers to make their own choice and accept the fact that not all people appear to be afraid of GM food. Interestingly, out of 3,750 customers only 2% of the responses were registered by the selling groups as negative to the choice available, whereas 53% were neutral and 45% were positive. This indicates that the emotionality of the public debate stands in strong contrast to the pragmatic behavior of consumers at the market stand (Aerni et al. 2011)

In December 2010, the European Commission (EC) published a compendium "A Decade of EU-funded GMO Research (2001-2010)" which summarized the results of 50 research projects addressing primarily the safety of GMOs for the environment and for animal and human health. The compendium reported that the European Union (EU) has funded a significant number of projects on GMOs worth €200 million or US$250 million between 2001 and 2010 and invested over €300 million on research on the bio-safety of GMOs since 1982. Launching the compendium, the **European Commissioner for Research, Innovation and Science Máire Geoghegan-Quinn** said ***"The aim of this book is to contribute to a fully transparent debate on GMOs, based on balanced, science–based information. According to the findings of these projects GMOs potentially provide opportunities to reduce malnutrition, especially in lesser developed countries, as well as to increase yields and assist towards the adaptation of agriculture to climate change. But we clearly need strong safeguards to control any potential risks"*** (European Commission, 2010).

This new publication aims to contribute to the debate on GMOs by disseminating the outcomes of research projects to scientists, regulatory bodies and to the public. It is a follow-up to previous publications on EU-funded research on GMO safety. Over the last 25 years, more than 500 independent research groups have been involved in such research. According to the projects' results, there is, as of today, no scientific evidence associating GMOs with higher risks for the environment or for food and feed safety than conventional plants and organisms (European Commission, 2010).

Farmer Testimonies and Views

Jim McCarthy, who has an extensive farming business in Ireland, the US, Eastern Europe and Argentina, said ***"GM crops would allow EU farmers to use less agrochemicals and help them lower production costs. GM was the biggest development in agriculture since the tractor"*** (McCarthy, 2010).

Progress with Biotech Crops in Africa

Africa maintained steady progress at all levels in 2011 in planting, regulatory and in research activities on biotech crops. The map of Africa (Figure 46) provides a self-explanatory summary of the three countries which are commercializing biotech crops (Burkina Faso, Egypt, South Africa), and the six, including the latter three countries that are conducting field trials with biotech crops: Burkina Faso, Egypt, Kenya, Nigeria, South Africa and Uganda. Malawi gave an approval to conduct biotech cotton trials in 2011 but planting has not started. A number of trials focusing on Africa's pro-poor priority staple crops such as cassava, banana and sweetpotato are making good progress. Importantly, most of the new trials have paid attention to traits of high relevance to challenges facing Africa such as drought tolerance, nutritional enhancement and with resistance to tropical pests and diseases. Examples include drought tolerant maize through the Water Efficient Maize for Africa (WEMA) project with multiple season on-going trials in three countries (Kenya, South Africa and Uganda), cassava with increased pro-vitamin A, iron and proteins through the BioCassava Plus in Kenya and Nigeria, nutritionally enhanced banana with iron and pro-Vitamin A, and, bacterial wilt resistant banana both in Uganda and insect resistant cowpea in Burkina Faso and Nigeria.

In Egypt, a research team at the Agricultural Genetic Engineering Research Institute (AGERI) has developed drought-tolerant transgenic wheat (with *hvaI* gene F13) which was cultivated in 2011. The event was evaluated under rainfed conditions at the North coast of Egypt. Some of the transgenic lines have 20% more grain yield than their non-transgenic parental genotype. Synthetic hexaploid (provided by ICARDA) has been proven to be drought tolerant. Regular crossing/backcrossing with the transgenic drought-tolerant lines and the most drought-tolerant synthetic hexaploid wheat was started in the year, to stack genes for drought stress tolerance. Five institutes are involved in the assessment of the recovered germplasm; AGERI, Field Crops Research Institute (FCRI), Soil, Water and Environment Institute (SWERI) and Regional Center for Food and Feed (RCFF).

The expanding number of confined field trials is a clear indication that Africa is progressively moving towards placing important food security biotech crops in the market. The vibrant research is taking place either using existing legislation or stand-alone biosafety structures with promising results.

Stacked traits are also being field tested in Africa. In Uganda, for example, the country is in its third season of trials with a stacked trait for insect resistance (Bollgard®) and herbicide tolerance (Roundup Ready®) cotton and outcomes have been encouraging. The National Agricultural Research Organization (NARO) estimates cotton yield losses in the country due to insect pests to be about 40% and losses due to weeds at about 30%. This suggests that the choice of the stacked or both traits combined could double yields without expansion of cultivated area. The country's favorable agro-climatic conditions provide for production of a high quality, long staple cotton, which guarantees a stable demand in international markets. It is therefore expected that Uganda would realize substantial benefits from increased productivity and subsequent export revenue. Like its neighboring country Kenya, commercialization of transgenic cotton is projected to commence by 2014, thus providing an opportunity for farmers in Eastern Africa to join millions of farmers all over the world and more notably in South Africa and Burkina Faso, who are already benefiting from commercial planting of biotech cotton.

In the area of biosafety legislation, two new countries in West Africa namely Ghana and Nigeria approved their Biosafety Laws in 2011. The Ghanaian Law was unanimously passed by the country's parliament on 21 June 2011 while the Nigerian Senate passed theirs on 1 June 2011. The two pieces of legislation now await Presidential assent in preparation for their implementation. This brings to six the number of West African countries that have approved biosafety legislation to govern activities related to commercialization of biotech crops. They include: Burkina Faso, Mali, Ghana, Nigeria, Senegal and Togo. Development of practical implementing regulations should follow to expand research and commercialization of biotech crops in the sub-region.

In Eastern and Central Africa, significant progress was achieved on various fronts in 2011. The Kenya Biosafety implementing regulations became operational through publication in the official Kenya Gazette as legal notices numbers 96, 97 and 98. The three sets of regulations comprise: the contained use, the environmental release and the import, export and transit of genetically improved products in Kenya. These regulations provide the necessary legal framework to enforce the Biosafety Act of 2009 on procedures to follow in the areas of research, commercialization and trade with genetically modified organisms. By gazetting the regulations, the country is now fully compliant with the international requirements on the development and utilization of modern biotechnology. The country has a Biotechnology Policy, a Biosafety Act, a functional institutional arrangement through the National Biosafety Authority and a mechanism for public participation through the National Biotechnology Awareness Strategy (Bio AWARE).

Another important development in 2011 for Kenya was the authorization for the first time by the government to import biotech maize from South Africa. This was a direct response to the severe famine in the country where more than 3 million Kenyans were facing starvation. The dire situation was occasioned by prolonged drought and perpetual crop failure over the years leading to a sharp rise in food prices that also triggered food riots. According to local millers, the imported biotech maize is expected to make a significant contribution to lowering of food prices especially maize, which is a major food consumed by millions of Kenyans.

Efforts to fast-track commercialization of biotech cotton by 2014, following completion of essential research by Kenyan researchers have been intensified. Training of extension service providers and research support on stewardship issues were conducted in the major cotton growing areas of the Coastal, Eastern and Western regions of the country. A taskforce and roadmap outlining the key activities and players at each stage of the commercialization process from determination of suitable varieties in different agro-ecological zones to establishment of systems for seed multiplication and distribution to farmers, guide the process. An elaborate outreach and communication program is also in place. Members of the task force include all players in the cotton sub-sector value chain from researchers to ginners, regulators, service providers in extension, inputs supply, marketing and communications. This is an appropriate public-private sector partnership that is poised to deliver to Kenyan farmers, the long-awaited biotech cotton seeds by 2014. The National Biosafety Authority, itself a member of the task force is working closely with the partners to promptly provide regulatory guidance on the commercialization process and ensure adherence to international practice for safety and responsible deployment of the technology. An application for multi-locational trials is under development.

Several other innovative public–public and public-private partnerships (PP&PP) have been adopted to improve the pace of research and delivery of biotech crops relevant to Africa’s needs. One of the big players include the Bill and Melinda Gates Foundation who is supporting biotech crops research work on various crops of direct benefit to millions of African farmers and consumers such as cassava, banana and drought-tolerant maize through the African Agricultural Technology Foundation (AATF). The AATF is partnering with national agricultural research organizations in those countries, Consultative Group on International Agricultural Research centers such as the International Maize and Wheat Improvement Center (CIMMYT) and International Institute of Tropical Agriculture (IITA), international institutes such as the Donald Danforth Plant Science Center and local private seed companies to ensure smooth deployment of products along the value chains.

Other initiatives with much relevance to addressing limiting factors in the African agricultural sector include the Improved Maize for African Soils (IMAS) project. The project, now in its second year aims at developing maize varieties that use fertilizer more efficiently and help smallholder farmers get higher yields, even where soils are poor and little commercial fertilizer is used. The project, led by CIMMYT with funding of US$19.5 million grant from the Bill & Melinda Gates Foundation and United States Agency for International Development (USAID), will develop maize varieties that are better at capturing the small amount of fertilizer that African farmers can afford, and use the nitrogen they take up more efficiently to produce grain. The project's partners are: DuPont Business, Pioneer Hi-Bred, the Kenya Agricultural Research Institute (KARI), and the South African Agricultural Research Council (ARC). The team will use cutting-edge biotechnology tools such as molecular markers – DNA "signposts" for traits of interest – and transgenic approaches to develop varieties that ultimately yield 30-50% more than currently available varieties, with the same amount of nitrogen fertilizer applied or when grown on poorer soils.

Additional key indications of positive developments in crop biotechnology in Africa in 2011 include intensified efforts by many governments to partner with the AATF and other existing initiatives to create awareness and educate the public about the attributes of the technology. The Open Forum on Agricultural Biotechnology in Africa (OFAB) is one such example. A new OFAB chapter was launched in Ghana on 18th August 2011, bringing to six the number of countries with an OFAB chapter. Operational ones include: Egypt, Kenya, Ghana, Nigeria, Tanzania and Uganda. The forum brings together stakeholders in biotechnology and enables interactions between scientists, journalists, civil society, policymakers and farmer groups on a regular basis. It offers stakeholders an opportunity to discuss all aspects of biotechnology with a view of expanding their knowledge base and enhance informed contributions to policy on the way forward with the technology in their respective countries. While officiating the launching of the Ghanaian chapter, Ms. Sherry Ayittey, the Ghanaian Minister for Environment, Science and Technology (MEST), acknowledged biotechnology as a vital tool which could contribute considerably to the country's food security. She said; ***"It is well-known that many developed countries thrive on biotechnology products It is therefore necessary to embrace the initiative (OFAB) to create an open forum to dialogue on the many issues that surround modern biotechnology to improve decision-making."***

The formation and launching of the Uganda Biotechnology and Biosafety Consortium (UBBC) for advancing the cause for biotechnology in improving livelihoods is another strong indicator of growing acceptance of biotech crops in Africa. The consortium is a unique development and was born out of a strong need to form a multi-sectoral, multi-stakeholder and multi-competent organization that will bring together stakeholders around a common cause of biotech science advancement. It is a coalition of different stakeholders ranging from policy makers, scientists, private sector leaders, civil society organization leaders and government officers in their individual capacities as well as stakeholder agencies from both public and private sectors.

Further south, the Southern African Confederation of Agricultural Unions (SACAU) adopted a policy framework on genetically modified organisms in 2011. Among others, the policy recognizes the need for evidence-based decision-making; the right of consumers to choose whether to eat or not to eat GMOs; the need for more research and development as well as the widespread dissemination of the results of such research; the importance of involving farmers directly in research on GMOs and the related standards-setting processes and structures; that benefit-cost analysis should also look into the cost of non-adoption of GMOs; the need to monitor trade in GMOs in the region; and, the importance of political will and harmonization of policies in the sub-region, including the urgent need for a regional biosafety regime which ensures responsible development and regulation of GMOs in the region. SACAU has 16 members in 12 countries of southern Africa namely; Botswana, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

Several regional initiatives on harmonization of policies and regulatory frameworks are on-going to allow for cost-efficiency in the sharing of knowledge, expertise and resources. After more than nine years, consultations among member states of the Common Market for Eastern and Southern Africa (COMESA) have produced draft policies and biosafety guidelines on GM technology, aimed at a regional approach to handling issues of commercial planting and trade in GM crops. Implementation of national consultations on the draft regional biosafety guidelines among member states has been conducted in 16 out of the 19 COMESA members. The consultations were prompted by a decision from the Third Meeting of the Joint COMESA Ministers of Agriculture, Environment and Natural Resources during their annual meeting in July 2010, in Lusaka, Zambia to ensure inclusiveness and wide ownership of the policy documents. The regional harmonization process aims at sharing information, resources and expertise for cost-effectiveness in capacity building and drawing synergies to avoid redundancies. Under the proposals, a country which desires to grow a GM crop commercially would inform COMESA, which would then conduct a science-based risk assessment audit. The body would judge whether the crop is safe for the environment and human consumption. If the assessment proved positive, broader regional approval would be given for the crop to be grown commercially in all COMESA countries. National governments would retain the power to decide whether or not to proceed (Nature, 1 October 2010).

COMESA is the largest economic trading bloc in Africa. It has 19 member states, a collective population of 390 million people, an annual import trade of around US$32 billion, and an export trade of US$82 billion. Agriculture plays a big role in the economies of COMESA countries in terms of livelihood, employment and international trade. Agricultural commodities are therefore major drivers for growth in intra-COMESA trade. COMESA trade statistics indicate that total intra-COMESA trade during 2008 amounted to some US$6.3 billion. Of this, food and agricultural raw materials constituted US$2.1 billion. However, cyclical droughts and abiotic stresses in the region predispose these countries to food insecurity, while biotic challenges such as disease pathogens and pests affect productivity of most staple crops. Adoption of biotech crops would thus make a significant contribution in raising productivity, incomes and environmental conservation as well as contributing to alleviation of poverty.

In West Africa, as Burkina Faso farmers continued in their fourth year of growing of biotech cotton, neighboring countries of Togo, Ghana and Mali made major policy decisions that are likely to spur developments in the country's biotech sector in the near term. The Malian Cabinet in 2010 adopted a draft decree specifying detailed procedures for testing of genetically modified organisms. The decree provides research institutes and laboratories in the country with the regulatory framework necessary for starting experiments, trials and the environmental release of genetically modified organisms in a safe and responsible way. A draft decree establishing the duties, composition and working procedures of the National Biosafety Committee (NBC) was also adopted. The National Biosafety Committee was established by Law No. 08-42 of 1 December 2008 to provide guidance and make recommendations to the national competent authority responsible for biosafety and biotechnology matters in the country. The Committee has since been seeking assistance from regional partners to explore ways of operationalizing the country's legislative framework. Ghana passed its Biosafety law while Togo conducted trainings for its biosafety regulators on how to conduct field trials as a way of building capacity for biosafety once the trials start. The training organized by the African Biosafety Network of Expertise (ABNE), unanimously emphasized the importance of developing regulatory frameworks that are workable, credible, evidence- based, transparent and predictable.

The important role that the NEPAD Planning and Coordinating Agency (NPCA) can play in cultivating ownership and institutionalization of the biosafety capacity building process among member states gained momentum in 2011. A number of African countries endorsed the NEPAD Agency – ABNE, the implementing arm of the African Union, as the appropriate platform for mobilizing member states to develop common positions that advance the continent's interests in biosafety international negotiation forums.

It is noteworthy, that with more knowledge of developments on biotech crops in other countries around the world, African farmers are now starting to demand biotech crops. At the Southern African Confederation of Agricultural Unions (SACAU) Annual General Meeting on 18 May 2011, the members acknowledged that GM technology is one of the options that can increase productivity, improve productivity and incomes of farmers and contribute towards addressing food security in the region.

As a member of the SACAU, the Farmers Union of Malawi has expressed frustration at the lack of implementation of biotechnology opportunities in agriculture. While a regulatory and policy framework for genetically modified organisms (GMOs) was developed in 2002, followed by government approval of the Malawi National Biotechnology and Biosafety Policy in 2008, it was not until August 2011 that trials of GMO seed (Bt cotton) received approval by the Malawian regulatory authorities. The Union has taken an active role in arguing that farmers need an option for improving productivity and reducing costs, especially for crops such as cotton, and biotechnology is one of the key options, says the Union. These interventions were presented at a conference on biotechnology that was held in Lilongwe Malawi, in July 2011.

Quotes in support of Biotech/GM crops and GE technology:

Kenya:
Kenyan Prime Minister **Hon. Raila Amolo Odinga** on safety of biotech/GM crops in August 2011: ***"There is no evidence anywhere in the world that GMOs are harmful."***

Kenyan parliamentarian and woman Presidential hopeful in 2012 General Elections
Hon. Martha Karua (24th February 2011): ***"In order to achieve food security in Kenya, it is important to use all technologies available in Agriculture, I have read that Biotechnology offers potential to increase yield. It therefore needs to be given a chance and the National Biosafety Authority should help the country to move and catch up with the times."***

Kenyan Minister for Agriculture **Hon. Dr. Sally Kosgei** (10 August 2011): ***"So much time gets wasted talking about GMOs while there is no evidence that it has any harmful effect on human health. I have been consuming soya beans from Britain which are GMOs, yet they have not had an effect on my health, so nobody can die out of eating GMO foods, GMO cannot make people infertile."***

Egypt:
Egyptian Minister for Agriculture and Land Reclamation **Dr. Salah Farag** (July 2011): ***"The most important problem that faces Egypt today is the shortage of water and one way to overcome this problem is through the use of biotech plants."***

Nigeria:
Nigerian member of the seventh Senate **Mr. Ajayi Boroffice**, at the passing of the Biosafety Law in Nigeria (1 June 2011): ***"The passage of the Nigeria Biosafety bill will have a positive impact on the economy."***

Mozambique:
Mozambican Minister for Science and Technology, **Hon. Venancio Massingue** on revision of the country's Biosafety regulations (25 May 2011): ***"The government recognizes the important role of science and of biotechnological applications in development. The revision of the regulations,***

seeks to legislate for the genetic crossing of seeds in order to improve the productivity of crops, and to ensure that the tests for such hybrids are carried out under conditions of maximum safety."

Burundi:
Burundi Chief of Cabinet, Minister in charge of Environment, **Mr. Epimaque Murengerantwar** (April 2011): ***"Biotechnologies in particular GMOs when integrated in the existing production system may considerably improve food security in our poor countries. Under the auspices of the AU, African leaders agreed to exploit the potential of biotechnologies. It is important to harmonize biosafety policies in particular in the COMESA sub-region."***

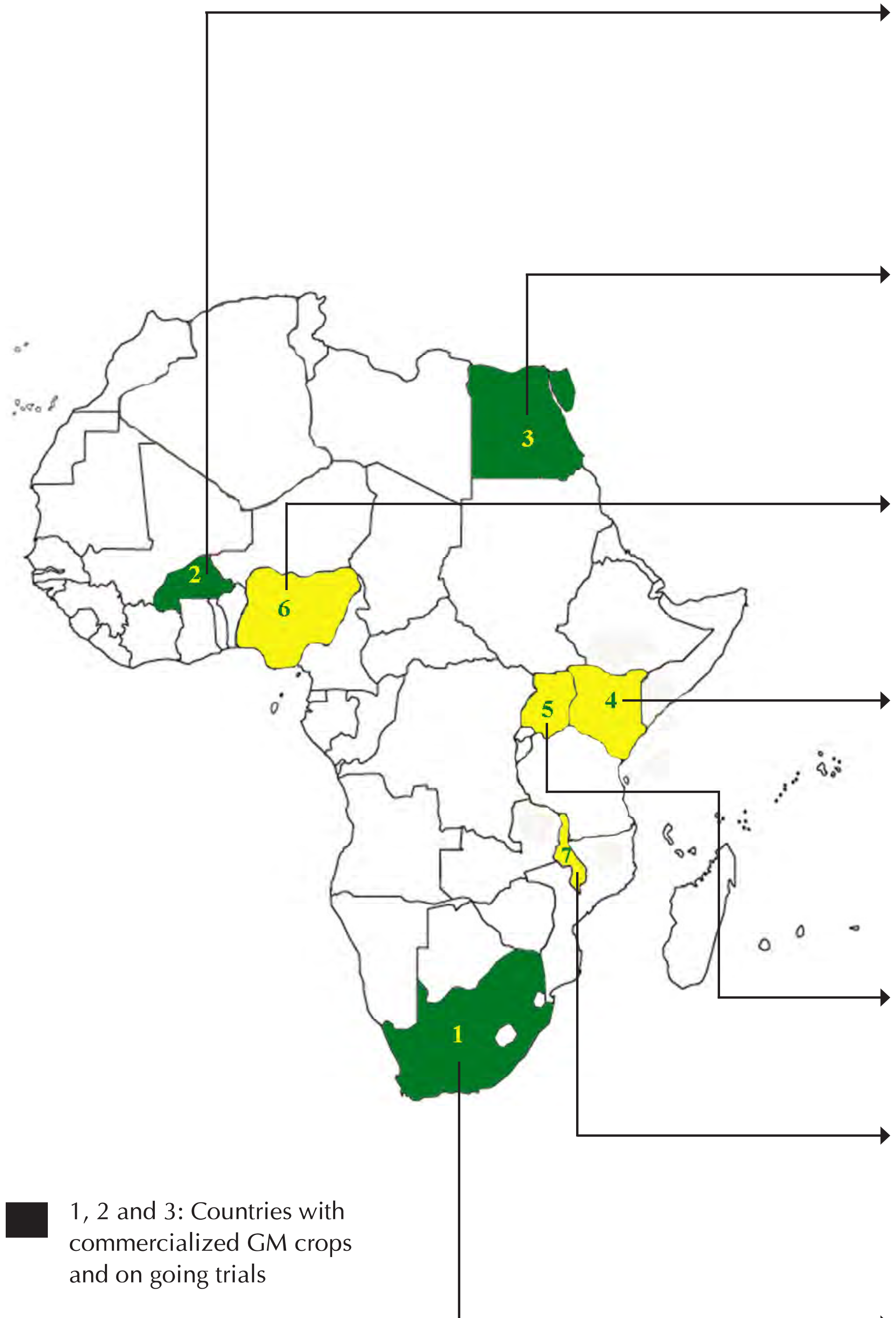
Swaziland:
Minister for Tourism and Environmental Affairs Hon. Macford Sibandze (January 2011)
"If we are to meet the challenges of the 21st century it is essential that we improve public engagement in science and increase the influence of scientific evidence on public policy."

Bill and Melinda Gates Foundation:
Bill Gates, co-chair of the Bill and Melinda Gates Foundation (October 2011) while accepting the World Food Program USA's George McGovern Leadership Award, ***"The world has the knowledge, tools, and resources to help the world's poorest overcome hunger and extreme poverty."***

International Fund for Agricultural Development (IFAD), President Dr. Kanayo F. Nwanze (September 2011):
To African Union leaders: ***"Africa should not wait for the international community to solve its problems. Africa will conquer hunger when African governments give Africans the tools and resources they need to feed themselves. Change – real change – comes from within."***

Farmer Opinion
Mr. Gilbert Arap Bor is a Kenyan framer who grows maize and vegetables and raises dairy cows on his 25-acre farm near Kapseret. He recently shared his views on biotech crops and the EU policy on the technology. ***"Thankfully, Kenya is beginning to take positive steps. Last year, our government approved the commercial planting of genetically modified crops, becoming the fourth African country to do so after Burkina Faso, Egypt and South Africa. This will give our farmers access to one of the world's most important hunger-fighting tools. We can also draw upon tremendous resources in human capital, from the scientific expertise at the Kenya Agricultural Research Institute to the business know-how of the Kenya Seed Company...the billions in aid that Europe sends to Africa every year do nothing to encourage the use of agricultural technology, and often discourage or prevent it. Africa's farmers and their would-***

Figure 46. Summary of Biotech Crop Commercialization and Field Trials in Africa as of October 2011



1, 2 and 3: Countries with commercialized GM crops and on going trials

4, 5, 6 and 7: Countries with on goings trials

Country	Crop	Trait	Institutions involved	Stage as in 2011
Burkina Faso Bt cotton commercialized in 2008	Cowpea, *Vigna unguiculata*	Insect resistance	INERA, AATF, NGICA, CSIRO, PBS, Monsanto	CFT - 1st season
Egypt Bt maize approved for commercialization in 2008	Maize, *Zea mays* L.	Insect resistance	Pioneer	Open Field trials - 4th season
	Cotton, *Gossypium barbadense*	Insect resistant	ARC	Open Field trials F10 stage waiting approval
	Wheat, *Triticum durum* L.	Drought tolerant/salt tolerant	AGERI	Open Field Trials - 9th season
		Fungal resistance	AGERI	Open Field Trials - 2nd season
	Potato, *Solanum tuberosum* L.	Viral resistance	AGERI	CGH
		Insect resistance	AGERI	Field trials - 10th season
	Tomato, *Lycopersicon esculentum*	Viral resistance	AGERI, Cairo University	CGH - 2nd season
	Sugarcane, *Saccharum officinarum*	Insect resistance	AGERI, Cairo University	Experimental field trial - 1st season
		Fungal resistance	AGERI*	Experimental field trial - 1st season
Nigeria Biosafety Law passed in 2011	Cassava, *Manihot esculenta Crantz*	Biofortified with increased the level of beta-carotene, provitamin A	National Root Crops Research Institute DDPSC, IITA	CFT - 2nd season
	Cowpea, *Vigna unguiculata*	Insect Resistant against Maruca pest	AATF, Institute of Agricultural Research	CFT - 2nd season
	Sorghum (ABS), *Sorghum bicolor Moench*	Enhanced Vit A levels, Bioavailable Zinc and Iron	Africa Harvest, Pioneer Hi-Bred, a company of DuPont business, IAR and NABDA	CFT - 1st season planted
Kenya Biosafety Act approved in 2009 Biosafety implementing regulations published in 2011	Maize, *Zea mays* L.	Drought Tolerance (WEMA)	AATF, CIMMYT, KARI, Monsanto	CFT - 2nd season
	Cotton, *Gossypium hirsutum* L.	Insect resistance	KARI/Monsanto	CFT - 5th season
	Cassava, *Manihot esculenta Crantz*	Cassava mosaic disease	KARI, Danforth Plant Science Center (DDPSC)	CFT - 1st season
		BioCassava Plus Vitamin A enriched	KARI, DDPSC, IITA, CIAT,	CFT - 1st season
	Sweet potato, *Ipomoea batatas*	Viral diseases	KARI/Monsanto	CFT - 1st season
	Sorghum (ABS), *Sorghum bicolor Moench*	Enhanced Vit A levels, Bioavailable Zinc and Iron	Africa Harvest, Pioneer Hi-Bred, a DuPont business and KARI	Approved for Contained Greenhouse trial by the NBA
	Pigeon pea	Insect resistance	Kenyatta University	Lab and Greenhouse transformation approved by NBA in March 2011
	Sweet potato	Insect resistance	Kenyatta University	Lab and Greenhouse transformation approved by NBA in April 2011
Uganda	Maize, *Zea mays* L.	Drought tolerance	NARO, AATF, Monsanto	CFT*, 2nd season
	Banana, *Musa*	Bacterial wilt resistance	NARO, AATF, IITA	CFT - 1st season
		Nutrition enhancement (Fe and Pro-vitamin A)	NARO, QUT (Queensland University of Technology)	CFT - 1st season
	Cassava, *Manihot esculenta Crantz*	Virus resistance	NARO, DDPSC, IITA	CFT - 2nd season
	Cotton, *Gossypium hirsutum L.*	Bollworm resistance and herbicide tolerance	NARO, Monsanto	CFT - 3rd season
	Sweetpotato, *Ipomoea batatas*	Weevil resistance	NARO, CIP	Contained Greenhouse trials on-going
Malawi	Cotton, *Gossypium hirsutum L.*	Bt and HT	Bunda University, Monsanto Ministry of Agric, Envi. Affairs Dept National Commission for S&T	CFT approved in August 2011, not yet planted
South Africa 1st Commercialized 1998	Maize, *Zea mays* L.	Drought tolerance	Monsanto	CFT Planted
		Herbicide tolerant	Pioneer Hi-Bred	CFT Planted
		Insect resistance		CFT Planted
		Insect/herbicide tolerance	Monsanto	CFT Planted
			Pioneer Hi-Bred	CFT Planted
	Cassava, *Manihot esculenta Crantz*	Starch enhanced	ARC-Industrial Crops Research Institute	CFT Planted in 2010
	Cotton, *Gossypium hirsutum* L.	Insect/herbicide tolerance	Bayer	CFT Planted
		Herbicide tolerance		
	Potato, *Solanum tuberosum* L.	Insect resistance	ARC-OVI	CFT
	Bulb Flower, *Ornithogalum dubius x thyrsoides*	Virus Resistance	Agricultural Research Council-Vegetable and Ornamental Plants Institute	CFT Planted
	Sugarcane	Alternate sugar (rattoon); Increased yield and sugars; Increased cellulose Increased yield and starch; Decreased starch	South African Sugar Research Institute	CFT Planted
	Sorghum, *Sorghum bicolor*	Biofortified – Pro-vitamin A, protein, digestibility, iron and zinc	Africa Harvest, Pioneer, a DuPont business and CSIR	Contained Greenhouse Trials (CGH)

be customers are being held hostage by scientific illiterates whose well-paid jobs involve raising money by frightening people about biotechnology" (Bor, 2011).

Cuba

Cuba, a country of 11 million people, imports around 60% of its food and feed, including large tonnages of maize, soy and wheat. The President of Cuba has called for increased agricultural output to contribute to "national security" following the unprecedented food price crisis in 2008. Food and feed imports were valued at US$1.5 billion of foreign exchange in Cuba in 2009. During the food crisis of 2008, the situation was exacerbated due to three hurricanes that battered Cuba causing losses estimated at US$10 billion in damages and destroyed 30% of the country's crops, resulting in brief food shortages.

In a determined and carefully planned research effort to significantly increase productivity of maize, Cuba, is developing biotech Bt maize to control losses from the insect pest fall armyworm *(Spodoptera frugiperda)*. Like many other tropical countries, armyworm is the most serious threat to maize production in Cuba, where it causes significant yield losses. The Bt maize is being developed and field-tested in a rigorously designed biosafety program, which meets the demanding standards of international protocols, by the country's internationally recognized Institute for Genetic Engineering and Biotechnology (CIGB).

To-date, field tests in Cuba have indicated that the significant and multiple benefits associated with Bt maize are similar to those reported by other countries which have already commercialized Bt maize. These benefits include, reduction in insecticides for the control of fall armyworm, less exposure of farmers and the environment to pesticides, protection of the enhanced diversity of more prevalent beneficial insects, and sustainable increases in productivity of up to 30%, or more, depending on the severity of the armyworm infestation, which varies significantly with climatic and ecological conditions.

The multiple location field trials involving biotech maize hybrids conducted in 2010 continued in 2011. The field trials featured biotech maize hybrids and mycorrhizal additives (with no insecticides, in a sustainable management system) and generated excellent results with the biotech maize yielding up to 40% more than the conventional maize in the same experiments. The rigorously executed program of regulated field trials is designed to address the issues of producers, consumers and society by comprehensively evaluating all aspects of the technology, prior to the final submission of an extensive dossier to the regulatory authorities in Cuba, for commercial approval consideration in the near term.

In the interim, an initiative for “regulated commercialization” is underway in which farmers seek permission to grow biotech maize “commercially” – an estimated 5,000 hectares were grown under “regulated commercialization” in 2011 – the arrangement is somewhat similar to the biotech maize scheme in place in Colombia which is monitored but not included in the ISAAA database. This is also similar to the situation in some EU countries where farmers have to seek permission to grow Bt maize.

The Bt maize being developed by Cuba is similar to that grown on over 50 million hectares in over 16 countries in 2011 alone. Thus, Cuba has the advantage of benefiting from the extensive and long term commercial experience over more than 15 years of a large number of countries in all continents of the world, including six EU countries which have been successfully growing and benefiting from Bt maize for more than a decade, and which also import large tonnages of biotech crops. The potential benefits of commercializing Bt maize in Cuba are significant. The latest published import information indicated that Cuba imported significant tonnages of maize ranging from 599,917 tonnes in 2006 valued at approximately US$86 million to approximately 700,000 tons in 2007 to 2009 valued at up to US$200 million (Table 44). Some of these imports could be substituted by domestic production, if the yield losses due to armyworm alone, which are up to 30%, are controlled, thus making the country substantially more self-sufficient in maize production. This is a very important benefit to Cuba because the alternative is to keep relying on imports, which are likely to become more expensive as prices of staples trend upwards in the future. Work is also underway in Cuba to develop biotech soybean, potatoes and tomato, but unlike Bt maize, these biotech crops are at the R&D stage.

Table 44. Imports of Maize Grain into Cuba, 2006 -2009

Maíze grain	2006	2007	2008	2009
Quantity MT*	599,917	708,389	716,984	682,526
Value $ million	86.600	146.863	207.542	147.402

Source: Annuario Estadistico de Cuba, 2009 * metric tonnes

Distribution of Biotech Crops, by Crop

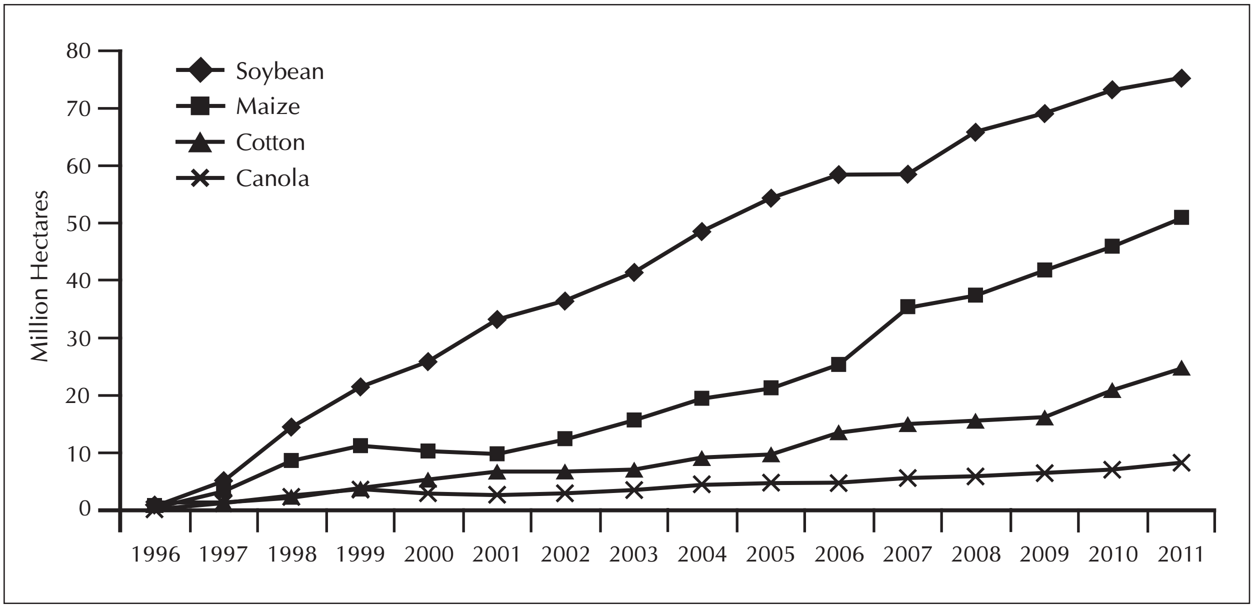
The distribution of the global biotech crop area for the four major crops is illustrated in Figure 47 and Table 45 for the period 1996 to 2011. It clearly shows the continuing dominance of biotech soybean occupying 47% of the global area of biotech crops in 2011; the entire biotech soybean hectarage is herbicide tolerant. Biotech soybean retained its position in 2011 as the biotech crop occupying the largest area globally, occupying 75.4 million hectares in 2011, 3% higher than 2010; biotech maize had the second highest area at 50.1 million hectares and also had the second highest year-to-year absolute growth for any biotech crop at 5.0 million hectares. Upland biotech cotton reached 24.7 million hectares in 2011 and grew at the fastest rate of 18% between 2010 and 2011. Canola reached 8.2 million hectares in 2011 with a 17% year-to-year global growth rate with record plantings of canola in Canada. Sugarbeet is a relatively new biotech crop first commercialized in the USA and Canada in 2007, and plateaued at 95% in 2011, the same adoption rate as 2010. RR®alfalfa, first grown in 2006, had a five year gap of no planting, pending legal clearance, occupied ~200,000 hectares, equivalent to approximately 10 to 15% of the 1.3 million hectare seeded in the USA in 2011. Small hectarages of biotech virus-resistant squash and papaya continued to be grown in the USA; China also grows about 5,000 hectares of PRSV resistant papaya and ~500 hectares of Bt poplar.

Biotech soybean

In 2011, biotech soybean accounted for 47% of all the biotech crop hectarage in the world and was grown in 11 countries. The global hectarage of herbicide tolerant soybean in 2011 was 75.4 million hectares, up by 2.1 million hectares, or 3% from 2010 at 73.3 million hectares. The increase resulted from the following changes at the country level. The largest increase, by far, in RR®soybean, was in Brazil with an increase of 16%, equivalent to 2.8 million hectares. Biotech soybean hectarage dropped in both the USA (29.2 million hectares) and Argentina (19.2 million hectares) because of lower total plantings of soybean. Modest increases were recorded in Canada, Paraguay, Uruguay and Bolivia. There were 11 countries which reported growing RR®soybean in 2010. The top three countries, growing by far the largest hectarage of herbicide tolerant soybean, were the USA (29.2 million hectares), Argentina (19.2 million hectares) and Brazil (20.6 million hectares). The other eight countries growing RR®soybean in decreasing order of hectarage include Paraguay, Canada, Uruguay, Bolivia, South Africa, Mexico, Chile and Costa Rica. Of the global hectarage of 100 million hectares (FAO, 2009) of soybean grown in 2011, an impressive 75% or 75.4 million hectares were RR®soybean.

The increase in income benefits for farmers growing biotech soybean during the 15-year period 1996 to 2010 was US$28.4 billion and for 2010 alone, US$3.3 billion (Brookes and Barfoot, 2012, Forthcoming).

Figure 47. Global Area of Biotech Crops, 1996 to 2011: by Crop (Million Hectares)



Source: Clive James, 2011.

Table 45. Global Area of Biotech Crops, 2010 and 2011: by Crop (Million Hectares)

Crop	2010	%	2011	%	+/-	%
Soybean	73.3	50	75.4	47	2.1	+3
Maize	46.0	31	51.0	32	5.0	+11
Cotton	21.0	14	24.7	15	3.7	+18
Canola	7.0	5	8.2	5	1.2	+17
Sugar beet	0.5	<1	0.5	<1	– –	– –
Alfalfa	0.1	<1	0.2	<1	– –	– –
Papaya	<0.1	<1	<0.1	<1	– –	– –
Others	<0.1	<1	<0.1	<1	– –	– –
Total	**148**	**100**	**160**	**100**	**12.0**	**+8**

Source: Clive James, 2011.

Biotech maize

In 2011, biotech maize increased by 9%, equivalent to a record 5.0 million hectares, the largest absolute increase in hectarage and the third highest percent increase after biotech cotton and canola. In 2011, biotech maize was grown on 51.0 million hectares, up from 46.0 million hectares in 2010 – an increase of 5.0 million hectares, or a year-over-year growth rate of 9%. It is noteworthy that 16 countries grew biotech maize in 2011. There were five countries which grew more than 1 million hectares of biotech maize in 2011 in decreasing order of hectarage they were: USA 33.9 million hectares, Brazil 9.1 million, Argentina 3.9 million, South Africa 1.9 million and Canada 1.3 million hectares. The three largest increases at the country leveling in 2011 was the US, up 2.1 million hectares, followed by Brazil at a 1.8 million hectare increase and Argentina with an increase of 0.9 million hectares. Modest increases were reported by several countries with no decreases. The six maize growing countries of the EU reported increased level of 114,490 hectares, an increase of 26%, or 23,297 hectares over 2010. An important feature of biotech maize is stacking, which is discussed in the sections on countries and traits.

Of the global hectarage of 159 million hectares (latest FAO STAT data for 2009) of maize grown in 16 countries in 2011, almost one-third, 32% or 51.0 million hectares, were biotech maize; this compares with 29% or 46.0 million hectares grown in 16 out of 29 biotech crop countries worldwide in 2010. Preliminary projections of yield gains from biotech drought tolerant maize in the USA, expected to be available about 2013, or earlier, 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 are projected to increase by up to 7.5 metric tons per hectare.

As the economies of the more advanced developing countries in Asia and Latin America grow at much higher rates (8%+) than North America and Europe, this will significantly increase demand for feed maize to meet higher meat consumption in diets, as people become wealthier and more prosperous with more surplus income to spend. Coincidentally, maize continued to be used for ethanol production in the US, estimated at 40% to 50% of total maize hectarage in 2011.

The increase in income benefits for farmers growing biotech maize during the 15 years (1996 to 2010) was US$21.7 billion and US$5 billion for 2010 alone (Brookes and Barfoot, 2012, Forthcoming).

Biotech cotton

The area planted to biotech cotton globally in 2011 was a record 24.7 million hectares up by 3.7 million hectares or an impressive 18% over 2010. This is the highest percent increase for any biotech crop at 18% and the second largest hectarage increase at 3.7 million hectares. A major reason for this is the very high increase after several years of declining cotton prices, which drove down hectarage, the unprecedented high prices in 2010 provided strong incentives for farmers to plant more cotton including more biotech cotton. A total of 13 countries grew biotech cotton in

2011 and four grew more than 1.0 million hectares – they are listed here in descending order of hectarage: India 10.6 million hectares, up from 9.4 million in 2010, USA with 4.9 million hectares, China 3.9 million, and Pakistan 2.6 million hectares. The other nine countries in descending order of biotech hectarage were Argentina, Brazil, Myanmar, Burkina Faso, Mexico, Colombia, South Africa and Costa Rica.

RR®Flex cotton was introduced in the USA and Australia for the first time in 2006 and widely grown in 2011. It is notable that in 2011, the biotech cotton area in India again continued to grow despite an adoption rate of 86% in 2010. In 2011, biotech hybrid cotton in India, the largest cotton growing country in the world, occupied 10.6 million hectares of approved Bt cotton increasing by an impressive 13% gain between 2010 and 2011, despite almost optimal levels of adoption which reached 86% in 2010. The advantages of Bt cotton hybrid in India are significant and the substantial increase in 2011 was due to the significant gains in production, economic, environmental, health and social benefits, which has revolutionized cotton production in India. It is notable that, Burkina Faso which grew 8,500 hectares of Bt cotton (Bollgard®II) for the first time in 2008, increased this hectarage to 115,000 hectares in 2009 and to 247,000 hectares in 2011, with a marginal decrease over 2010 due to various facts unrelated to the performance of Bt cotton. Australia planted its largest crop of cotton ever at 600,000 hectares of which 99.5% was biotech, and the US planted a significant area of 4.9 million hectares out of total of 5.4 million hectares of upland cotton equivalent to a high 90% adoption rate.

Based on a global hectarage of 30 million hectares (latest FAO STAT data for 2009, whereas best estimate for 2011 is 36 million hectares) of cotton grown in 2011, over two thirds, 68% (based on 36 m has) to 82% (based on 36 million hectares) equivalent to 24.7 million hectares, were biotech cotton and grown in 13 of the 29 biotech crop countries worldwide.

The increase in income benefits for farmers growing biotech cotton during the 15-year period 1996 to 2010 was US$25.4 billion and US$5.2 billion for 2010 alone (Brookes and Barfoot, 2012, Forthcoming).

Biotech canola

The global area of biotech canola in 2011 is estimated to have increased by a significant 1.2 million hectares, from 7.0 million hectares in 2010 to an estimated 8.2 million hectares in 2011, a significant increase of 17% from 2010. This increase is attributed to a significant addition of 1.4 million hectares in Canada offset by a modest decrease in the US and a static hectarage in Australia at 139,000 hectares. Canada, by far is the largest grower of canola globally, has consistently increased reaching a record 96% in 2011 compared with 94% in 2010. Only four countries currently grow biotech canola: Canada, the USA, Australia and Chile but the global hectarage and prevalence could increase significantly in the near term in response to the likely increased use of canola for vegetable oil and biodiesel. Less than 1% of the canola crop in Canada was used for biodiesel in 2008 and this is expected to remain low at around 2% until 2012 when new biodiesel plants come on stream.

Of the global hectarage of 31 million hectares of canola grown in 2011, 26%, or 8.2 million hectares (up from 23% and 7.0 million hectares in 2010) were biotech canola grown in Canada, the USA, Australia and Chile.

The increase in income benefits for farmers growing biotech canola during the 15 year period 1996 to 2010 was US$2.7 billion and US$0.5 billion for 2010 alone (Brookes and Barfoot, 2012, forthcoming).

Biotech alfalfa

Herbicide tolerant RR®alfalfa was first 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 represented 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 was 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. After several court hearings RR®alfalfa was cleared for planting in early 2011 and it is estimated that US hectarage of RR®alfalfa in 2011 will total up to ~200.000 hectares (APHIS, 2011).

Other biotech crops

Small areas of biotech virus resistant squash (2,000 hectares) and PRSV resistant papaya in Hawaii (2,000 hectares with a 60% adoption) continued to be grown in the USA in 2011; the papaya industry in Hawaii was destroyed by PRSV and saved by the biotech papaya which is resistant to PRSV. In China, in 2010 there were approximately 5,000 hectares of PRSV resistant papaya (99% adoption rate) and 490 hectares of Bt poplars.

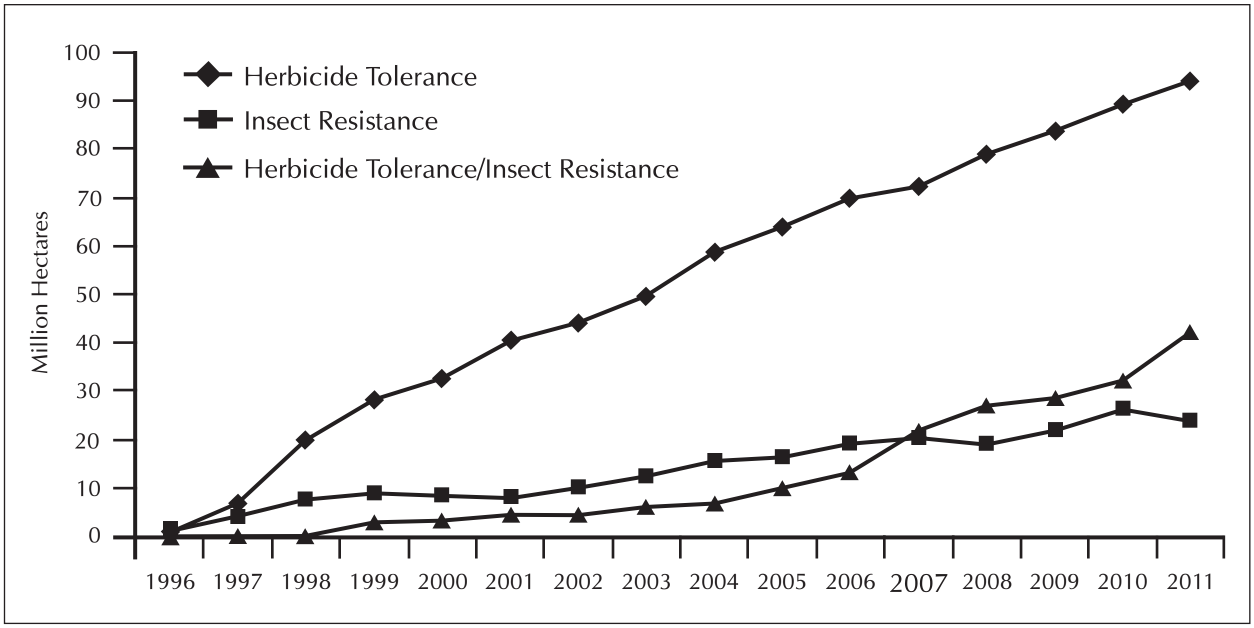
Distribution of Biotech Crops, by Trait

During the 16 year period 1996 to 2011, herbicide tolerance has consistently been the dominant trait (Figure 48). In 2011, herbicide tolerance, deployed in soybean, maize, canola, cotton, sugarbeet and alfalfa occupied 93.9 million hectares or 59% of the 160 million hectares of biotech crops planted globally (Table 46); this compares with 89.3 million hectares equivalent to 61% in 2010. In contrast to the 93.9 million hectares of herbicide tolerant crops in 2011, there was much less stacked traits at 42.2 million hectares, and hectares of insect resistance dropped by 9% to 23.9 million hectares from 26.3 million hectares in 2010. The large increases in the stacked genes were due to large increases in maize and modest increases in cotton. Of the large increase in maize stacks, Brazil has the most contribution, planting an additional 3.4 million hectares of stacked maize in 2011compared with 2010. Brazil was followed by the USA, Argentina and Canada, all of whom planted significantly more stacked maize in 2011 than 2010. In 2011, the stacked traits in both maize and cotton reached 42.2 million hectares, up from 32.3 million hectares in 2010. Biotech crops with Bt genes alone occupied 15% of the global biotech area in 2011, compared with 26% of stacked traits for herbicide tolerance and insect resistance deployed in both cotton (Bt/HT) and maize (Bt/Bt/IR, Bt/HT, and Bt/Bt/HT) (Table 46). The Bt/Bt/IR stack refers to different Bt or other IR genes that code for different traits, for example above ground pests and below ground pests in maize. In terms of year-over-year increases the highest growth was for the stacked at 31%, followed by herbicide tolerance at 5% with insect tolerance decreasing by -9%. These significant increases in stacks were off-set by decreases in Bt and HT and this trend is expected to continue as country markets mature and more stocks are offered in the market.

The stacked traits in maize and cotton increased by 9.9 million hectares or 31%, between 2010 and 2011. For the longer term, stacked traits in both maize and cotton are expected to continue to increase because they reflect the needs of farmers who have to simultaneously address the multiple yield constraints associated with both 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 with SmartStax™ comprising 8 genes coding for three traits, launched in the USA and Canada in 2010, and realizing continued growth in 2011.

The deployment of stacked traits of different Bt genes and herbicide tolerance is becoming increasingly important and is most prevalent in the USA which had approximately 73% of the 42.2 million (30.7 million hectares) as "stacked traits" in 2011, this compares with 85% in 2010, so the percentage in the US will drop as stacks become relatively more prevalent in other countries. In 2011, the other six principal countries, of a total of 11, which deployed stacked traits in 2011 were: Argentina (4.1 million hectares), Brazil (4.0 million hectares), South Africa (1.1 million hectares), Canada (1.0 million hectares), Australia (0.6 million hectares), Philippines (0.54 million hectares)

Figure 48. Global Area of Biotech Crops, 1996 to 2011: by Trait (Million Hectares)



Source: Clive James, 2011.

Table 46. Global Area of Biotech Crops, 2010 and 2011: by Trait (Million Hectares)

Trait	2010	%	2011	%	+/-	%
Herbicide tolerance	89.3	61	93.9	59	4.6	+5
Stacked traits	32.3	22	42.2	26	9.9	+31
Insect resistance (Bt)	26.3	17	23.9	15	-2.4	-9
Virus resistance/Other	<0.1	<1	<1	<1	<1	<1
Total	**148.0**	**100**	**160.0**	**100**	**12.0**	**+8**

Source: Clive James, 2011.

and Mexico (0.2 million hectares). Uruguay, Honduras, Chile, and Colombia, planted less than 0.1 million hectares each. 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 to single biotic stress.

Distribution of economic benefits at the farm level by trait, for the first fifteen years of commercialization of biotech crops 1996 to 2010 was as follows: all herbicide tolerant crops at US$34.8 billion and all insect resistant crops at US$43.4 billion, with the balance of US$0.2 billion for other minor biotech crops. For 2010 alone, the benefits were: all herbicide tolerant crops US$4.3 billion, and all insect resistant crops US$9.5 billion plus a balance of US$0.2 billion for the minor biotech crops for a total of ~US$14 billion (Brookes and Barfoot, 2012, Forthcoming).

Dominant Biotech Crops in 2011

Herbicide tolerant soybean continued to be the dominant biotech crop grown commercially in 11 countries in 2011; listed in order of hectarage, the 11 countries were: USA, Argentina, Brazil, Paraguay, Canada, Uruguay, Bolivia, South Africa, Mexico, Chile and Costa Rica. Globally, herbicide tolerant soybean occupied 75.4 million hectares, (up 2.1 million hectares, or 3% from 2010), and representing 47% of the global biotech crop area of 160 million hectares for all crops (Table 47).

The second most dominant biotech crop was maize with stacked traits, which occupied 37.3 million hectares, (up 8.5 million hectares, or 30%) and occupied 23% of the global biotech area and planted in nine countries, the USA, Brazil, Argentina, South Africa, Canada, the Philippines, Uruguay, Honduras, 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. Maize with stacked traits occupied a total of 37.3 million hectares in 2011 compared with 28.8 million hectares in 2010 a 30% year-to-year increase, and occupying 23% of global biotech crop hectarage.

The third most dominant crop was Bt cotton, which occupied 17.9 million hectares, equivalent to 11% of the global biotech area, up 1.8 million hectares, or 11%, since 2010 and planted in eleven countries, listed in order of descending hectarage: India, China, Pakistan, Myanmar, Burkina Faso, Brazil, USA, Argentina, Australia, Colombia, and Costa Rica.

Table 47. Dominant Biotech Crops in 2011 (Million Hectares)

Crop	2010	2011	Change 2011-2010	% Change	% Global
Herbicide tolerant Soybean	73.3	75.4	2.1	+3	47
Stacked traits Maize	28.8	37.3	8.5	+30	23
Bt Cotton	16.1	17.9	1.8	+11	11
Herbicide tolerant Canola	7.0	8.2	1.2	+17	5
Herbicide tolerant Maize	7.0	7.7	0.7	+10	5
Bt Maize	10.2	6.0	-4.2	-41	4
Stacked traits Cotton	3.5	4.9	1.4	+40	3
Herbicide tolerant Cotton	1.4	1.8	0.4	+29	1
Herbicide tolerant Sugar beet	0.5	0.5	– –	– –	<1
Herbicide tolerant Alfalfa	0.1	0.2	0.1	+100	<1
Others	0.1	0.1	– –	– –	<1
Total	**148.0**	**160.0**	**12.0**	**8**	**100**

Source: Compiled by ISAAA, 2011.

The fourth most dominant crop was herbicide tolerant canola, occupying 8.2 million hectares, equivalent to 5% of global biotech crops, and planted in four countries, Canada, USA, Australia and Chile.

The fifth most dominant crop was herbicide tolerant maize occupying 7.7 million hectares, equivalent to 5% of global biotech crop area and planted in eight countries – the USA, Brazil, Canada, Argentina, South Africa, the Philippines, Honduras and Chile.

The sixth most dominant crop was Bt maize which occupied 6.0 million hectares, with a negative growth of 41% equivalent to 4% of global biotech area and was planted in 16 countries in descending order of hectarage – Brazil, South Africa, USA, Argentina, Uruguay, Spain, Canada, the Philippines, Portugal, Czech Republic, Poland, Egypt, Slovakia, Honduras, Chile, and Romania.

The seventh most dominant crop was stacked cotton, occupying 4.9 million hectares, up 1.4 million hectares or 40% from 2010 (the second largest percent increase of any crop in 2011) and occupying 3% of global biotech area, and planted in seven countries – USA, Argentina, Australia, Brazil, Mexico, Colombia and South Africa.

The eighth most dominant trait was herbicide tolerant cotton occupying 1.8 million hectares or 1% of all biotech crops globally and planted in seven countries – USA, Brazil, Argentina, Australia, Mexico, Colombia and South Africa.

The balance of other crops listed in Table 47 occupied less than 1% of global biotech crop area and include, in descending order of area: herbicide tolerant sugarbeet grown on 0.5 million hectares in the USA and Canada and herbicide tolerant alfalfa grown on 0.2 million hectares in the USA in 2011. China grows about 5,000 hectares of virus resistant papaya. The "Others" category, with a total of less than 1,000 hectares, includes virus resistant papaya and squash in the USA, Bt poplars, 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 48 and Figure 49). The data indicate that in 2011, 75% (75.4 million hectares) of the 100 million hectares of soybean planted globally (FAO, 2009) were biotech. Of the 30 million hectares of global cotton, 82% or 24.7 million hectares were biotech in 2011 compared with 64% or 21.0 million hectares planted to biotech cotton in 2010. Note that 82% is based on 30 million global hectares – the latest statistics from FAO for 2009 – whereas the pre-estimate for 2011 is 36 million hectares, equivalent to an adoption rate of 69%, which is probably closer to actual. Of the 159 million hectares of global maize planted in 2011 (FAO, 2009), almost one-third (32%) or 51.0 million hectares were biotech maize. Finally, of the 31 million hectares of canola (FAO, 2009) grown globally in 2011, over one quarter (26%) were herbicide tolerant biotech canola, equivalent to 8.2 million hectares, compared with 7.0 million hectares or 21% in 2010. If the global areas (conventional plus biotech) of these four crops are aggregated, the total area is 320 million hectares, of which exactly half, 50%, or 160 million hectares, were biotech in 2011 – up from 47% and 148 million hectares in 2010.

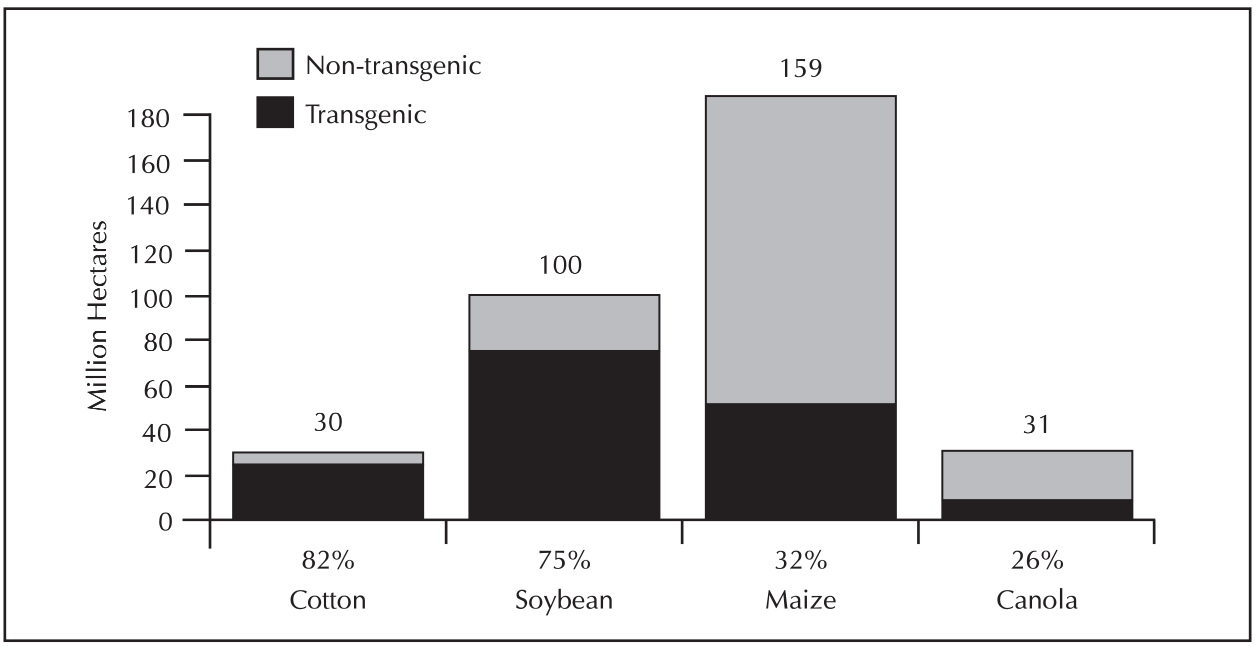
Whereas critics of biotech crops often contend that the current focus on biotech soybean, maize, cotton and canola reflects only the needs of large commercial farmers in the richer industrial countries, it is important to note that two-thirds of these 320 million hectares are in the developing countries, 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.

Table 48. Biotech Crop Area as Percent of Global Area of Principal Crops, 2011 (Million Hectares)

Crop	Global Area*	Biotech Crop Area	Biotech Area as % of Global Area
Cotton	30	24.7	82
Soybean	100	75.4	75
Maize	159	51.0	32
Canola	31	8.2	26
Others	- -	0.7	- -
Total	**320**	**160.0**	**50**

Source: Compiled by ISAAA, 2011. *Latest FAO 2009 hectarage

Figure 49. Global Adoption Rates (%) for Principal Biotech Crops, 2011 (Million Hectares)



FAO Global hectarages for 2009.
Source: Compiled by Clive James, 2011.

The Global Value of the Biotech Crop Market

Global value of the biotech seed market alone was valued at US$13.3 billion in 2011 with commercial biotech maize, soybean grain and cotton valued at ~US$160 billion for 2010.

In 2011, the global market value of biotech crops, estimated by Cropnosis, was US$13.3 billion, (up from US$11.8 billion in 2010); this represents 22% of the US$59.6 billion global crop protection market in 2011, and 35% of the ~US$34 billion commercial seed market (Table 49 in Appendix 3). The US$13.3 billion biotech crop market comprised US$6.5 billion for biotech maize (equivalent to 49% of global biotech crop market, up from 48% in 2010), US$4.4 billion for biotech soybean (33%, down from 3-8% in 2010), US$1.8 billion for biotech cotton (14%), and US$0.3 billion for biotech canola (2%). Of the US$13.3 billion biotech crop market, US$10.3 billion (77%) was in the industrial countries and US$3.0 billion (23%) 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 16 year period, since biotech crops were first

Table 49. The Global Value of the Biotech Crop Market, 1996 to 2011

Year	Value (Millions of US$)
1996	93
1997	591
1998	1,560
1999	2,354
2000	2,429
2001	2,928
2002	3,470
2003	4,046
2004	5,090
2005	5,714
2006	6,670
2007	7,773
2008	9,045
2009	10,607
2010	11,780
2011	13,251
Total	**87,401**

Source: Cropnosis, 2011 (Personal Communication).

commercialized in 1996, is estimated at US$87.4 billion. The global value of the biotech crop seed market is projected at ~US$14 billion for 2012.

A holistic estimate of the value of biotech crops globally and in the USA was recently documented by Carlson (2009) who noted that the annual ISAAA estimates (James, 2008) detailed above, are only "for seeds and licensing revenues rather than from 'crops', which have much greater market value." He also indicated that "Worldwide farm-scale revenues from GM crops are difficult to assess directly, but that good data are available for the United States." The USDA Economic Research Service reports that 80-90% of all corn, soy, and cotton grown in the United States is biotech (Figure 47).

Published reports by Carlson (2009) enabled him to estimate revenues from the major GM crops at about US$65 billion in 2008 in the USA alone. Given that the USA has approximately 50% of global biotech crop plantings, Carlson estimated that "global farm-scale revenues from GM corn, soy and cotton in 2008 were about double the US gains of US$65 billion, equivalent to US$130 billion." For the US alone, taking into account the biotech crop revenue figure of US$65 billion plus contributions from GM drugs ('biologics') and GM industrial products (fuels, materials, enzymes), which Carlson had previously estimated (Carlson, 2007) – he estimated that US revenues alone in 2007 from all GM products (biotech crops, biologics and industrial products) was approximately US$240 billion and growing at 15-20% annually. Given the US GDP, of about US$14.3 trillion in 2008, Carlson estimated that revenues from all GM products in the USA could amount to the equivalent of about 2% of US GDP in 2009.

The estimated global farm-gate revenues for the harvested commercial "end products", (the biotech grain and other harvested products) is obviously many-fold greater than the value of the biotech seed alone (US$11.2 billion). Extrapolating from the 2008 data of Carlson, 2009, detailed above, the value of the biotech harvested grain from biotech seed would be worth ~US$160 billion globally in 2011, and projected to increase at up to 10 - 15% annually.

A recent Philips McDougal publication reported that the costs for discovery, development and authorization of a new plant biotechnology trait introduced between 2008 and 2012 was US$136 million. The survey also concluded that: the time from the initiation of a discovery project to commercial launch was on average 13.1 years; the time associated with registration and regulatory affairs is increasing from a mean of 3.7 years for an event introduced before 2002, to the current (2011) estimated 5.5 years; regulatory science, registration and regulatory affairs accounts for the longest phase in product development, estimated at 36.7 percent of total time involved; and the trend in the number of units (candidate genes, constructs or genetic events) being screened in order to develop one trait is increasing (McDougal, 2011).

Global Status of Regulatory Approvals

While **29** countries planted commercialized biotech crops in 2010, an additional **31** countries, totaling **60** have granted regulatory approvals for biotech crops for import for food and feed use and for release into the environment since 1996. Turkey started approving biotech crops for import into the country in 2011. A total of **1,045** approvals have been granted for **196** events for 25 crops. Thus, biotech crops are accepted for import for food and feed use and for release into the environment in **60** countries, including major food importing countries like Japan, which do not plant biotech crops. Of the 60 countries that have granted approvals for biotech crops, USA tops the list followed by **Japan, Canada, Mexico, South Korea, Australia, the Philippines, New Zealand, the European Union, and Taiwan**. Maize has the most events approved (65) followed by cotton (39), canola (15), potato and soybean (14 each). The event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 25 approvals (EU=27 counted as 1 approval only), followed by insect resistant maize MON810 with 23 approvals, herbicide tolerant maize NK603 with 22 approvals each, and insect resistant cotton (MON1445) with 14 approvals worldwide.

THE FUTURE

On 31 October 2011, the UN declared that the world has reached the important historical milestone of 7 billion living persons, only twelve years after Adnan Nevic was declared to be the 6th billionth living person born on 31 October 1999. The world needs at least 70% more food by 2050. For the developing countries, where 2.5 billion small resource-poor farmers survive, (representing some of the poorest people in the world), food production needs to be doubled by 2050 (Save and Grow Report, FAO 2011). Current investments in agriculture in developing countries are woefully inadequate. Current expenditures on agriculture in the developing countries is ~US$142 billion per annum and it is estimated that an additional US$57 billion per year, will be required annually for a total of US$209 billion per year in 2009 dollars from now until 2050 (How to feed the world in 2050, IFPRI, 2011). Given that the history of the past is one of the essential steps to consider for predicting the future, the current status of biotech crops, and progress to-date during the last 16 years since biotech crops were first commercialized in 1996, are reviewed. Future prospects of biotech crops are discussed in the following paragraphs within the context of the Challenges and Opportunities for biotech crops globally in the foreseeable future.

A long term assessment of the potential of technology to increase crop production

The famous Rothamsted Agricultural Experimental Station in the UK has the longest-running continuously cropped field experiment in the world – it is named “Broadbalk field.” It was first cropped with wheat in 1843, 168 years ago. Different parts of the field have been subject to different treatments and hence can be used to compare the effect of different farming practices over the long term. Wheat yields on Broadbalk vary from a low of 1 ton per hectare to a high of 10 tons, depending on farming practice. The parcel with the lowest yield of 1 ton per hectare has not received any fertilizer, pesticides or any other input during more than 160 years, and is considered equivalent to a typical field in Africa today. The parcel with the mid yield of 4 to 5 tons per hectare features a typical wheat of the 1960s and has received levels of inputs typically used during the wheat green revolution of the 1960s and 1970s – this is considered similar to wheat farming practices today in India or Argentina. The third and last parcel, features a current top yielding wheat variety plus optimal recommended inputs that would be considered best practice in 2010 – the yield in this parcel was 10 tons per hectare, equivalent to the best wheat yields in the world. However, the high yield of 10 tons has plateaued during the last decade (Feeding the World, The Economist 26 February 2011).

The general conclusion from Broadbalk is that yield will stagnate and then plummet, unless you continuously use the optimal technology package including the best current varieties and input practices. Thus, it is not the fault of today's African farmer that yield per hectare is only 1 ton per hectare in Africa, it is lack of access to the best package of technology and farming practices – 1 ton yields on Broadbalk using a similar technology package to Africa yields the same as in Africa. The plateauing of the best yields in Broadbalk at around 10 tons over the last 15 years is due to many factors – it is partly due to the fact that wheat, unlike maize, has not benefited from biotechnology for the last 15 years, since biotech crops were first commercialized in 1996. Studies in the US over an 8 year running period show that the total increase in yield over 8 years was 4% in wheat, compared with over 14% for maize, and over 10% for soybean – both maize and wheat which have benefited from biotechnology inputs, whereas wheat has not. The yield increase in maize was more than three-fold higher than wheat. A consequence is that US farmers, (like their counterpart around the world) will always choose the most profitable crop option and have decreased plantings of wheat significantly in favor of more profitable maize and soybean. Coincidentally, a consortium of wheat exporting countries, which four years ago concluded that it was premature to consider development and commercialization of biotech wheat have now revisited their earlier decision and have agreed to collectively support biotech wheat. Accordingly, many of the major wheat countries, such as the US and Australia are fast-tracking biotech wheat, working on traits such as drought tolerance, quality and disease resistance so that wheat does not continue to be disadvantaged versus other crops such as maize and soybean which have benefited from biotech. Similarly, developing countries like China, the biggest producer and consumer of wheat in the world, and the major multinationals, are working on biotech wheat, which could be ready for commercialization.

CHALLENGES

The major goal of ISAAA is to alleviate poverty and hunger, which pervasively pollutes the lives of 1 billion suffering people, a humanitarian condition that is morally unacceptable. Today, poverty is mainly a rural phenomenon, however, this will change in the future as urbanization continues to increase from its current level of just over half the world's population. In 2011, approximately half of the world's poor were small resource-poor farmers, whilst another 20% were the rural landless who are completely dependent on agriculture for their livelihoods. Thus, 70% of the world's poor are dependent on agriculture – some view this as a problem, however it should be viewed as an opportunity, given the enormous potential of both conventional and the new biotechnology applications to make a significant contribution to the alleviation of poverty and hunger and to doubling food, feed and fiber production by 2050. The encouraging news is that the application of appropriate policies and technologies has the potential to adequately feed the world of tomorrow. Whether appropriate polices and technologies will be allowed to contribute will depend on political will to facilitate urgent action to support innovative technology. Global society also needs to ensure that words are translated into urgent action and that politicians practice what they preach in terms of allocating the financial and material support necessary to achieve food security for global society.

Population, Poverty and Hunger

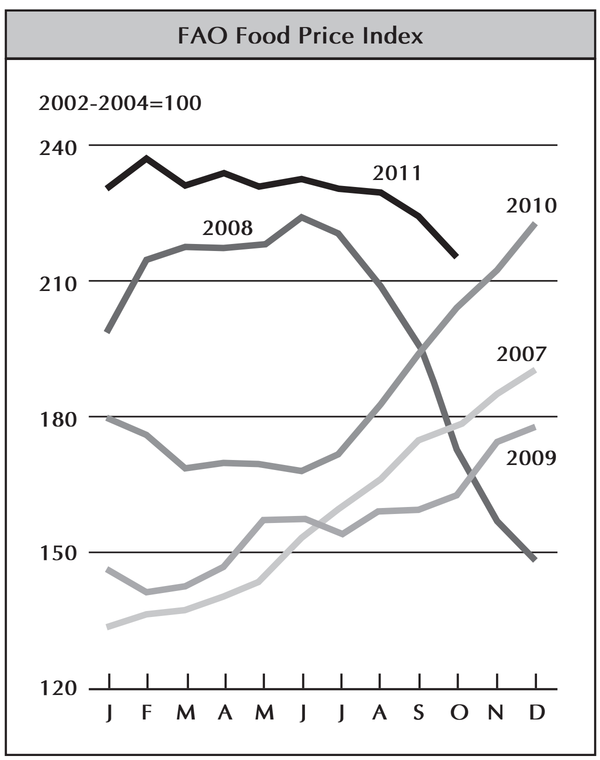
The 31st of October 2011 is a birthday for the world, when we welcomed the 7th billion living person to this planet. The most recent study (United Nations, 2011) by the Population Division of the United Nations (UN) has increased its projection of global population from 9.2 billion to 9.3 billion for 2050. More importantly and unlike previous estimates which predicted plateauing in 2050, continuing global growth is now projected until the end of this century to reach 10.1 billion people in 2100. Population growth in Africa, already struggling with food production, will continue to be high and could increase from the current 1 billion to an extraordinary high of 3.6 billion by 2100. Countries like Nigeria, the most populous country in Africa, could climb from today's 162 million to 730 million, Malawi from 15 million to 129 million and Yemen, a country whose population has quintupled since 1950, with a current population of 24 million could soar to 100 million by 2100. These "explosions" in population in "high fertility" African countries represent unprecedented challenges for Africa, where even today, food-deficit countries in the horn of Africa, Somalia, Kenya Ethiopia and Djibouti, have over 10 million at risk from famine, principally associated with their oldest and most important enemy – a devastating drought. The positive aspect is that a well integrated food security initiative, in which both conventional and crop biotechnology applications feature in a broad multiple thrust strategy (involving policy, population stabilization, food waste reduction and distribution) can make a significant contribution to the formidable task of feeding 10.1 billion people in 2100, of which more than one-third will be in Africa.

As food production per capita decreases in Africa, wealth is being created in some lead developing countries like China and India in Asia, and Brazil in Latin America resulting in the growth of a new middle class projected to reach 2 billion, which demand enhanced diets and consume more meat; this in turn requires substantially more animal feed stocks of maize and soybean because the conversion from grain to meat is very inefficient requiring 7 kilos of grain to produce 1 kilo of beef. The trend to consume more meat thus exacerbates the challenge of increasing crop production, which is the major source of food and animal feed.

Prices of Commodities

During the food crisis of mid 2008, when prices of food commodities reached an all time peak hundreds of millions of poor people, who spend more than 70% to 80% of their income on food suffered badly. Food riots were reported in up to 30 countries, two governments fell and exports of commodity crops were banned by many grain exporting countries in order to provide a secure domestic supply. In early 2011, a food crisis similar to 2008 was witnessed with the food index of the FAO reaching peaks higher than 2008 (Figure 50).

Figure 50. FAO Food Price Index, 2007 to 2011



Source: FAO, 2011.

The drought affecting wheat in China fuelled new concerns linked to the rising price of oil and commodities and the political uprisings in the Middle East. The internationally recognized economist, Jeffrey Sachs has expressed his concern at the consequences, stating that food prices were entering a new and uncharted era which is of particular concern for poor people. On the political front, President Sarkozy of France and the group of 20 has assigned top priority to controlling volatility in the price of food, and the philanthropist Bill Gates has focused more funding on agriculture in the developing countries. Observers have opined that the era of cheap food is over with demand for feed stocks exacerbated by increased consumption of meat in Asia, where the creation of a new wealthier middle class is resulting in more demand for both food crops and meat.

The State of Food Insecurity in the World

The latest edition of FAO's published report in October 2011 The State of Food Insecurity in the World, (FAO, 2011) focuses on the impact of food price volatility and high food prices. The Report predicts that both price and volatility are likely to continue to increase in the future. The G20 Finance Ministers and Central Bank Governors have become engaged in finding cost-effective ways to reduce price volatility and mitigate its effects when they do occur. The food and economic crises of 2006 to 2008 are challenging efforts to achieve the Millennium Development Goal of reducing, by half, the proportion of people who suffer from hunger. The major conclusions of the Report were that:

- **Small import-dependent countries, especially in Africa, were deeply affected by the food and economic crises.** Some exporting countries provided themselves some protection by restricting or halting grain exports which in turn increased volatility in international markets.

- **High and volatile food prices are likely to continue.** Increased demand from wealthier consumers in emerging countries and population growth in high fertility countries, as well as further growth in biofuels, will result in additional demands on the food supply. This was exacerbated in some countries due to lower rates of crop productivity and natural disasters due to drought and floods.

- **Price volatility makes both smallholder farmers and poor consumers increasingly vulnerable to poverty.** Food is a large share of small farmer income and the budget of poor consumers, thus large price changes have large effects on real incomes. For example, crops sold at low prices make it less likely that poor farmers can invest in conventional or biotech-based technology to increase productivity.

- **Large short-term price changes can have long-term impacts on development.** Volatility and higher prices leads to a reduction in children's food consumption which increases malnutrition in the first 1,000 days of life, and which in turn leads to a permanent reduction in their future earning capacity, and increased probability of poverty, which eventually impacts negatively on economic development.

- **High food prices worsen food insecurity in the short term.** Larger farmers with access to land and other resources, are the major beneficiaries of high crop prices whilst the subsistent poorest farmers have to pay higher prices for the food they have to buy. High prices negatively impact on the urban poor and the landless rural poor.

  High food prices present incentives for increased long-term investment in the agriculture sector, which can contribute to improved food security in the longer term. Domestic food prices increased during the 2006-08 world food crises. Despite higher input prices, (for example, fertilizer) this resulted in higher production in many countries. It is important to build on this short-term success with increased investments, particularly for small resource-poor farmers.

- **Safety nets are crucial for alleviating food insecurity in the short term, as well as for providing a foundation for long-term development.** To effectively reduce the negative consequences of price volatility, targeted safety-net mechanisms are a must, and should be designed in advance with the vulnerable people.

- **A food-security strategy that relies on a combination of increased productivity in agriculture, greater policy predictability and general openness to trade will be more effective than other strategies.** Predictable Government policies and private sector participation in trade will generally decrease price volatility.

- **Investment in agriculture remains critical to sustainable long-term food security.** Investments in irrigation, better farm practices, and improved seeds, reduce production risks, especially to smallholders, and reduce price volatility. Whereas, private investors will be the majority stakeholders public investment has an important complementary role to play in supplying public goods, and protection of natural resources.

The Millennium Development Goal (MDG)

Poverty and hunger are inextricably linked and today afflict approximately 1 billion people in the world, mainly in the developing counties. However, during the current economic crisis, even in the US, the most advanced and powerful economy in the world, poverty in 2010 was estimated at 15.1% of the population (the highest since 1993) equivalent to 46.2 million unemployed, the highest on record (US Census Bureau, 13 Sept 2011). Ten years ago, in 2010, global society made a pledge, The Millennium Development Goal (MDG), to cut poverty by 50% by 2015, with 1990 as the starting benchmark (The Economist, 25 September 2010). In 1990 poverty, in the developing countries was 46% (World Bank estimate), and by 2005 had decreased to 27% – thus, 23% seems feasible by 2015, four years from now. However, many observers have cautioned that success in halving the percentage of poor people in the developing world should not be attributed to the UN MDG initiative alone, but principally to China for decreasing its poverty rate from 60% in 1990 to 16% in 2005 – an impressive 72% reduction. Given that China and India, (the two most populous countries in the world with a combined population of almost 2.5 billion) accounted for 62% of the world's poor in 1990, changes in percent poverty globally are highly dependent on China and India. Thus, the global percentage of poor is not an appropriate indicator for gauging progress for the majority of countries. Whereas the percentage of poor has decreased, the absolute number of poor, hungry and malnourished, remains at an unacceptably high level of approximately 1 billion exacerbated by the high price of food in 2008 which has been exceeded in 2010/11 (FAO, Food Index, 2011). Whereas in 1990, 90% of the poor were in the poorest countries, in 2010, almost three quarters of the world's poor people now live in middle income developing countries such as India, Pakistan, Indonesia and Nigeria, and only a quarter live in Africa (The Economist, 30 September 2010). A significant increase in poverty resulted from the price hikes of food commodities in 2008, and the same trend is again evident in the events of the Arab spring in 2011, partly due to the fact that poor people could not afford adequate food. In the midst of a global economic crisis many economists are warning of further price hikes of food in the near future.

Hidden hunger

Understandably, when people do not have enough calories, the major emphasis in terms of food security and hunger has been on increasing calories, focusing on cereals such as rice which provide the cheapest calorie remedy. However, hidden hunger related to micronutrient deficiencies affects even larger numbers of people than those suffering from calorie deficiency. Appropriately, more emphasis is now being placed on addressing micro nutrient deficiencies and biotech crops can play a very important role. The top four priorities are, in descending order of importance, lack of iron, zinc, iodine and Vitamin A (The Economist, 26 March 2011). Shortage of iron leads to anemia affecting up to half of all women of child bearing age in poor developing countries. Zinc which affects brain and motor development is estimated to result in 400,000 deaths every year. Lack of iodine, an essential element, is a major cause of mental retardation affecting approximately 2 billion people worldwide. Vitamin A deficiency results in half a million children becoming blind each year with half of them dying, equivalent to about 6,000 deaths per day. The death toll associated with lack of micronutrients is high and unacceptable, when potential remedies are at hand, using biotech and other approaches, including supply of supplements and more balanced diets, with more vegetables and fruit. Golden Rice is, by far, the most publicized biotech product designed to remedy Vitamin A deficiency, and is expected to be approved for commercialization in the Philippines in 2013, (see below for more detail). There are currently a myriad of projects worldwide utilizing biotech to remedy micronutrient deficiencies and malnutrition. Hopefully, the advent of Golden Rice in 2013 will at last spur increased interest in malnutrition and provide a working role model for other biotech initiatives addressing deficiencies related to iron, zinc and iodine.

The contribution of biotech crops to Sustainability

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987).

Biotech crops are already contributing to sustainability and can help mitigate the effects of climate change in the following five ways and have enormous potential for the future:

- **Contributing to food, feed and fiber security and self sufficiency, including more affordable food, by increasing productivity and economic benefits sustainably at the farmer level**

  Biotech crops already play an important role by increasing productivity per hectare and coincidentally decreasing cost of production as a result of reduced need for inputs. Economic gains at the farm level of ~US$78 billion were generated globally by biotech crops during the fifteen year period 1996 to 2010, of which 40% were due to reduced production costs (less ploughing, fewer pesticide sprays and less labor) and 60% due to substantial yield gains of 275.5 million tons. The 275.5 million tons comprised 97.5 million tons of soybean, 159.4 million tons of maize, 12.5 million tons of cotton lint, and 6.1 million tons of canola over the fifteen year period 1996 to 2010. For 2010 alone, economic gains at the farm level were ~US$14 billion, of which approximately 24%, were due to reduced production costs (less ploughing, fewer pesticide sprays and less labor) and approximately 76%, due to substantial yield gains of 44.1 million tons. The 44.1 million tons comprised 13.1 million tons of soybean, 28.3 million tons of maize, 2.1 million tons of cotton lint, and 0.65 million tons of canola in 2010 (Brookes and Barfoot, 2012, Forthcoming). Thus, biotech crops are already making a contribution to higher productivity and lower costs of production of current biotech crops, and have enormous potential for the future when the food staples of rice and wheat, as well as pro-poor food crops such as cassava, will benefit from biotechnology.

- **Conserving biodiversity, biotech crops are a land saving technology**

  Biotech crops are a land-saving technology, capable of higher productivity on the current 1.5 billion hectares of arable land, and thereby can help preclude deforestation and protect biodiversity in forests and in other in-situ biodiversity sanctuaries. Approximately 13 million hectares of biodiversity – rich tropical forests are lost in developing countries annually. If the 276 million tons of additional food, feed and fiber produced by biotech crops during the period 1996 to 2010 had not been produced by biotech crops, an additional 91 million hectares of conventional crops would have been required to produce the same tonnage. Some of the additional 91 million hectares would probably have required fragile marginal lands, not suitable for crop production, to be ploughed, and for tropical forest, rich in biodiversity, to be felled to make way for slash and burn agriculture in developing countries, thereby destroying biodiversity. Similarly, for 2010 alone, if the 44.1 million tons of additional food, feed and fiber produced by biotech crops during 2010 had not been produced by biotech crops, an additional 14 million hectares of conventional crops would have been required to produce the same tonnage for 2010 alone (Brookes and Barfoot, 2012, Forthcoming).

- **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 completely 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 (70%) of the world's poorest people. **To-date, biotech cotton in countries such as China, India, Pakistan, Myanmar, Burkina Faso and South Africa have already made a significant contribution to the income of ~15 million poor farmers in 2011, and this can be enhanced significantly in the remaining 4 years of the second decade of commercialization, 2012 to 2015 principally with biotech cotton, maize and rice.** Of special significance is biotech rice which has the potential to benefit 250 million poor rice-growing households in Asia, (equivalent to one billion beneficiaries based on 4 members per household) growing on average only half a hectare of rice with an income as low as US$1.25 per day – they are some of the poorest people in the world. It is evident that much progress has been made in the first fifteen 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 (MDG). **This offers a unique opportunity for the global crop biotechnology community, from the North and the South, the public and the private sectors, to define in 2010 the contributions that biotech crops can make**

to the 2015 Millennium Development Goals and also a more sustainable agriculture in the future – this gives the global biotech crop community five years to work towards implementing a global strategy and action plan for biotech crops that can deliver on the MDG goals of 2015.

- **Reducing agriculture's environmental footprint**

Conventional agriculture has impacted significantly on the environment and biotechnology can be used to reduce the environmental footprint of agriculture. Progress to-date includes: a significant reduction in pesticides; saving on fossil fuels; 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. The accumulative reduction in pesticides for the period 1996 to 2010 was estimated at 443 million kilograms (kgs) of active ingredient (a.i.), a saving of 9.1% in pesticides, which is equivalent to a 17.9% 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 corresponding data for 2010 alone was a reduction of 43.2 million kgs a.i. (equivalent to a saving of 11.1% in pesticides) and a reduction of 26.1% in EIQ (Brookes and Barfoot, 2012, Forthcoming).

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 over 9 billion by 2050. The first biotech maize hybrids with a degree of drought tolerance are expected to be commercialized by 2013 in the USA, and the first tropical drought tolerant biotech maize is expected by ~2017 for sub-Saharan Africa. The advent of drought tolerance in temperate tropical maize in the industrial countries will be a major milestone but will be of even much greater significance in tropical maize in sub-Saharan Africa, Latin America and Asia. Drought tolerance has also been incorporated in several other crops including wheat, which has performed well in initial field trials in Australia, with the best lines yielding 20% more than their conventional counterparts. **Drought tolerance is expected to have a major impact on more sustainable cropping systems worldwide, particularly in developing countries, where drought is more prevalent and severe than industrial countries.**

- **Helping mitigate climate change and reducing greenhouse gases**

The important and urgent concerns about the environment have implications for biotech crops, which contribute to a reduction of greenhouse gases and help mitigate climate change in two principal ways. First, permanent savings in carbon dioxide (CO_2) emissions through reduced use of fossil-based fuels, associated with fewer insecticide and herbicide sprays; in 2010, this was an estimated saving of 1.7 billion kg of CO_2, equivalent to reducing the number of cars on the roads by 0.8 million. Secondly, additional savings from conservation tillage (need for less or no ploughing facilitated by herbicide tolerant biotech crops) for biotech food, feed and fiber crops, led to an additional soil carbon sequestration equivalent in 2010 to 17.6 billion kg of CO_2, or removing 8 million cars off the road. Thus in 2010, the combined permanent and additional savings through sequestration was equivalent to a saving of 19.3 billion kg of CO_2 or removing 9 million cars from the road (Brookes and Barfoot, 2012, Forthcoming).

Droughts, floods, and temperature changes are predicted to become more prevalent and more severe as we face the new challenges associated with climate change, and hence, there will be a **need for faster crop improvement programs to develop varieties and hybrids that are well adapted to more rapid changes in climatic conditions.** Several biotech crop tools, including tissue culture, diagnostics, genomics, molecular marker-assisted selection (MAS) and biotech crops can be used collectively for 'speeding the breeding' and help mitigate 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 particularly moisture, and reducing pesticide spraying as well as sequestering CO_2.

In summary, collectively the above five thrusts have already demonstrated the capacity of biotech crops to contribute to sustainability in a significant manner and for mitigating the formidable challenges associated with climate change and global warming; and the potential for the future is enormous. Biotech crops can increase productivity and income significantly, and hence, can serve as an engine of rural economic growth that can contribute to the alleviation of poverty for the world's small and resource-poor farmers.

Biotech crops and Climate Change

According to the Intergovernmental Panel on Climate Change (IPCC, 2007) cited by the US EPA (2011), several factors directly connect climate change and crop productivity, and are summarized in the six paragraphs below:

- **Increases in average temperature** will result in the following effects: i) a positive effect in high latitude temperate regions as a result of the lengthening of the growing season, ii) adversely affect crops in low altitude subtropical and tropical regions where summer heat is already limiting productivity, iii) negatively affect productivity due to an increase in soil evaporation rates, and iv) a negative effect due to an increased probability of more frequent and more severe droughts.

- **Change in amount of rainfall and patterns** will affect soil erosion rates and soil moisture, both of which are important for crop yields. Precipitation will increase in high latitudes, and decrease in most subtropical low latitude regions – some by as much as about 20%.

- **Rising atmospheric concentrations of CO_2** will boost and enhance the growth of some crops but other aspects of climate change (e.g., higher temperatures and precipitation changes) may offset any beneficial boosting effect of higher CO_2 levels.

- **Pollution levels of tropospheric ozone** may increase due to CO_2 emissions resulting in higher temperatures that will offset the increased growth of crops resulting from higher levels of CO_2.

- **Changes in the frequency and severity of heat waves, drought, floods and hurricanes,** remain a key uncertain factor in future climate change and that may potentially affect agriculture.

- **Climatic changes will affect agricultural systems** and may lead to emergence of new pests and diseases.

Generally in the higher latitude temperate industrial countries, the impact on agriculture is expected to be less than in low latitude sub-tropical and tropical developing nations, where farmers also have more limited ability to adapt. Indeed, the effect of climate change on world agriculture will depend not only on changing climate conditions, but on the agricultural sector's ability and the speed with which it can adapt and develop new and improved crops to deal with constraints related to climate change. Similarly, there will be a need to adapt crop management practices, to meet the new demands of climate change. Adapting technology and cropping practices will be more of a challenge in the low latitude developing countries than in the higher latitude industrial countries where the constraints are less. Thus, the biggest challenges will be in the developing countries, where poverty and lack of technology and limitations of all resources are much greater than industrial countries.

Climate Change and Food Availability

Whereas, there could be agricultural gains in some crops in some regions of the world, the overall impact of climate change on agriculture is expected to be negative, and exacerbate the threat of global food security. Populations in the developing world, which are already vulnerable and food insecure, are likely to be the most seriously affected. In 2011, almost 40% of the world population of 6.7 billion, equivalent to 2.5 billion, rely on agriculture for their livelihood and will thus likely be the most severely affected (IFPRI, 2009).

The IFPRI analysis suggests that agriculture and human well-being will be negatively affected by climate change, particularly in the developing countries, in the following ways:

- Yield declines in the most important crops, and South Asia will be particularly hard hit;

- Yields of irrigated crops will vary across regions, but yields for all crops in South Asia will experience large declines;

- Increasing prices for the most important agricultural crops – rice, wheat, maize, and soybeans. Higher feed prices will result in higher meat prices;

- Calorie availability in 2050 will decline relative to 2000 levels throughout the developing world, leading to child malnutrition increase of 20%. To remedy these negative effects, IFPRI is recommending aggressive increases in agricultural productivity investments of US$7.1 – 7.3 billion to raise calorie consumption to offset the negative impacts of climate change on the health and well-being of children.

An Urgent Need for Action

Scientist have proposed that 450 ppm of CO_2 in the atmosphere should be the 2020 target acknowledging that it would create a rise in global temperature of 2 degrees centigrade with a 0.7 probability of exceeding 3 degrees with a 0.5 probability. This 450 ppm target is a rise of about 65 ppm from today's levels, and to be achievable, action to mitigate emissions needs to be taken now. The feasibility of achieving the global target of 450 ppm by 2020 is questioned by some observers because, in some cases, to peak at this level of carbon in the atmosphere by 2020 requires emission reductions of 50-80% from current levels. For example, in the US, current emissions are around 20 tons of CO_2 per capita. In a business-as-usual scenario, emissions are projected to increase to 40 tons per capita in 40 years. To reach the target of an 80% reduction would mean that emissions should fall to 4 tons per capita against a projected business-as-usual emission of 10 times that amount (Knudsen and Morgan 2010).

Climate Change and the Role of Biotech Crops

The annals of history of the first half of the 21st Century are likely to record that climate change was the defining scientific challenge of the time; thus, it is imperative that the role of biotech crops be fully realized, as a contributor to the formidable challenges associated with climate change. The

Science Alliance stated that ***"The two biggest issues facing the world population today are the threat of food insecurity and the possible negative implications of climate change,"*** (Scientific Alliance, 1 October, 2010). The Alliance noted that ***"climate change mitigation policy is increasingly favoring sustainable intensive agriculture, including the use of GM crops. In this case, climate policy and food security needs are perfectly aligned."*** The Alliance concluded that the challenge of feeding the world of 2050 is ***"an undeniable reality"*** for the following logical reasons. With a population of over 9 billion by 2050, and limited opportunities for expanding crop hectarage beyond the current 1.5 billion hectares, and wealthier emerging nations consuming more meat, (which is much less efficient than plant protein), the inescapable conclusion is that the world will require at least 70% more food by 2050 – this is reality. In contrast, unlike food security, the Alliance has concluded that ***"the impacts of climate change are now just projections from computer models which may be right, they may be wrong, but the fact is, they are based on the supposed dominance of a single factor: the known warming effect of increasing levels of carbon dioxide in the atmosphere, amplified by positive feedback effects. Deep cuts in*** CO_2 ***emissions worldwide are prescribed as the only way to avoid a future catastrophe. We have one quite clear and imminent problem (food security) and one credible but unproven hypothesis which could conceivably wreak havoc later in the century (anthropogenic global warming)."***

Contribution of Biotech Crops to the production constraints associated with Climate Change

Given that agriculture is a significant contributor (14%) of greenhouse gases (GHG) and therefore part of the problem in climate change, it is appropriate that biotech crops also be part of the solution. There is credible, peer reviewed and published evidence that biotech crops are already contributing to the reduction of CO_2 emissions in the following ways:

- Biotech crops require fewer pesticide sprays which results in savings of tractor/fossil fuel and thus less CO_2 emissions.
- Increasing productivity on the same current 1.5 billion hectares of crop land, makes biotech crops a land saving technology and reduces deforestation and CO_2 emissions – a major bonus for climate change.
- Herbicide tolerant biotech crops facilitate zero or no-till, which in turn significantly reduces the loss of soil carbon and CO_2 emissions.
- Herbicide tolerant biotech crops reduce ploughing, which in turn enhances the conservation of water substantially, reduces soil erosion significantly, and builds up organic matter which

locks up soil carbon and reduces CO_2 emission.

- Biotech crops can overcome abiotic stresses (through drought and salinity tolerance) and biotic stresses (weed, pest and disease resistance) in environments made unproductive by climate change because of variations in temperature, water level leading to more damaging epidemics and infestations which preclude the growing of conventionally bred crops (for example, several countries have discontinued conventional cotton in some areas due to excessive losses from bollworm).

- Biotech crops can be modified faster than conventional crops – thus allowing implementation of a "speeding the breeding" strategy to meet the more rapid changes required by more frequent and severe changes associated with climate change.

Increasing support from environmentalists for biotech crops

Whereas in general environmentalists have been opposed to biotech crops, climate change specialists, tasked with cutting CO_2 levels as the only remedy to avoid a future catastrophe, are now becoming increasingly supportive of biotech crops because biotech crops are viewed as a pragmatic remedy, where the twin goals of food security and climate change can be enjoined in one thrust that "kills two birds with one stone." Readers are referred to the section on sustainability in this Brief which documents the quantitative contribution that biotech crops are already making to sustainability, and in turn to climate change – the potential for the future is enormous.

Indeed, former leaders of the green movement, such as Mark Lynas and Stewart Brand, now acknowledge that the green movement opposition to biotech crops is out of sync with current knowledge and thinking, and this has precluded biotech crops from optimizing their contributions for the benefit of society in the strategic areas of food security and climate change (Ecologist, 15 November 2010). Stewart Brand opined that ***"I daresay the environmental movement has done more harm with its opposition to genetic engineering than with any other thing we've been wrong about. We've starved people, hindered science, hurt the natural environment, and denied our own practitioners a crucial tool... It's worth knowing and remembering who was leading Greenpeace International... and Friends of the Earth International... when those two organizations went to great lengths to persuade Africans that, in the service of ideology, starvation was good for them."*** Lynas, Brand and colleagues concluded that the same is true for nuclear power where opposition by the green movement has exacerbated, rather than helped the situation, where the alternate option to nuclear, coal fired power plants, have now become major CO_2 generators and polluters, thereby exacerbating, rather than solving, the problems associated with climate change.

Leading economists and scientists have supported the view that crop biotechnology can make a contribution to the challenges of climate change. Dr. M.S. Swaminathan, the father of the Green Revolution in India, observed that ***"Biotechnology can offer new ways to address climate change. Drought tolerance can be built into crops, for instance rice, by transferring genes. Opportunities abound by combining traditional and modern technologies like genetic modification and marker assisted selection"*** (http://www.globalchange-discussion.org/interview/ms_swaminathan/full_interview).

Joachim von Braun, former Director General of the International Food Policy Research Institute (IFPRI) in Washington DC, USA opined that ***"Biotechnology can play a helpful role in addressing the long-term sustainability issue and climate change. It is much more relevant for developing countries, than it is for developed countries. This is because of the emerging consequences of climate change, and because of the existing problems on food scarcity and food quality"*** (http://www.globalchange-discussion.org/interview/joachim_von_braun/full_interview).

Golden Rice, the Road to Commercialization

After more than a decade, Golden Rice, a biotech genetically-modified rice that contains enhanced levels of beta carotene, is advancing towards the completion of its regulatory requirements in the Philippines and Bangladesh. In the Philippines, the International Rice Research Institute (IRRI) has successfully bred the Golden Rice traits into IR64 and Asian mega varieties including the Philippine and Bangladeshi varieties, PSBRc82 and BRRI dhan 29, respectively. In the wet season of 2010 (September to December), IRRI completed one season of confined field tests of IR64-GR and received the certificate of completion from the National Committee on Biosafety of the Philippines. In the dry season of 2011 (February to June), the Philippine Rice Research Institute (PhilRice) conducted confined field test of PSBRc82 with the Golden Rice traits. IRRI scientists will be sharing the Bangladeshi varieties with the GR traits for confined field testing at the Bangladesh Rice Research Institute (BRRI) (IRRI, 2011).

In 2011, IRRI, PhilRice and BRRI were joined by the Helen Keller International (HKI) institute to assess how the daily consumption of Golden Rice can help reduce vitamin A deficiency. HKI is a leading global health organization that advocates and conducts programs to reduce blindness and prevents malnutrition worldwide over the last 40 years. They have been partnering with governments and other health agencies to reach those most in need through various interventions.

Ms. Nancy Haselow, (HKI vice president and regional director for Asia-Pacific, who has been designing, implementing, and testing vitamin A delivery programs for more than 20 years) observed that ***"the most vulnerable children and women in hard-to-reach areas are often missed by***

existing interventions to improve vitamin A status, including vitamin A supplementation, food fortification, dietary diversification, and promotion of optimal breast-feeding." Following the completion of studies to reassure that GR is safe, other studies to determine the effectiveness of Golden Rice in vitamin A-deficient women will be conducted in the Philippines. Daily consumption of GR and vitamin A-supplemented white rice for 90 days is designed to show the comparable efficacy of GR. In addition, the partners will design and test a delivery program for needy farmers and consumers in the Philippines and Bangladesh. With this partnership in place, (currently supported by the Bill and Melinda Gates Foundation) vitamin A deficiency, the leading cause of preventable blindness in children, will be addressed. Recent estimates show that 670,000 children die every year globally and another 350,000 become blind because they are vitamin A-deficient. According to the American Journal of Clinical Nutrition, about 150 g of uncooked golden rice can supply 50% of the recommended daily allowance of vitamin A for an adult. Golden Rice inventors Prof. Ingo Potrykus and Dr. Peter Beyer donated the technology in 2000 to resource-poor farmers in developing countries for free.

Current field testing and regulatory compliance experiments related to safety for Golden Rice regulatory dossiers are planned for submission in 2013 to the Philippine authorities and in 2015 to Bangladesh. Given that the GR trait is present in inbred lines, the GR varieties can be saved for replanting and will have similar cost to the varieties. In an article by Ingo Potrykus (2010) in ISAAA Brief 42, he concluded that biotech crops (GM) ***"could save millions from starvation and malnutrition, if they can be freed from excessive regulations."*** He reached this conclusion from his experience over the past 11 years chairing the Golden Rice Humanitarian project (http://www.goldenrice.org), and after a meeting hosted by the Pontifical Academy of Sciences at the Vatican last year on biotech crops for food security in the context of development (Potrykus and Amman, 2010). Given that conventional breeding cannot increase Vitamin A, Golden Rice is possible only with biotech crops. Golden Rice was stalled for more than ten years because of unnecessary and unjustifiable delays, whilst millions were condemned to suffering. Potrykus concluded that the lag was entirely due to unjustified regulatory processes discriminating against biotech crops versus conventional crops. Hence, Potrykus holds the view that ***"the regulation of genetic engineering is responsible for the death and blindness of thousands of children and young mothers."*** He estimated that it generally takes about ten times more money and ten years longer to bring a biotech crop to market compared to a conventional crop, and de-facto, because of the higher costs, precludes the participation of public research institutions in the development of biotech crops. Biotech crops have enormous potential to alleviate poverty and hunger and contribute to food security in the developing countries of the world.

OPPORTUNITIES

In the following paragraphs, the following topics are briefly reviewed:

- Biotech cotton – status, unmet needs and future prospects
- A biotech potato resistant to late blight – a unique opportunity for the EU to take the global lead in its development and deregulation
- Public-private sector partnerships and the three streams of technology – private, public-private and public
- Future prospects 2012 to 2015, the MDG year
- Similarities between the Global Food Security Crisis and the Global Economic Crisis
- Concluding Comments

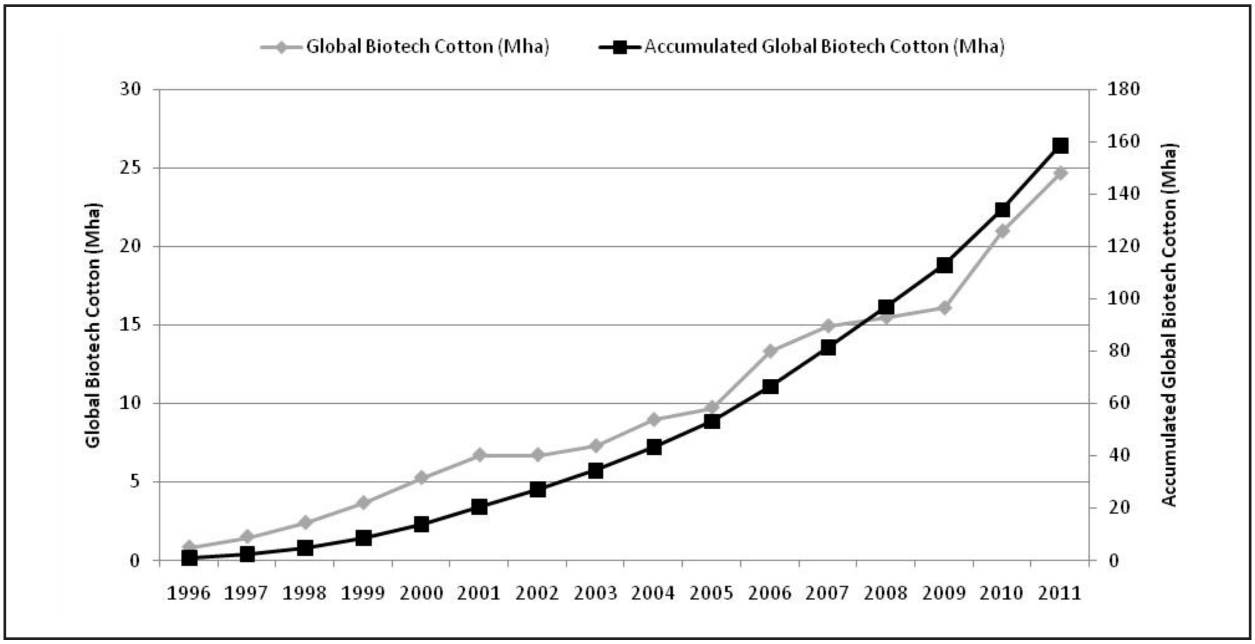
Biotech Cotton – *Status, Unmet Needs and Future Prospects*

This is a brief overview of the status and major developments in the deployment of biotech cotton over the past fifteen years as well as a discussion of unmet needs and future prospects. The author benefited from discussions with Dr. Neil Forrester and Dr. Kater Hake, and acknowledges their important contributions. Global plantings of cotton reached an all time high of 36 million hectares in 2011, and accusatively 160 million hectares of biotech cotton have now been successfully planted in 13 countries since 1996.

The increase in cotton plantings in 2011 was mainly in response to the meteoritic rise in cotton lint prices to a peak of US$2.05 per pound (US$4.51 per kilo) compared with a low of US$0.59 per pound (US$1.30 per kilo), two years ago. Substantial increases in hectarage were reported in several countries but particularly in India, USA, China, Pakistan, Australia and Mexico, all countries which deploy biotech cotton and benefit from substantial increases in productivity, and which usually require only half as much insecticides as conventional cotton.

Biotech cotton was first planted in 1996, the first year of commercialization of biotech crops. Insect resistant cotton, featuring Bt genes, and herbicide tolerant cotton were amongst the first products to be commercialized. Their impact has been substantial in all thirteen countries where they have been commercialized, growing from less than one million hectares globally in 1996 to ~25 million hectares in 2011, with annual growth from 2002 to 2011 of 24.7 million hectares (Figure 51). To-date, it is clear that of the two traits, insect resistant Bt cotton has been deployed on a larger area, ~100 million accumulated hectares in 2011, compared with 38 million hectares for the stacked product and 22.0 million hectares for herbicide tolerant cotton. Bt cotton has been the major contributor to adoption and growth, however, it is the stacked traits of insect resistance (Bt) and herbicide

Figure 51. Global Adoption of Biotech Cotton, in Hectares, and Accumulated Hectares, 1996 to 2011



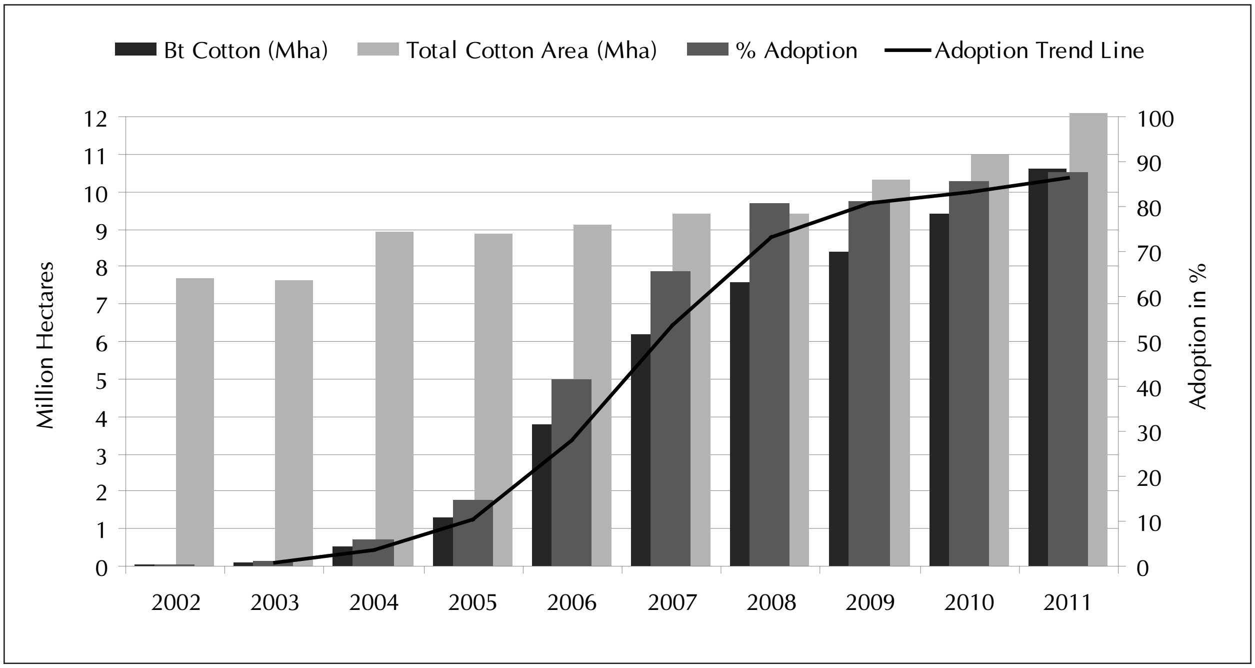
Source: Compiled by ISAAA, 2011.

tolerance that have substantial potential for longer term growth in the future. Adoption is expected to continue to increase in the future as new countries adopt biotech cotton plus an increase in the percentage adoption in countries already using the technology. The accumulative area of biotech cotton planted in the 16 year period 1996 to 2011 was ~160 million hectares, equivalent to five times the annual hectares planted to cotton globally (Figure 52).

Of the 13 countries which grew biotech cotton in 2011 four grew more than 1 million hectares: India 10.6 million hectares, USA 4.0, China 3.9 million, and Pakistan 2.6 million hectares. The other nine countries were Australia, Argentina, Myanmar, Burkina Faso, Brazil, Mexico, Colombia, South Africa and Costa Rica. In 2011, biotech hybrid cotton in India, the largest cotton growing country in the world, occupied 10.6 million hectares with an 88% adoption (Figure 52). It is notable that India is the only country utilizing biotech hybrids, as opposed to biotech varieties which are used by all other countries.

The USA, the second largest grower of cotton in the world, has been the lead country to adopt biotech cotton, and has consistently exerted leadership in the introduction of new and improved biotech cotton products. Initially in 1996, insect resistance for the bollworm family of lepidopteran pests, featured only one Bt gene, but relatively quickly this was increased to two genes to achieve

Figure 52. A Decade of Adoption of Bt Cotton Hybrids in India, 2002 to 2011



Source: Compiled by ISAAA, 2011.

more durable resistance. There are now already advanced products in the R&D pipeline with three genes, with different mechanisms of resistance. The three gene products not only significantly decrease the probability of a breakdown in resistance to lepidopteran pests but offer broader control of a wider range of pests. For example, the VIP3A gene provides control of the *Spodoptera* pests that are important pests in some countries/regions such as Egypt and Central America. Similarly, there are advanced biotech cotton products in the R&D pipeline with more than one herbicide tolerant gene, that provide tolerance to a broader range of herbicides, which in turn allows more effective control of weeds that develop resistance to specific herbicides.

The increase in income benefits for farmers growing biotech cotton during the 15 year period 1996 to 2010 was US$25.4 billion and US$5.2 billion for 2010 alone (Brookes and Barfoot, 2012, Forthcoming).

Unmet needs for biotech cotton

The largest groups of potential beneficiary countries that have yet to adopt and benefit from biotech cotton are in sub-Saharan Africa where, at least 15 countries, each growing more than 100,000 hectares of cotton, for a total of ~4 million hectares of cotton could benefit significantly, plus Egypt in North Africa. Countries in Latin America which could also benefit include Paraguay (approved biotech cotton in October 2011), as well as several countries in Central America, which used to grow a significant hectarage but had to discontinue cultivation because insect pest infestations were unmanageable. In Eastern Europe, countries such as Uzbekistan, where pest pressure is generally lower, biotech cotton can also offer benefits as well as in Turkey which grows ~650,000 hectares of cotton. In summary, there are probably at least 20 to 25 additional developing or emerging countries globally, which grow a substantial hectarage of 100,000 hectares or more, which could benefit significantly from biotech cotton which is already used effectively in 13 countries. This number will grow over time as new traits are introduced. In countries deploying single Bt genes, the challenge is to quickly complete the switch to the two gene products before resistance breaks down – the Australian experience of a complete change over in one year is an excellent example to emulate. Similarly, the future strategy should be to switch from two to three gene products as soon as these become available for both insect resistance and herbicide tolerance and eventually stacks of those respective products.

Future Prospects

For the near, mid and long term there are numerous new products at different stages of R and D development. They include:

- insect resistance – high priority is now being assigned to sucking pests (lygus and mirids) as they understandably have become the next top priority in the absence of the former top priority bollworm pests, now effectively controlled by current biotech insect resistant cotton;

- disease resistance to the pathogens *Fusarium, Verticillium, Rhizoctonia, Pythium* and Cotton Leaf Curl Virus (CLCV) – the latter is critically important in Pakistan and some areas of the Punjab in India; nematode resistance is being explored;

- products which are more tolerant to abiotic stresses, particularly drought. Unlike maize where the critical stage for drought avoidance is the relatively short period of silking, in cotton it is required over the much longer period of flowering. Even though cotton is one of the most drought tolerant of the major crops, the degree of difficulty of achieving adequate levels of drought tolerance should not be underestimated;

- improved cotton which is more tolerant to selected abiotic stresses which include salinity, high and low temperatures, and water logging;

- improved nutrient use efficiency;

- quality traits ranging from improved fiber, to better oil quality, and gossypol free seed; and

- in the longer term increases in yield/productivity, through an accumulative introduction of the above traits and enhancement of yield potential per se by increasing efficiency of critical metabolic pathways such as photosynthesis.

A biotech potato, resistant to late blight – a unique opportunity for the EU to take a global lead in its development and deregulation

The deployment of multiple resistance genes from wild potatoes offers the EU the best opportunity for achieving durable resistance to late blight of potato, which caused the Irish famine of 1845 in which 1 million people perished and remains today the most devastating disease of potatoes. This one disease alone costs global society up to US$7.5 billion annually, of which up to US$1.5 billion is in the EU. The following is a brief overview of the status, importance of incorporating resistance to potato late blight into commercially important potato varieties. The focus is on the EU and the near term prospects of utilizing marker-free, multiple cisgenes from wild potato to rapidly confer durable resistance to this devastating disease.

Importance of the Potato Crop

The potato (*Solanum tuberosum*) is the third most important food crop in the world after rice and wheat. More than 1 billion people consume potatoes and the crop plays an increasingly important role in world food security. Globally, approximately 20 million hectares are planted with an average yield of 17 tons/hectare for a world production of 330 million tons valued annually at approximately US$50 billion, at a farm-gate price of US$150 per ton; the value at the consumer level is at least US$100 billion. Just over half of global potato production is produced in developing countries, and there is a trend for them to become increasingly important producers. The 10 largest potato producing countries, in the world in 2009 (FAOSTAT), were China (73 million tons), India (34), Russia (31), US (20), Ukraine (19), Germany (12), Poland (9), Netherlands (7), France (7) and Belarus (7), which together produce approximately two-thirds of global potato production. Note that 4 of the top 10 countries are in the EU and that Russia and Ukraine in Eastern Europe are in the top five of global producers.

In the EU, two million hectares, or approximately 10% of global hectares are cultivated intensively and produce 20% of global production, with an average yield of 30 tons per hectare, worth approximately US$10 billion/year. Neighboring countries to the EU in Eastern Europe, such as Russia and Ukraine, have less intensive production systems with half the yield (14 tons/ha). Table 50 indicates that the top 10 EU countries grow approximately 1.8 million hectares with an average yield of 31 tons and total production of 55 million tons. Within the EU countries there is a considerable

Table 50. Top 10 EU Potato Countries, Listed by Hectares (Thousands), Yield kg/ha and Production (Million Metric Tons), 2009

Year	Hectares (Thousands)	Yield (Tons/ha)	Production (Million tons)
Poland	489	19.9	9.7
Germany	264	44.1	11.6
Romania	260	15.4	4.0
France	172	42.1	7.2
Netherlands	155	46.3	7.2
UK	149	43.1	6.4
Spain	85	29.1	2.5
Belgium	74	44.7	3.3
Italy	71	24.8	1.8
Denmark	39	41.6	1.6
Total	**1,758**	**31.4**	**55.3**

Source: FAO STAT, 2009.

range in hectares, yield and production between the top 10 countries. Poland has by far the largest hectarage at 0.5 million hectares, and Germany has the highest production at 11.6 million tons. The Netherlands has the highest yield at 46.3 tons/ha compared with the lowest in Romania and Poland at 15.4 and 19.9 tons/ha respectively – less than half the yields of Germany, Belgium and the UK.

Plant Protection Constraints to Potato Production

The potato is a vegetatively propagated crop, where the tubers, and not the "true seed", are used to propagate the crop commercially. Thus, unlike crops propagated through the seed, potatoes do not benefit from the natural barrier provided by the seed for blocking transmission of many plant pathogens. Hence, like other tuber crops, the prevalence and importance of diseases is high in potatoes, compared with seed propagated crops. Global potato yield loss estimates due to fungal and bacterial pathogens is 22%, plus 8% for viruses for a total of 30% for all diseases. That is in addition to the estimated losses of 18% for insect pests, and 23% for weeds (Oerke and Dehne, 2004). Without crop protection, about 70% of attainable potato production would be lost to pests, not including nematodes, which cause devastating losses in localized areas. Of the many pests that attack potatoes, late blight is the single most important disease, accounting for 15% of potato yield losses due to plant pathogens. Other diseases are caused by other fungi, bacteria and a complex of viruses, including potato virus Y (PVY) and potato leaf roll virus (PLRV). Of the insect pests, the

Colorado beetle is the most important globally, followed by virus vectors (aphids and leafhoppers) and the tuber moth which is prevalent in a number of developing countries. Seed certification programs, for field tubers grown for propagation, and plant tissue cultural systems, both requiring infrastructure and recurrent use of resources to produce clean potato stock annually, are historically used to provide effective control of some diseases particularly insect vectored viruses including PVY and PLRV. They are not very effective against the spread of destructive late blight.

Biotech/GM Potatoes

Biotech/GM potatoes featuring non-conventional virus resistance, conferred by coat protein technology, were successfully deployed in the USA and Canada in the late 1990s. In the same timeframe, Colorado beetle resistant potatoes featuring a Bt gene were also successfully deployed in the USA and Canada. Both biotech potatoes were discontinued in these markets, not because they were not effective technologies, which they were, but because of a perceived lack of retail market support for biotech food crops. This perception stopped major potato processors from utilizing tubers of biotech varieties and the technology quickly vanished from North American commercial potato production. This is in sharp contrast to 2011 when 100 million hectares of other biotech crops (cotton, corn, canola and soybean) were planted in the USA and Canada with high adoption rates of 80% or more. "Amflora", a potato modified to produce amylopectin, approved for industrial use and animal feed, was commercialized in the EU in 2010 and grown in Sweden, the Czech Republic and Germany in 2011. It is currently the only biotech potato variety grown commercially and production encompasses only a few acres in each country.

Late blight – the most important disease of potatoes

Late blight, caused by the fungus *Phytopthora infestans*, was the principal cause of the Irish famine in 1845, when 1 million people perished. It remains today, by far, the most important disease of potatoes worldwide. Although the potato was introduced to Europe from its center of origin, South America, in 1565, potato late blight was not detected in Europe until 1843, only two years before it caused devastation in Ireland. Only recently has the fungus significantly increased in virulence due to the presence and spread of the A2 mating type which enables rapid spread of resistant biotypes. Today, late blight results in an estimated annual economic loss of up to US$7.5 billion per annum globally, of which US$1.5 billion, or 20%, is in the EU. In the EU, economic loss is due to 2 factors: cost and application of fungicides and loss of production due to unmarketable disease damaged tubers. For example, fungicide protection can cost up to US$750 per hectare with up to 15 sprays in the Netherlands (Haverkort et al. 2008 and 2009). Together, these two factors account for approximately 15% of the total cost of production. Not surprisingly, there is a large variation in late blight epidemic levels, by country, by year and climate.

The disease has become progressively more aggressive over time with the evolution of more virulent races of the pathogen. Globally, losses due to late blight are conservatively estimated at approximately 15% of cost of production, with some locations experiencing crop failure to the disease. Late blight is important in developing countries, like India and Bangladesh, where it exacerbates the challenges of achieving food security. Late blight is also prevalent in countries such as Russia and Ukraine in Eastern Europe, where the significantly lower yields are frequently the result of epidemics of the disease. EU environmental policy and legislation assigns a high priority to minimize the use of pesticides, particularly on food crops like potato, and urgently seeks more benign remedies. There is also growing concern amongst both producers and consumers about the potential negative long-term impact of intensive application of pesticides on the environment (surface and ground water contamination as well as impact on beneficial organisms such as bees and butterflies) and the overall sustainabilty of pesticide intensive crop production systems in the EU.

Progress in developing resistance to late blight

Conventional breeding programs have targeted late blight of potato as a top priority for more than 50 years. The most successful breeding programs utilized 11 race specific R resistance genes from the wild potato *Solanum demissum*, but one by one, all eleven genes have succumbed to new virulent pathogen races relatively recently. Experience has consistently confirmed that single genes cannot provide complete protection against plant pathogens, so the new goal of plant breeding is to incorporate multiple genes targeting the same pathogen. Unfortunately, the multiple genes necessary for late blight protection cannot be incorporated by conventional potato breeding programs, leaving biotechnology as the only viable option for this important crop. The varieties Bionica and Toluca do posses a measure of resistance through a single gene (*Rpi blb-2*). However, because of the virulent races detected in the EU, in practice these varieties can only be grown on very few hectares in low disease pressure areas to support a very small organic niche market (VIB, 2011).

No progress has been made in incorporating an adequate level of resistance in the more well-accepted major varieties, such as "Desiree", favored by consumers because of their preferred taste and texture. Two factors have contributed to the lack of success. First and foremost, is the fungus' innate ability to rapidly generate new aggressive and virulent strains to overcome any newly incorporated single gene resistance. Secondly, the genetics and vegetatively propagated nature of the potato crop requires at least a 15 year investment in conventional breeding to develop resistant varieties, which, ***unfortunately, succumb after a few years. Similarly, new fungicides also quickly become ineffective due to the rapid development of new late blight strains.***

Alternative approach for controlling late blight with multiple cisgenes from wild potato

Cisgenics, defined as using genes from species which can naturally cross-breed, as opposed to transgenics where the species cannot cross-breed, is a promising new approach which offers increased probability of success and time savings compared with a conventional breeding program which requires many years of continuous backcrossing and selection to eliminate undesirable traits. An innovative 10 year project named Durable Resistance to *Phytopthora* (DuRPh) funded by the Dutch Government, was initiated by Wageningen University and Research Centre (WURC) in the Netherlands in 2005. The project goal is to simultaneously incorporate several marker-free cisgenes from wild potato for controlling late blight. The DuRPh project is described here, to illustrate the five steps involved and the potential merits of the approach (Haverkort et al. 2008, 2009).

Step 1. Detect and Clone multiple R genes that confer resistance from several wild potato species, including *Solanum berthaultii, S. pinattisectum, S. chacoens*;.

Step 2. Transform selected varieties with "cassettes" carrying several different R genes in different combinations.

Step 3. Select potato transformants that are marker-free and true to type of well-accepted commercial varieties;

Step 4. Develop a Resistance Management Program by conducting studies on the effectiveness of different R genes in different combinations in different varieties to determine optimal modes of deployment, both spatially and temporally, for cultural practices that optimize the durability disease resistance.

Step 5. Communicate research results frequently to all stakeholders, including the EU Commission, with a transparent interpretation and discussion of the data, to reach a consensus on the path forward benefiting from the wealth of experience generated by the project.

The environmental risks associated with the cisgene method is low in the EU because there are no wild relatives which can cross-breed with potatoes and gene flow, due to cross pollination, is not an issue in vegetatively propagated potatoes. Also, the health risks should not exceed those of conventionally bred potatoes since the introduced genes are already present in historically consumed varieties. As with all new conventional varieties, these new varieties are being screened prior to commercialization to ensure that they meet healthful levels of nutritional composition.

The Durable Resistance to *Phytopthora* (DuRPh) project is examining the feasibility of biotechnology methods to effectively and economically incorporate marker-free multiple cisgenes from wild potatoes conferring durable potato late blight resistance not possible with conventional breeding programs. The project is proof of concept research that, if successful, provides a technology platform, with multiple advantages over conventional breeding programs, to support the commercial development of cisgenic disease resistant biotech/GM potatoes and other crops. Finally, and importantly, the project will address the EU regulatory policy for GM crops by facilitating a re-examination, based on the wealth of new data generated by the project, of the rational underpinning the GM – directive 2001/18/EC which does not distinguish between the regulatory requirements for cisgenics and transgenics.

Involvement of EU institutions and companies in novel late blight potato projects

Public sector institutions and private sector companies from EU countries are already active, and networked internationally, with the first product from this research, "Fortuna" from BASF, which is expected to be released as early as 2014/2015, subject to regulatory approval. The following is a selection of projects in EU countries, and associated international networks, on late blight and, in particular, the use of multiple genes from wild potato for disease control.

- **Wageningen University and Research Center (WURC), Netherlands** – A 10 year DuRPh project started in 2005, detailed above, for the detection and cloning of R genes from wild potato and their incorporation as marker-free multiple gene cassettes into well-accepted commercial varieties for deployment in sustainable and durable late blight resistance programs. The project is progressing well as 12 genes have already been cloned and the first successful field trials with a stack of 3 marker-free cisgenes were completed in 2011.

- **WURC, as part of a tripartite agreement, cooperates with Cornell University, USA, through the Agricultural Biotechnology Support Program (ABSP II)** to help serve the needs of developing country partners through sharing knowledge and technology that contributes to food security. ABSP II is facilitating field testing of potatoes with a new resistance gene (RB), cloned by the University of Wisconsin, USA, from the diploid wild potato *Solanum verrucosum*. The RB gene is race non-specific and has demonstrated high level of resistance to most races of late blight since 1953. ABSP II facilitates projects in Indonesia, India and Bangladesh.

- **WURC, as part of the same tripartite agreement with Cornell University, cooperates with the International Potato Center (CIP), Peru,** to serve the needs of developing countries in Central Africa and East Asia through building human capacity, providing stewardship and protection of intellectual property rights, training farmers in integrated pest management (IPM) and the preservation of potato germplasm diversity critical to longterm food security. CIP has a program in Rwanda, Uganda and Kenya pyramiding 3 R genes (2 genes from *S. bulbocastanum* and 1 from *S. venturii*) in the variety "Desiree", an African variety "Asante" in Kenya, and the variety "Victoria" in Uganda. The first contained field trials are under consideration.

- **John Innes Center, Norwich, UK**
  Jonathan Jones and his laboratory, at the John Innes Center, UK, is using intra- and inter-specific crosses to reveal multiple dominant late blight resistant (R) genes in wild diploid potatoes. Current research is on the fine mapping and cloning of a number of these genes. Two R genes, *Rpi-vnt1* and *Rpi-mcq1*, have been tested in field trials against UK races of blight. *Rpi-vnt1* has proved effective in 2 years of trials.

- **BASF Plant Science, Limburgerhof, Germany**
  Two late blight R genes, *Rpi-blb1* and *Rpi-blb2*, were cloned from the wild potato *Solanum bulbocastanum* in Mexico and were incorporated into a leading potato variety in the EU. The strategy is to provide dual protection from the 2 genes. The new variety named "Fortuna" has undergone successful field testing in several EU countries and is expected to be available for commercialization by 2014/15, subject to regulatory approval.

- **Carlow Research Center, Ireland**
  Phytophthora infestans populations are being characterized phenotypically and genotypically by this Irish research center. The presence and spread of the A2 mating type "Blue 13" confirmed that the *Phytopthora* population in Ireland is undergoing significant changes.

- **Euroblight Network**
  This EU wide potato late blight network includes approximately 40 institutes in Europe whose useful aim is to consolidate and share knowledge on many aspects of late blight (www.blight/net). The network has access to 25,000 characterized isolates of *P. infestans* that have been sampled from potatoes throughout Europe over time.

In summary, given that:

- late blight of potato is of unique historical and economic significance to the EU;
- it is an appropriate opportunity to substantially decrease pesticide applications on a food crop and contribute to a more sustainable environment;
- it allows recovery of economic losses valued at up to US$1.5 billion annually in the EU;
- experience has consistently confirmed that single genes introduced through conventional breeding cannot provide protection;
- multiple genes, are a must, and cannot be incorporated by conventional breeding programs leaves biotechnology as the only feasible option; and
- biotechnology can significantly reduce breeding time and effect faster delivery of improved varieties

It follows that an initiative to develop cisgenic multiple gene late blight resistant potatoes is a unique opportunity for the EU offering the best promise of delivering a successful, durable product in the shortest timeframe that will generate a significant return on investment. The late blight initiative is also an ideal candidate as a model project for assessing the relative comparative advantages and disadvantages of biotech crops over conventional technology. In summary, the rationale for the biotech initiative on late blight of potato is based on the following 10 reasons:

1. It is an excellent example of **innovative technology** espoused by the EU in its science policy directives and will contribute in a substantial way to **sustainability**.

2. **It will confer, for the first time, a sustainable and durable level of resistance to the most important disease of potatoes** which costs nearly US$7.5 billion globally each year and US$1.5 billion in the countries of the EU which produce 20% of the world's potatoes.

3. **Success will result in decreased use of pesticides and contribute to a safer and more sustainable environment, an EU policy goal.** Decreased application of fungicides will result in less fungicide contamination of surface and ground water as well as less exposure to fungicides for producers and consumers. The greatest gains will be in EU countries utilizing more intensive production systems like the Netherlands where 10 to 15 fungicide applications are necessary each season.

4. **Reduced yield losses because of late blight will contribute to the increased productivity of the potato crop, the third most important food crop in the world and, in turn, to food security.** Productivity increases will be higher in countries with less intensive cropping systems where fungicide applications are too costly, such as Poland, where current yields (19.9 tonnes/ha) are significantly constrained by late blight. Know-how on increasing productivity and controlling late blight could be shared with a legion of potato-growing developing countries in Africa, Asia and Latin America through EU international development projects.

5. Conventional breeding of potato is very expensive, in time and resources. A new commercial variety can take up to 15 years to develop. On the other hand, using biotechnology in conjunction with a conventional breeding program, has the potential to significantly reduce breeding time and resources. In the specific case of late blight, even after decades of effort, conventional breeding has failed to deliver an adequate, sustainable and durable level of resistance. **Biotech/GM crops, modified with cisgenes technology, offer a reduced time and cost strategy to incorporate essential multiple marker-free R genes, providing durable resistance.** In the EU there are no wild relatives that can cross-breed with potatoes, and gene flow due to cross pollination is not an issue in vegetatively propagated potatoes.

6. **The new and urgent challenges associated with climate change, demand faster delivery of improved crops from breeding programs.** Climate change results in more pressure and urgency, to counter, for example, more frequent and more severe droughts, epidemics and pest infestations. **The new bio-technologies, which work faster, can provide valuable tools in responding to this more urgent need.**

7. Given that diseases and insect pests decrease potato yield by nearly 30% and 18%, respectively, the potato crop represents a unique opportunity for recovering significant losses through the development and deployment of biotech crops. Some of these technologies for viruses, and for the insect pest Colorado beetle, have already been developed and deployed and others are under development in EU institutions, for example, potato cyst nematode resistance at Leeds University, UK. **Thus, a unique opportunity exists to rapidly enhance the benefits by building on a successful late blight initiative by pyramiding genes that code for other beneficial biotech traits in the potato such as virus resistance and insect resistance that have already been developed.**

8. **Late blight resistant potatoes was specifically identified by an EU member country, Denmark, as an "appropriate crop for biotechnology application"** that would be an early candidate for deregulation and deployment due to the significant productivity and environmental (less fungicide) benefits it offers. Other EU countries which support active R&D programs in the public and private sector in biotech potatoes include the Netherlands, United Kingdom, and Germany.

9. **Importantly, there exists in the EU today a network of internationally recognized institutions/companies in the public and private sector which are already engaged in the development of durable resistance to late blight with the first product, "Fortuna" from BASF, expected in 2014/2015.** What is lacking in today's EU is the political will to support a science-based approval system that provides a cost/time effective deregulation process for commercialization of a technology which can benefit 500 million EU citizens, with a safe, more environmentally friendly and more affordable product of the highest quality. Equally important, the initiative would provide the incentive, encouragement and recognition to EU public institutions and companies to practice innovation in food technology and exert global leadership in food security initiatives, consistent with EU policy.

10. **Unlike transgenics, cisgenics do not involve cross genera genes and hence regulatory bodies should apply less onerous science-based requirements that would expedite responsible deregulation.** Appropriate regulations that are responsible and also cost and time effective would have enormous impact for a myriad of institutions in the public sector

in the EU and globally, including developing countries which are urgently in need of new technologies to ensure food security but are unable to engage in transgenics because of the prohibitive and long-term cost of gaining import approval to lucrative markets such as the EU.

In October 2011, 41 leading Swedish biological scientists, in a strongly-worded open letter to politicians and environmentalists, spoke-out about the need to revise European regulation to allow society to benefit from GM crops using science-based assessments of the technology. A contingent of scientists from the United Kingdom endorsed the Swedish petition (Jansson et al. 2011). A recent article from Europe (Tait and Barker, 2011) also called for a change in EU regulation of GM crops; it focused on European issues related to Global Food Security and the governance of modern biotechnologies and drew the following conclusions:

- European regulatory systems, – instead of scientific progress – will determine whether technology-based solutions are part of the future of agriculture;

- GM crops are already contributing to increased yields, greater ease and predictability of crop management, a reduction in pesticide use and fewer post- harvest crop losses;

- there has been a move away from top-down government towards bottom-up governance, with the underlying assumption that this will lead to more democratic decision making;

- the interaction between the governance-based approach and the precautionary principle has exposed the decision making process on the regulation of GM crops to influences from politically motivated parties; from surveys to focus groups to citizen juries, GM crops have probably been engaged with more than any other technology: and

- the main concern of the EU should be to enable science and technology to contribute to food security; if Europe is to meet its own food security needs and contribute to the food requirements of the rest of the world policy, and regulatory changes will be necessary.

Public-Private Sector Partnerships and the three streams of technology products: private, public-private, and public

This important subject understandably evokes much discussion. There are now several working-model projects being implemented, and one of them, involving vegetables, is used here to illustrate some of the challenges and the opportunities. Whereas vegetables are high-cost products and are a good potential fit to absorb the higher costs associated with transgenics, they lack the large hectarage of field crops such as maize, soybean, cotton and canola and may not be assigned priority by multinational companies focused on global macro-markets. This should not be viewed as a problem but as an opportunity for public sector institutes and national indigenous companies in developing countries to develop transgenics for their home-country or regional market. An excellent example is Mahyco's generous and creative Bt brinjal initiative in India where Mahyco seeks to market the Bt brinjal hybrids, whilst coincidentally donating the same Bt technology to public institutes in India for use in open-pollinated varieties of brinjal – eggplant – the queen of the vegetables in India. Mahyco has gone a step further and also donated the same Bt technology for open-pollinated varieties to public institutes in the Philippines and Bangladesh – this is a win-win-win situation.

Regulatory delays in approving Bt brinjal in India have denied both farmers and consumers timely access to Bt brinjal and the benefits it offers the country; however the Philippines and Bangladesh are progressing with the approval process. Mahyco has a number of other transgenic vegetables under development, including okra, cabbage, cauliflower and potato which can improve productivity, and deliver significant environmental and economic benefits. The Government of India also supports a portfolio of transgenic vegetable projects at its institutes, including brassica, tomato, cabbage, and cauliflower. Thus, there is in India, and similarly in other developing countries, the opportunity to build a portfolio of projects involving both the public and private sector within the context of a need-based national biotech crop strategy, utilizing the respective comparative advantages of the different partners, to facilitate the coincidental development and delivery of **three complementary streams of biotech crops:**

- **a private sector stream of biotech crops** from multinationals and national indigenous companies focused on global and home/regional markets respectively, which accounts for the vast majority of the 160 million hectares of first generation biotech maize, soybean, cotton and canola planted globally today, and developed, by and large, by the private sector;

- **a public-private partnership stream of biotech crops** exemplified by the Mahyco Bt brinjal project in India, the Monsanto and Gates/Buffet Foundations project for Africa to deliver biotech drought tolerant maize by ~2017, and the EMBRAPA BASF project in Brazil which has delivered a herbicide tolerant soybean which has already been approved for commercial planting; and

- **a public sector stream of biotech crops** exemplified by the Bt fused-gene cotton, developed by the Chinese Agricultural Academy of Sciences (CAAS) in China, and the biosafety-approved phytase maize and Bt rice that are undergoing standard field production trials in China; the virus resistant papaya commercialized in Hawaii, and developed by Dr. Gonsalvez at Cornell University, and finally the recently approved EMBRAPA.5.1 biotech *Phaseolus* bean, resistant to Bean Golden Mosaic Virus (BGMV) developed entirely by EMBRAPA in Brazil.

The above initiatives represent impressive progress, particularly the leadership exerted by the lead developing countries of BRIC – Brazil, India and China. Given the substantial and rapidly-increasing biotech budgets in public institutes in the lead developing countries like China and Brazil (the annual budget of EMBRAPA in Brazil is US$1.1 billion), and their own increasing capacity to both develop and approve their own home-grown products, this augers well for the future. Like India, China has a portfolio of transgenic vegetable projects which include tomato, potato, cabbage, sweet pepper, and chili. Of particular importance is the exciting new institutional opportunity of building South-South partnerships including the sharing of knowledge and experience about an array of appropriate biotech applications, ranging from marker-selection to transgenic biotech crops. It is noteworthy that both Brazil and China are increasing their commitments to agricultural development in Africa which in due course will include transfer of appropriate biotechnology crop applications. There is a high likelihood that technologies developed in the tropical countries of the South, for mega-agricultural environments like the “cerrado” in Brazil, will be more appropriate for Africa than technologies developed in temperate agricultural environments. Furthermore, because both Africa and Brazil are tropical environments they will have an opportunity to build joint projects to address the mutually important new crop production constraints, such as higher temperatures, that will be associated with climate change in the tropics, expected to be the worse affected region worldwide. Africa will need all the partners it can secure as its population more than triples from the current 1 billion to 3.6 billion in 2100, soaring from less than one-sixth of the global population in 2010 to more than one-third of the population of 10.1 billion by the end of this century in 2100.

Future Prospects 2012 to 2015, the MDG year

The adoption of biotech crops in the four-year period 2012 to 2015 will be dependent on three factors: first, the timely implementation of appropriate, responsible and cost/time-effective regulatory systems; second, strong political will and enabling financial and material support; and third, a continuing wave of improved biotech crops that will meet the priorities of industrial countries and developing countries in Asia, Latin America and Africa.

The outlook for biotech crops in the remaining 4 years of the second decade of commercialization, 2012 to 2015, is cautiously optimistic. Following the bumper year of 2010 when the increase in hectarage of biotech crops was the second highest in history and substantial progress was made on all fronts, the growth in 2011 represents a phase of consolidation of gains to-date, which is expected to continue in 2012, with Vietnam possibly becoming the 30th country to plant biotech crops globally. The consolidation of gains in 2011 and 2012 is projected to be followed by a more active period during which up to 10 countries are projected to adopt biotech crops for the first time, bringing the total number of biotech crop countries globally to ~40 by ~2015. These new biotech countries are likely to include three more countries in Asia, up to 7 countries in sub-Saharan Africa, (subject to regulatory approval), and possibly some additional countries in Latin/Central America and Western/Eastern Europe. Western Europe is a particularly difficult region to predict because the issues are not related to science and technology considerations but are of a political nature and influenced by ideological views of activist groups. A biotech potato resistant to late blight, (discussed earlier) offers an attractive and appropriate opportunity for selected potato-growing countries in the EU to join the growing number of countries benefiting from biotech crops globally.

There is considerable potential for increasing the biotech adoption rate of the four current large hectarage biotech crops (maize, soybean, cotton, and canola), which collectively represented over 160 million hectares of biotech crops in 2011 from a total global potential of 320 million hectares; thus, there are approximately 150 million hectares for potential adoption, of which 30 million hectares are in China where demand for maize as a feed crop is growing fast, as the country consumes more meat. **In the near and mid- term, the timing of the deployment of biotech maize and rice, as crops, and drought tolerance as a trait (first in maize and later in other crops) are seminal for catalyzing the further adoption of biotech crops globally.** In contrast to the first generation biotech crops that realized a significant increase in yield and production by protecting crops from losses caused by pests, weeds, and diseases, the second generation biotech crops will offer farmers additional new incentives for also improving quality of products. For example, quality traits, such as enhanced Vitamin A in rice, soybean free of trans-fat and reduced saturated fat, and omega-3 rich soybean, will become more prevalent providing a much richer mix of traits for deployment in conjunction with a growing number of input traits. Five years ago in North America, a decision was made to delay the introduction of biotech herbicide tolerant wheat, but this decision has been revisited. Many countries and companies are now fast-tracking the development of a range of biotech traits in wheat including drought tolerance, disease resistance and grain quality. The first biotech wheat is expected to be ready for commercialization around 2017.

In summary, future prospects up to the MDG year of 2015 and beyond, look encouraging: an increase of up to 10 new developing countries planting biotech crops, led by Asia and Latin America, and there is cautious optimism that Africa will be well-represented: the first biotech based drought tolerant maize planned for release in North America in 2013 and in Africa by 2017; Golden Rice to be released in the Philippines in 2013/2014; biotech maize in China with a potential of ~30 million hectares and thereafter Bt rice which has an enormous potential to benefit up to 1 billion poor people in rice-growing households in Asia alone. Biotech crops, whilst not a panacea, have the potential to make a substantial contribution to the 2015 MDG goal of cutting poverty in half, by optimizing crop productivity, which can be expedited by public-private sector partnerships, such as the WEMA project, supported in poor developing countries by the new generation of philanthropic foundations, such as the Gates and Buffet foundations.

Similarities between the Global Economic Crisis and the Global Food Crisis

Five aspects of the current global economic crisis are similar to the emerging global food security crisis.

- First, **the principal underlying constraints are political rather than technical.**

- Second, **both require urgent action and an unprecedented level of financial and material support** to contain a contagion that has already caused devastation to parts of global society and has the potential to seriously destabilize society, if appropriate and urgent remedial action is not taken.

- Third, unlike the past, the **lead emerging countries like Brazil and China have weathered the storm and have fared better** than the traditional western countries leading global political organizations.

- Fourth, the attempts to resolve the crises have resembled a band-aid approach whereas the gravity and urgency of the situation demands immediate major surgery – **too little and too late.**

- Fifth and last, the **world lacks leadership** to spearhead a global campaign that requires a credible and able leader who has the trust and confidence of global society to conduct the leaderless world orchestra assembled to resolve the crises.

Three major and sequential steps are required for resolving the crisis:

- Global society must have awareness and a **common understanding and analysis of the challenge** – the importance of sharing knowledge.

- **Define the problem first and then agree to a common solution** to the challenge – the two sequential steps in problem-resolution are definition and solution.

- The public and private sectors in industrial, emerging and developing countries must **agree and cooperate to execute a common implementation plan.**

CLOSING COMMENTS

In the next fifty years the world will consume twice as much food as the world has consumed since the beginning of agriculture 10,000 years ago – a startling statement !! However, regrettably, the vast majority of global society is completely unaware of this formidable challenge of feeding the world of tomorrow and the potential contribution of technology, particularly the role of the new innovative bio-technologies, such as biotech crops, that already successfully occupy 160 million hectares or 10% of global arable land. Given this lack of awareness about the challenge and the role of the new innovative crop biotechnologies, ISAAA initiated a program more than 10 years ago to freely share science-based knowledge about biotech crops with global society, whilst respecting the right of society to make independent informed decisions about the role of the new technologies. Two initiatives have been particularly successful, the first is ISAAA's Annual Brief on the global status of biotech crops and their impact. The major findings from the latest 2010 ISAAA Brief is estimated to have reached a remarkable 1.8 billion people (a quarter of the world's population) in over 75 countries in over 40 languages – the publication stimulated over 2,000 multi-media reports and the Brief is the most widely quoted publication on biotech crops globally. The second initiative is a weekly email which summarizes the major developments in biotech crops that are of particular interest to developing countries. The free weekly e-newsletter, named Crop Biotech Update (CBU), now reaches 1.2 million subscribers in 200 countries and translations are available in more than 10 of the major languages of the world, including Chinese, Arabic, Bahasa Indonesia, Spanish, Portuguese and French. In 2011, the number of CBU subscribers grew, on average, at up to ~15,000 per month confirming that there is a tremendous thirst for knowledge about biotech crops. About 80% of the CBU subscribers are from the developing countries which are ISAAA's client/partner countries. The subscriber base is made up of the following categories, in descending order of representation; students (35%), faculty and academic staff (32%), scientists and researchers (12%), private sector (9%), government officials (6%), and NGOs and media (6%).

ISAAA was founded more than 20 years ago to establish creative new partnerships to facilitate the transfer of crop biotech applications from the industrial countries, particularly the private sector, for the benefit of small resource-poor farmers in the developing countries who represent a significant segment of the poorest people in the world. Subsequent to the founding of ISAAA in 1990 it became evident that the lack of awareness by society of the potential of the new innovative biotech crops was a major constraint to acceptance, exacerbated by well-resourced and extensive mis-information campaigns about biotech crops by opponents of the technology.

In summary, since its founding over 20 years ago ISAAA has championed three causes.

- First, ISAAA has facilitated the sharing of science-based knowledge about new crop biotechnology applications to increase the awareness, understanding and acceptance by society of new innovative biotech crops which can contribute to food security and the alleviation of poverty in developing countries.

- Second, ISAAA has established creative and innovative partnerships to share knowledge and facilitate transfer of biotech crops for the benefit of small resource-poor farmers in developing countries.

- Third, ISAAA recognized that biotech crops are a product of innovation, defined as "the ability to manage change as an opportunity and not as a threat" (James 2010). Whilst biotech crops are not a panacea, they are an essential element in any strategy to feed the world of tomorrow and alleviate poverty which afflicts 1 billion people.

The three causes championed by ISAAA, sharing knowledge, creative partnerships and the critical importance of innovation are consistent with the actions proposed by Bill Gates to the G20 in November 2011 in Cannes, France and summarized in the following paragraphs.

Bill Gates called on the G20 leaders group to invest more in innovation for development characterizing it as ***"the most powerful force for change in the world…*** because… ***innovation fundamentally shifts the trajectory of development."*** Gates' report, entitled ***"Innovation with Impact: Financing 21st Century Development",*** was delivered to G20 leaders, was prepared at the invitation of France's President Sarkozy, with the goal of finding new and creative ways to mobilize more resources for development. Gates concluded that ***"innovation has not played as big a role in development as it could have. Some innovations take hold in rich countries quickly but take decades to trickle down to poor countries. The pace of innovation specifically for the poor has been too slow. But I believe it can be sped up, and the rapidly growing countries of the G20 are especially well positioned to drive this improvement."*** Gates suggested that the G20 should identify the ***highest priority innovations for development*** and indicated that his Foundation would be happy to participate in this process. "***With a systematic list of innovations as a starting point, the G20 could help broker agreements in which member countries commit to work together on specific innovations. This approach could accelerate innovation in many key areas of development, including agriculture, health, education, governance, and infrastructure."*** Gates opined that the capacity to innovate is not just in rich countries and that the ***"binary model of the developed world on the one hand and the developing world on another has become irrelevant. This unique combination gives them both the insights and the skills to create breakthrough tools for development."*** Gates called on the G20 to collaborate and ***"devote significantly more funds to triangular partnerships – made up of traditional donors, rapidly growing countries, and poor countries. In the long run, these provide a model for how to deploy the world's combined resources to benefit the poorest."*** He concluded that ***"there's a lot of pressure on aid budgets given economic conditions, but aid is a very small part of government expenditures. The***

world will not balance its books by cutting back on aid but it will do irreparable damage to global stability, to the growth potential of the global economy and to the livelihoods of millions of people" *(Gates, 2011; SciDev, 4 November, 2011).*

The G20 released a statement at the end of the meeting confirming G20 support for Gates' proposal to ***"encourage triangular partnerships to drive priority innovations forward… and to establish a tropical agriculture initiative to enhance capacity-building and knowledge-sharing to improve agricultural production and productivity."***

In response to the proposals by Gates, F. Reifschneider, from Brazil (co-chair of Africa-Brazil Agricultural Innovation Marketplace) confirmed that ***"The Bill and Melinda Gates Foundation is supporting Brazil and particularly Embrapa to further share its expertise with African countries in different crops. Gates Foundation just joined the Africa-Brazil Agricultural Innovation Marketplace providing the platform with an additional US$2.5 million. Gates is joining forces with FARA, Embrapa, The World Bank, IFAD, DFID and the Brazilian Cooperation Agency (ABC/MRE). African participants will identify problems relevant to their countries, and the Brazilians will work with them to devise solutions based on their experience"*** (http://www.africabrazil.org/). The leadership exerted by Brazil in terms of food security and alleviation of poverty was appropriately recognized in 2011 with President Lula being awarded the World Food Prize.

The international community involved with biotech crops from the public and private sectors globally, as well as the political, donor scientific communities and partner developing countries have not taken full advantage of the MDG anniversary in 2015, to make global society aware of the gravity and urgency of the impending global food crisis. If global food insecurity is to be averted, and there is no other option, urgent action is required now to make society aware of the humanitarian consequences of inaction, and the important contribution that innovative technology, including biotech crops, can make to food security and the imperative of "the right to food and the alleviation of poverty". The innovative partnership that is proposed would engage all points of the compass, North, South, East and West, embracing both public and private sectors, in a collective effort by committed individuals and institutions to optimize the contribution of biotech crops to productivity, whilst using less resources, and helping to alleviate poverty by 2015 and beyond. There is no better way to contribute to the MDG goal of alleviating poverty, hunger and malnutrition, by 50% by 2015, which coincidentally marks the end of the second decade of commercialization of biotech crops, than to pledge, as individual global citizens, to contribute to a 3D strategy, **develop, deregulate and deploy:**

- DEVELOP innovative crop biotechnology applications recognizing that sharing knowledge amongst partners stimulates innovation;

- DEREGULATE innovative biotech crop applications under the aegis of a science-based, cost and time effective deregulation system; and

- DEPLOY innovative biotech crop products in a timely mode to minimize opportunity costs and to optimize their contribution to food security, and alleviation of poverty.

The 3D strategy is dedicated to the survival of the world's one billion poor people, recognizing that the indignity that they unnecessarily suffer is unacceptable in a just society.

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ABC News. 2007. GM bananas could solve Panama plight. December 20, 2007. http://www.abc.net.au/news/stories/2007/12/20/2124584.htm?section=justin

AICOSCA. 2010. 50th Annual Report & Accounts 2009-10, All India Cottonseed Crushers' Association (AICOSCA), Mumbai, 2010.

Adam, D. 2008. GM will not solve current food crisis says industry. Guardian, June 27, 2008, United Kingdom. http://www.guardian.co.uk/environment/2008/jun/27/gmcrops.food

Adenle, A. 2011. Global capture of crop biotechnology in developing world over a decade. Journal of Genetic Engineering and Biotechnology. 1 October, 2011. http://www.sciencedirect.com/science/article/pii/S1687157X11000266

Aerni, P, J Scholderer, and D Ermen. 2011. How would Swiss consumers decide if they had freedom of choice? Evidence from a field study with organic, conventional and GM corn bread. SciVerse Science Direct. http://www.sciencedirect.com/science/article/pii/S0306919211001102 http://dx.doi.org/10.1016/j.foodpol.2011.08.002

AgrobioMexico. 2011. http://www.agrobiomexico.org.mx/

Ag-West Bio. 2011. Ag-West Bio leads Saskatchewan study to evaluate feasibility of developing crops and processing for bio-jet fuels. Sept. 22, 2011. http://www.agwest.sk.ca/upload_mce_image/file/NewsReleases/AWB-BioJetFuelStudy2011.pdf

Ahsan. R. and Z Altaf. 2009. Development, adoption and performance of Bt cotton in Pakistan – A review, Pakistan Journal of Agricultural Research, Vol. 22, No. 1-2, 2009.

Ali, A. and A Abdulai. 2009. The Adoption of Genetically Modified Cotton and Poverty Reduction in Pakistan, Journal of Agricultural Economics, vol. 61, issue 1, pages 175-192. 2010.

AllAboutFeed. 2011. GM approval system in EU too slow for Biotech firms. 13 Oct 2011. http://www.allaboutfeed.net/news/gm-approval-system-in-eu-too-slow-for-biotech-firms-12317.html

All Pakistan Textile Mills Association. 2007. Textile Industry Economic Contribution 2006-07, Production Report, All Pakistan Textile Mills Association (APTMA), 2007. http://www.aptma.org.pk/Pak_Textile_Statistics/tec.ASP

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

Arechavaleta, M. 2010. Family evolves with the farm. http://www.croplife.org/files/documentspublished/1/en-us/CS/5181_CS_2009_06_16_Farmer_Profile_-_Argentina_-_Arechavaleta_-_Family_evolves_with_the_farm.pdf

Australian Financial Review. 2009. www.afr.com. 13 Nov 2009.

Australian Minister for Agriculture, Fisheries, and Forestry Press Release. 2007. Australia: Oils ain't oils –

the benefits of GM oilseed crops. Press release. August 24, 2007. http://www.gmofoodforthought.com/2007/08/gm_crops_australian_brs_report_on_the_benefits_of_gm_oilseed_crops.html

Bajoria, S. 2010, Speech of Sandeep Bajoria, Golden Jubilee Celebration, 50th Annual General Meeting, All India Cottonseed Crushers' Association (AICOSCA), Mumbai, 3 Sept 2010.

BioSpectrum. 2011. Biospectrum-ABLE Biotech Industry Survey 2011, BioSpectrum, India, 2011.

Bor, G A. 2011. Africa Can Feed the World. http://online.wsj.com/article/SB10001424052970204190504577037701249563614.html?mod=googlenews_wsj

Brookes G and P Barfoot. 2011. GM Crops: Global Socio-economic and Environmental Impacts 1996-2009. P.G. Economics Ltd, Dorchester, UK. http://www.pgeconomics.co.uk/pdf/2011globalimpactstudy.pdf

Business Wire. 30 August 2010. Origin Agritech Limited Reports Third Quarter Financial Results for Three Months Ended June 30, 2010. http://www.originseed.com.cn/en/news/view.php?pid=22&id=677

Business Wire. 22 September 2010. Origin Agritech reaches worldwide agreement for Bt gene. http://www.marketwatch.com/story/origin-agritech-limited-reaches-worldwide-agreement-for-bt-gene-2010-09-22

CARITAS. 2004. Unfair Trade and Cotton: Global Challenges, Local Challenges.

CICR. 2011. CICR Vision 2030, Central Institute of Cotton Research (CICR), Indian Council of Agricultural Research (ICAR), June 2011.

Canola Council of Canada. 2007. An Agronomic and Economic Assessment of Transgenic Canola. http://www.canolacouncil.org/gmo_section5.aspx

Canola Council of Canada. 2010. http://www.canola-council.org

CELERES. 2011. http://www.celeres.com.br/1/index.html

Central Insecticides Board and Registration Committee (CIBRC). 2011. Ministry of Agriculture, Government of India. http://cibrc.nic.in/

Central Organization for Oil Industry and Trade (COOIT). 2010. Crop Estimate Information Sheet, 31st All India Seminar on Rabi Oilseeds crops, COOIT, Delhi, 12th March, 2010.

Chen M, S Shelton, and Y Gong-yin. 2010/11. Modified Rice in China: From Research to Commercialization. Annual Review of Entomol. 2011. 56:81 101. http://www.ento.annualreviews.org

China Daily. 15 September 2005. Biotech prepares for rapid expansion. http://www.edu.cn/20050915/3151906.shtml

China Daily. 25 August 2009. GM Rice may join the Menu. http://www.china.org.cn/business/2009-08/25/content_18394775.htm

Chorney, B. 2010. A Holistic Approach to Farming. http://www.croplife.org/files/documentspublished/1/en-us/CS/5252_CS_2010_01_21_Farmer_Profile_-_Canada_-_Chorney_-_A_holistic_approach_to_farming.pdf

Chupungco, AR, AC Rola and DD Elazegui (eds.) 2008. Consequences of Bt Cotton Technology Importation in the Philippines. ISPPS-CPAF-UPLB, UPLB-FI, College, Laguna; DA Biotechnology Program, Quezon City; and PhilRice, Muñoz, Nueva Ecija.

Clay, J. 2010. Earth needs more from less. http://sl.farmonline.com.au/news/nationalrural/agribusiness-and-general/general/earth-needs-more-from-less/1913852.aspx?storypage=0

Cookson, C. 2008. Time to sow? GM food could curb cost of staples. Financial Times. 10 July 2008. http://www.truthabouttrade.org/content/view/12053/54/ http://www.ft.com/cms/s/0/f8b45556-4e97-11dd-ba7c-000077b07658.html?nclick_check=1

Cotton Advisory Board (CAB). 2008. Minutes of the meeting for the cotton year 2007-08 and cotton projection for 2008-09, Office of the Textile Commissioner, Ministry of Textile, Government of India. http://www.txcindia.com/html/production,%20yield%202007089%20cabmeeting%2020102008.pdf

Cotton Advisory Board (CAB). 2011. Minutes of the meeting for the cotton year 2010-11 and cotton projection for 2012-13, Office of the Textile Commissioner, Ministry of Textile, Government of India

Cotton Corporation of India. 2011. Cotton Statistics, Cotton Corporation of India, 2011, accessed on 14 Oct 2011. http://www.cotcorp.gov.in/

Cotton and Sericulture Department (CSD). 2011. Ministry of Agriculture and Irrigation (MOAI), Myanmar.

Crop Biotech Update. 8 January, 210. Increasing Agricultural Production In The UK: Constraints And Proposed Solutions. http://www.isaaa.org. Read http://www.ofc.org.uk/images/stories/File/Beddington%202010_Key%20issues%20Ag%20science.pdf and http://www.bbsrc.ac.uk/media/releases/2010/100106-only-greater-agricultural-science-co-operation-will-deliver-gains.html for more information.

Crop Biotech Update. 16 July 2010. Consumers, Scientists, Farmers, and Spanish Companies Demand GM Crop and Technology Access. Full Report in Spanish at: http://fundacion-antama.org/consumidores-cientificos-agricultores-y-empresas-espanolas-piden-en-bruselas-un-acceso-mas-justo-a-los-cultivos-transgenicos-y-tecnologicos/

Crop Biotech Update. 29 October, 2010. Britain Must Launch GM Food Revolution, says Chief Scientist. http://www.isaaa.org. Original article at http://www.guardian.co.uk/environment/2010/jan/06/gm-food-revolution-government-scientist

Crop Biotech Update. 29 October 2010a. Ministers of Agriculture in Southern Latin American Countries Issue Statement on Biotech. http://www.isaaa.org.The Spanish version at http://www.consejocas.org/data/cas_documentos/343692.PDF.

Crop Biotech Update. 5 November, 2010. EU Commission for 0.1 Percent Tolerance in Feed Imports. http://www.isaaa.org. http://www.gmo-compass.org/eng/news/544.docu.html

Crop Protection Agency, UK Booklet. 2011. Impact of the Global Food Crisis: Changing Attitudes Among UK Shoppers. http://www.cropprotection.org.uk/media/20934/impact_of_the_global_food_crisis.pdf

CSO. 2010. Selected monthly economic indicators –foreign trade, Central Statistical Organisation (CSO), Ministry of National Planning and Economic Development, Myanmar, August 2010.

Daily Times. 2010. Cotton Crisis Looming, Daily Times, 14 Sept 2010. http://www.dailytimes.com.pk/default.asp?page=2010\09\14\story_14-9-2010-pg5-11

Daily Times. 2011. Country may achieve lint target of 14.10m bales, Daily Times, 17 Sept 2011. http://www.dailytimes.com.pk/default.asp?page=2011%5C09%5C17%5Cstory_17-9-2011_pg5_6

DEFRA. 2011. Defra approves first UK GM wheat trial. 16 Sept, 2011. http://www.farmersguardian.com/home/latest-news/defra-approves-first-uk-gm-wheat-trial/41662.article

DGFT. 2010a. Compulsory registration of cotton yarn export contracts – regarding, Notification No. 38/2009-14, Directorate General of Foreign Trade (DGFT), Ministry of Commerce and Industry, 9th April 2010.

DGFT. 2010b. Compulsory registration of cotton yarn export contracts – regarding, Notification No. 38/2009-14, Directorate General of Foreign Trade (DGFT), Ministry of Commerce and Industry, 21st May 2010.

Derbyshire, D. 2011. Europe's opposition to GM crops is arrogant hypocrisy. Kenyan scientists warns. The Observer, UK 23 October 2011. http://www.guardian.co.uk/environment/2011/oct/23/gm-crops-africa-biotechnology?CMP=twt_g

Directorate General of Agriculture. 2010. Guidelines for marketing of Bt cotton seeds, Directorate General of Agriculture (Ext. & A.R.), Ministry of Agriculture, Punjab, Pakistan.

Dumayas, EE, AC Rola and DD Elazegui (eds). 2008. Returns to Research and Development Investments for Genetically Modified (GM) Abaca. ISPPS-CPAf-UPLB, UPLB-FI, College, Laguna; DA Biotechnology Program, Quezon City; and PhilRice, Munoz, Nueva Ecija.

EMBRAPA. 2011. Transgenic bean developed by Embrapa is approved in Brazil. Nº 347, 12 to 19 September 2011. http://www.cenargen.embrapa.br/_comunicacao/2011/cenargenda/cenargenda62_en_2011.html

EU Commission. 2011. A decade of EU Funded- GMO Research. http://ec.europa.eu/research/biosociety/pdf/a_decade_of_eu-funded_gmo_research.pdf

Ecologist. 15 November, 2010. Exclusive interview Mark Lynas: More than half of greens agree with me on GM & nuclear. http://www.theecologist.org/Interviews/682581/mark_lynas_more_than_half_the_green_movement_agrees_with_me_on_gm_and_nuclear.html

Economic Survey. 2010. Pakistan Economic Survey, 2009-10, Ministry of Finance, Government of Pakistan. http://www.finance.gov.pk/survey_0910.html

Elbehri, A and S MacDonald. 2004. Estimating the impact of transgenic Bt cotton on West and Central Africa: a general equilibrium approach. World Development, 32 (12): 2049-2064.

Enslyn, E. 2009. Improving productivity through technology. http://www.croplife.org/files/documentspublished/1/en-us/CS/5186_CS_2009_06_24_Farmer_Profile_-_South_Africa_-_Enslyn_-_Improving_Productivity_through_Technology.pdf

European Commission. 2010. A Decade of EU-funded GMO Research (2001-2010), European Commission (EC), 9 December 2010.
Available at: http://ec.europa.eu/research/biosociety/library/brochures_reports_en.htm

EU-Joint Research Council Report. 2008. Scientific and technical contribution to the development of an overall health strategy in the area of GMOs. September 2008. http://ec.europa.eu/dgs/jrc/downloads/jrc_20080910_gmo_study_en.pdf

European Food Safety Authority. 2008. Request from the European Commission related to the safeguard clause invoked by France on maize MON810 according to Article 23 of Directive 2001/18/EC and the emergency measure according to Article 34 of Regulation(EC) No 1829/2003 - Scientific opinion of the Panel on Genetically Modified Organisms. October 29, 2008. http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902156394.htm

Expatica.com. 2011. Europe's anti-GM nations warned against unilateral action. 8 Sept 2011. http://www.expatica.com/fr/news/french-news/europe-s-anti-gm-nations-warned-against-unilateral-action_174184.html

FAO. 2011. The State of Food Insecurity in the world. http://www.fao.org/publications/sofi/en/

FAO Food Price Index. 2011. March 11, 2011. http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/

FAO STAT. 2009. http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Falck-Zepeda, J, D Horna and M Smale. 2008. Betting on cotton: Potential payoffs and economic risks of adopting transgenic cotton in West Africa. http://www.aaae-africa.org/afjare/docs/AfJAREFalck-ZepedaFINAL.pdf

Francisco, S. 2009. Cost and Benefits of Bt Eggplant with Resistance to Fruit and Shoot Borer in the Philippines. In. GW Norton and DM Hautea (eds). 2009. Projected Impacts of Agricultural Biotechnologies for Fruits and Vegetables in the Philippines and Indonesia. International Service for the Acquisition of Agri-biotech Applications (ISAAA) and SEAMEO Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), Los Baños, Laguna. Pp35-54.

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

Foell, L. 2010. http://www.monsanto.co.uk/news/ukshowlib.phtml?uid=14450

Food and Agriculture Organization (FAO). 2011. Save and Grow Report, June 2011. Save and Grow Report, June 2011. http://www.fao.org/ag/save-and-grow/index_en.html

GAIN, USDA FAS. 2005. Burma agricultural biotechnology 2005, GAIN report no. BM5018, USDA FAS, 28 July 2005, Washington D.C., USA.

GAIN, USDA FAS. 2010. New technologies aiding Burmese cotton farmers by Tun Winn, GAIN report no. BM0025, USDA FAS, 3 Nov 2010. http://gain.fas.usda.gov/Recent%20GAIN%20Publications/New%20Technologies%20Aiding%20Burmese%20Cotton%20Farmers_Rangoon_Burma%20-%20Union%20of_11-3-2010.pdf

Gandhi, V and NV.Namboodiri. 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.

Gassmann, A J. J L Petzold-Maxwell, R S Keweshan and M W Dunbar. 2011. Field Evolved resistance to Bt maize by Western Corn Rootworm. 29 July 2011. http://www.plosone.org/article/info:doi/10.1371/journal.pone.0022629

Gates, W. 2010. Rethinking how to feed the world – Bill Gates Backs Genetically Modified Food Research. http://fora.tv/2010/01/29/rethinking_how_to_feed_the_world#bill_gates_backs_genetically_modified_food_research (video)

Gates, B. 2011. Innovation with Impact: Financing 21st Century Development. http://www.thegatesnotes.com/Topics/Development/G20-Report-Innovation-with-Impact News by Sharma, Y. 2011. Gates tell G20 innovation is the key to development. 4 November 2011. http://www.scidev.net/en/science-and-innovation-policy/innovation-policy/news/gates-tells-g20-innovation-is-the-key-to-development.html

Global Times. 2011. Ministry seeks to ease GM food safety fears. 30 September 2011 http://www.globaltimes.cn/NEWS/tabid/99/ID/677790/Ministry-seeks-to-ease-GM-food-safety-fears.aspx

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

Gonzales, LA. 2009. SocioEconomic Impact of Biotech Maize Adoption in the Philippines. In. Modern Biotechnology and Agriculture: A History of the Commercialization of Biotech Maize in the Philippines. SIKAP/STRIVE Foundation. Los Baños, Laguna, Philippines. Pages 144-212.

Government of Chile Statistics. SAG. 2011. http://www.sag.gob.cl

Goze, E, S Nibouche and J Deguine. 2003. Spatial and probability distribution of *Helicoverpa armigera* (*Lepidoptera: Noctuidae*) in cotton: systematic sampling, exact confidence intervals and sequential test. Environmental Entomology. 32 (5): 203–1210.

Gray, L. 2009. Chief scientist says GM and nanotechnology should be part of modern agriculture. http://www.telegraph.co.uk/earth/earthnews/6943231/Chief-scientist-says-GM-and-nanotechnology-should-be-part-of-modern-agriculture.html

Hamilton, R. 2010. GM canola, a useful tool at Albury. http://theland.farmonline.com.au/news/state/grains-and-cropping/general/gm-canola-a-useful-tool-at-albury/1871329.aspx?storypage=0

Haverkort, AJ, P M Boonekamp, R Hutten, E Jacobsen, L A P Lotz, G J T Kessel, R G F Visser and E A G van der Vossen. 2008. Societal Costs of Late Blight in Potato and Prospects of Durable Resistance Through Cisgenic Modification. Potato Research 51(1) 47-57. http://www.springerlink.com/content/215p35563774g367/

Haverkort, A J, PC Struik, R G F Visser and E Jacobsen. 2009. Applied biotechnology to combat late blight in potato caused by *Phytophthora infestans*. Potato Research 52(3): 249-264.

Huang, D. 2010. Chinese Experts Assure Safety of GM Foods. Crop Biotech Update 5 February, 2010. http://www.isaaa.org. Original story at http://english.cas.cn/Ne/CN/201002/t20100208_50788.shtml

Huang, J, R Hu, R Scott and C Pray. 2005. Insect-Resistant GM Rice in Farmers' Fields: Assessing Productivity and Health Effects in China. Science: 308:5722 (688-690). http://dx.doi.org/10.1126/science.1108972

Hussain, T. and M N Awan 2011. Future of Bt cotton in Pakistan, Paksitan Observer, 13 August 2011. http://pakobserver.net/detailnews.asp?id=108551

Hutchinson, WD. 2010. Areawide Suppression of European Corn Borer with Bt Maize Reaps Savings for Non-Bt maize. http://www.sciencemag.org/content/330/6001/222.full
News article at: http://cropwatch.unl.edu/web/cropwatch/archive?articleID=4351804

ICAC. 2011. Historical statistics on world cotton supply and use from 1940/41 to 2010/11, International Cotton Advisory Committee (ICAC), 2011.

IFPRI. 2009. Climate change impact on agriculture and cost adaptation.
http://www.ifpri.org/sites/default/files/publications/pr21.pdf

IFPRI. 011. How to feed the world in 2050.
http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

IMRB. 2009. Socio-economic benefits and product satisfaction of BG-I and BG-II in india, SAMIKSHA-09, IMRB International, Mumbai, Feb 2009.

Icamina, PM. 2008. 3-in-1 rice helps prevent Vitamin A deficiency. The Manila Times. November 3, 2008 issue.

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

International Cotton Advisory Committee (ICAC). 2006. Cotton: Review of the World Situation, Vol. 58, pp.2.

International Rice Research Institute (IRRI), 2011. Golden Rice. Fighting vitamin A deficiency in the Philippines and Bangladesh.

Institute of Agricultural Research (INIA). 2007.

Knudsen, O K and J P Morgan. 2010. Turning Black Swans Green: The Vittorio Santaniello Memorial Lecture. http://www.agbioforum.org/v13n2/v13n2a02-knudsen.htm

Korves, R. 2008. Burkina Faso plants Bt cotton. Truth about Trade and Technology, 22 August 200, India.

James, C. 2010. Global Status of Commercialized Biotech/GM Crops: 2010. ISAAA Brief No. 42. ISAAA: Ithaca, NY.

James, C. 2009a. China Approves Biotech Rice and Maize in Landmark Decision. Crop Biotech Update. 4 December, 2009.

James, C. 2009b. Global Status of Commercialized Biotech/GM Crops: 2008. ISAAA Brief No. 41. ISAAA: Ithaca, NY.

James, C. 2008. Global Status of Commercialized Biotech/GM Crops: 2008. ISAAA Brief No. 39. ISAAA: Ithaca, NY.

James, C. 2007. Global Status of Commercialized Biotech/GM Crops: 2007. ISAAA Brief No. 37. ISAAA: Ithaca, NY.

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.

Jansson, S et al (with 20 other scientists), 2011. Quasi-science prevents an environmentally-friendly agriculture and forestry. Oct. 5, 2011 http://blogg.slu.se/forskarbloggen/?p=433. Cited in Tribe, D. 2011. 41 Swedish plant scientists speak out against harmful EU regulation of modern plant genetics. Oct. 6, 2011. http://www.biofortified.org/2011/10/41-swedish-plant-scientists-speak-out-against-harmful-eu-regulation-of-modern-plant-genetics-methods/

Javier, PA, MV Agsaoay and JL 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.

Kakakhel, I. 2010. Government misses cotton sowing targets. Daily Times, 16 July 2010. http://www.dailytimes.com.pk/default.asp?page=2010%5C07%5C16%5Cstory_16-7-2010_pg5_8

Kathage, J and Qaim, M. 2011. Are the economic benefits of Bt cotton sustainable? Evidence from Indian panel data, Discussion paper, Georg-August University of Göttingen, Germany, June 2011.

Khalid, ZM. 2009. Status of Biotechnology and Biosafety of GM Crops in Pakistan, presentation during the Regional Biosafety Workshop, Asian Bio-Net, Department of Agriculture, Thailand, 30 November to 4 December 2009. http://it.doa.go.th/asianbionet/activities/thailandNov2009/doc/Pakistan/Pakistan.pdf

Kouser. S and Qaim. M. 2011. Impact of Bt cotton on pesticide poisoning in smallholder agriculture – a panel data analysis, Ecological Economics, Volume 70, Issue 11, Pages 2105-2113, 15 September 2011.

Ledford, H. 2011. Transgenic grass skirts regulators. Nature 475: 274-275. http://www.nature.com/news/2011/110720/full/475274a.html

Lin, G. 2009. Agriculture fastest-growing research in China. 12 November 2009. http://www.scidev.net/en/news/agriculture-fastest-growing-research-in-china.html

Lin, H. 2010. CAS Academician Discusses Potential for Bio-breeding. Crop Biotech Update 13 May 2010. http://www.isaaa.org.

Lugar, R. 2010. US Global Security Act to Battle Hunger Worldwide. Crop Biotech Update. For more details, visit http://www.irinnews.org/Report.aspx?ReportId=89467.

Lok Sabha, 2010, Requirement of Fertilizers/Pesticides, Unstarred Question No. 3433, Lok Sabha, the Parliament of India, 30 November 2010

MCSE. 2001. Rural population and farm families-land holding, statistics, Myanma Cotton and Sericulture Enterprise (MCSE), Ministry of Agriculture, 2001

Maotang, Z. 2010. Zu Maotang - The First Biotech Farmer in China. http://www.croplife.org/files/documentspublished/1/enus/CS/4760_CS_2009_05_13_Farmer_Profile_-_China_-_Zu_Maotang_-_the_first_biotech_farmer_in_China.pdf

Massoud, MA. 2005. The influence of encoding BT corn hybrids (MON 810 event) on the infestation of the corn borers in Egypt. The 3rd International Conference of Plant Protection Research Institute, 26-29 November, 2005, 83 (2): 469-496.

McCarthy, J. 2010. Argentine growers eye Scottisch malt barley market. http://www.pressandjournal.co.uk/Article.aspx/1592911?UserKey&UserKey&UserKey=#ixzz161LKUrBq

McDougal, P. 2011. Getting a biotech crop to market. (http://www.croplife.org/PhillipsMcDougallStudy)

McWilliams, J. 2008. China import approval bolters New Monsanto soybean seed. St. Louis Post – Dispatch, USA. Retrieved 8 September, 2008. http://www.soyatech.com/news_story.php?id=10146

Ministry of Agriculture. 2010. Directorate of Cotton Development, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.

Ministry of Agriculture and Fisheries, Denmark. 2009. Denmark: GMO crops can help climate and environment, according to a new report from the Danish Food Ministry. Sept. 18, 2009. http://bites.ksu.edu/news/135342/09/09/18/denmark-gmo-crops-can-help-climate-and-environment-according-new-report-danish-

Ministry of Agriculture, Rural Development, and Fisheries, Lisbon, Portugal, http://www.dgadr.pt/ 13 September, 2011.

Ministry of Agriculture, Spain, 2011. http://www.marm.es/es/calidad-y-evaluacion-ambiental/temas/

biotecnologia/Cuadro_CORREGIDO_para_WEB_de_Superficie_cultivada_de_Ma%C3%ADz_MON810_por_Provincias_(2009)_tcm7-172243.pdf

Ministry of Environment, Rural Development and Fisheries, Spain. 2011. Avances Suopefices y Producciones Agricolas, http://www.marm.es/es/estadistica/temas/avances-de-superficies-y-producciones-de-cultivos/cuaderno_Septiembre2011_tcm7-180212.pdf

Moloi, S. 2010. In Biotech in Africa: In South Africa, the welcome mat is out http://www.desmoinesregister.com/article/20100510/BUSINESS01/5100313/1029/BUSINESS/Biotech-in-Africa-In-South-Africa-the-welcome-mat-is-out

Moore, R. 2010. Biotechnology is future of farming. http://www.reviewatlas.com/news/x968905986/Biotechnology-is-future-of-farming

Murphy, D. 2008. Dan Murphy: Five Minutes With Luther Markwart, American Sugarbeet Growers. http://www.cattlenetwork.com/Dan-Murphy--Five-Minutes-With-Luther-Markwart--American-Sugarbeet-Growers/2008-03-03/Article.aspx?oid=624062

Myanmar Times. 2010. New cotton strain could yield exports by Soe Sandar Oo, Myanmar Times, October 11 - 17, 2010, Myanmar. http://www.mmtimes.com/2010/business/544/54402biz.html

Nature. 1 October 2010. Uganda prepares to plant transgenic papayas. http://www.nature.com/news/2010/101001/full/news.2010.509.html

Navarro, M. 2009. Trail blazing biotech in the philippines: an interview with academician Emil Q. Javier. In. Mariechel J. Navarro (ed) Brief 40. Communicating Crop Biotechnology: Stories from Stakeholders. International Service for the Acquisition of Agribiotechnology Applications (ISAAA). Los Baños, Laguna. Pp. 81-83.

Nazli, H, R Sarker, K Meilke, and D Orden. 2010. Economic Performance of Bt Cotton Varieties in Pakistan, Selected Paper prepared for presentation at the Agricultural and Applied Economics Association's 2010 AAEA, CAES & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010. http://ageconsearch.umn.edu/handle/61181

National Biosafety Committee (NBC). 2010. Minutes of the 8th meeting of National Biosafety Committee (NBC) held on 25th March, 2010, Ministry of Environment, Islamabad, Pakistan.

New York Times, 11 Nov 2010. EU Approves First Modified Crop for Planting in 12 Years. http://www.nytimes.com/2010/11/11/business/global/11biotech.html?src=busln

Norton, M. 2010. http://www.abc.net.au/news/stories/2010/05/19/2903920.htm

Nu, TT. 2011. Cotton Production Technology and Research in Myanmar, 5th Meeting of the Asian Cotton Research and Development Network, International Cotton Advisory Committee, February, 2011

Oerke, EC and H W Dehne. 2004. Safeguarding production – losses in major crops and the role of crop protection. Crop Protection 23 (4) 275-285. http://www.sciencedirect.com/science/article/pii/S0261219403002540

Origin Agritech. 2009. Origin Agritech Announces Final Approval of World's First Genetically Modified Phytase Corn. http://www.originseed.com.cn/en/news/view.php?pid=22&id=437

PCCC. 2011. Cotistics- Annual Cotton Statistical Bulletin, Pakistan Central Cotton Committee (PCCC), Ministry of Food and Agriculture, Govt of Pakistan, 2011

Pablico, S M. 2008. PhilRice Develops 3-in-1 Rice. The Philippine STAR. August 31, 2008 issue.

Pakistan Economic Survey, 2009-10, Ministry of Finance, Government of Pakistan. http://www.finance.gov.pk/survey_0910.html

Pakistan Industry Estimates. 2010

Pakistan Observer. 2011, Bio-tech corn awaits approval in Pakistan, Pakistan Observer, 8 June 2011. http://pakobserver.net/detailnews.asp?id=96493

Pakistan Textile Journal. 2010. Textile Briefs National, May 2010. http://www.ptj.com.pk/web-2010/05-10/Textile-Briefs-National.htm

Pakistan Today. 2011. Punjab Seed council okays 18 wheat varieties, Pakistan Today, 13 Jan 2011. http://www.pakistantoday.com.pk/2011/01/punjab-seed-council-okays-18-wheat-varieties/

Pakistan Cotton Ginner Association (PCGA). 2010. Estimate of Cotton Crop Loss, Pakistan Cotton Ginner Association (PCGA), 2010. www.pcga.org

Park J. I McFarlane, R Philipps and G Ceddia. 2011. The impact of the EU regulatory constraints on transgenic crops on farm income. http://modul.academia.edu/grazianoceddia/Papers/405026/The_impact_of_EU_regulatory_constraint_of_transgenic_crops_on_farm_income

Paz R, W Fernandez, O Zambrano and J Falck Zepeda. 2008. Socio-Economic considerations of genetically-modified soybean Adoptio: The Case of Bolivia. http://www.cbd.int/doc/external/mop-04/ifpri-cs-bolivia-en.pdf

People's Daily Online. 2009. From self-sufficiency to grain contribution, China's agriculture passes 60 memorable years, 26 August, 2009. http://english.people.com.cn/90001/90776/90882/6739421.html

Piggott, N E and M C Marra. 2007. The Net Gain to Farmers of a Natural Refuge Plan for Biollgard III®Cotton. AgBioForum 10 (1): 1-10. http://www.agbioforum.org/v10n1/v10n1a01-piggott.htm

Planning Commission. 2007. Pakistan in the 21st Century Vision 2030, Planning Commission, Government of Pakistan, August 2007.

Planning Commission. 2010. Agriculture Development, Annual Plan 2010-2011, Planning Commission, Government of Pakistan. http://www.planningcommission.gov.pk/annual%20plans/2010-11/Agriculture%20Development.pdf.

Porter, S. 2009. GM Sugar beet hit by California Court Ruling. Northern Colorado Business Report. Oct. 23, 2009. http://www.ncbr.com/article.asp?id=102674

Potrykus, I. & Ammann, K., eds. (2010).Transgenic Plants for Food Security in the Context of Development, New Biotechnology, Proceedings of a Study Week of the Pontifical Academy of Sciences, Elsevier, Amsterdam, New Biotechnology, Vol. 27/5, pp 445-718, ISSN 1871-6784.

Press Information Bureau (PIB), 2007. Export of cotton continues to increase, Press Information Bureau, Govt of India, 20 March 2007. http://pib.nic.in/release/release.asp?relid=26236

Press Information Bureau (PIB). 2010a. Ban of cotton exports, Press Information Bureau, Govt of India, 4 August 2010 available at: http://pib.nic.in/release/release.asp?relid=64126&kwd=

Press Information Bureau (PIB). 2010b. Government allows cotton exports up to 55 lakh bales in 2010-11 to review the cotton export scenario on 15th November 2010, Press Information Bureau, Govt of India, 4 Sept 2010. http://pib.nic.in/release/release.asp?relid=65557

Press Information Bureau (PIB). 2011. Details of Cotton/Yarn Export, Press Information Bureau, Govt of India, 8th August 2011. http://www.pib.nic.in/newsite/erelease.aspx?relid=74072

Punjab Seed Council. 2010. Minutes of 39th meeting of Punjab Seed Council (PSC) held on 31st March 2010, Ministry of Agriculture, Punjab, Pakistan.

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

Rao, I A. 2006. First Bt cotton grown in Pakistan, Advisory Biotechnology, Pak Kissan, 17 March 2006. http://www.pakissan.com/english/advisory/biotechnology/first.bt.cotton.grown.in.pakistan.shtml

Rao, I A. 2010. Personal communication with Mr Ijaz Ahmad Rao on 16 July 2010.

Sanchez, M A. 2010. Sustainable practices lead to farm growth, family security. http://www.croplife.org/files/documentspublished/1/en-us/CS/5183_CS_2009_06_16_Farmer_Profile_-_Argentina_-_Sanchez_-_Sustainable_Practices.pdf

Scientific Alliance. 1 October, 2010. Doing the right thing for the wrong reasons. http://gmopundit.blogspot.com/2010/10/doing-right-thing-for-wrong-reasons.html

Scottish Crop Research Institute. 2009. Potato Genome Sequencing. http://www.scri.ac.uk/research/genetics/GenomeBiology/potatosequencing

Seed Today, 2011. EU High Court Confirms France's GM Crop Ban is Illegal. http://www.seedtoday.com/articles/EU_High_Court_Confirms_France_s_GM_Crop_Ban_Is_Illegal-117105.html

Sharma, Y. 2011. Gates tell G20 Innovation is the key to development. 4 November 2011. http://www.scidev.net/en/science-and-innovation-policy/innovation-policy/news/gates-tells-g20-innovation-is-the-key-to-development.html

Shuping, N. 2008. China Approves big budget for GMO amid food worries. 10 July 2008. Reuters. http://www.reuters.com/article/environmentNews/idUSPEK11727520080710?feedType=RSS&feedName=environmentNews&sp=true

Smyth, S, G Michael, P Peter and C David. 2010. Assessing the Economic and Ecological Impacts of Herbicide Tolerant Canola in Western Canada. Report commissioned by the Canola Council of Canada. http://www.mcgacanola.org/documents/AssessingtheEconomicandEcologicalImpactsofHerbicideTolerantCanolainWesternCanada.pdf

Soomro, B. and P Khaliq. 1996. Cotton production in Pakistan- a success story, APAARI publication 1996/2, Asia Pacific Consortium of Agricultural Research Institutions (APAARI), Bangkok, Thailand.

Stone, R. 2008. China plans $3.5 billion GM Crops Initiative. Science 321:1279. Retrieved on Sept. 5, 2008. http://science-mag.aaas.org/cgi/content/summary/321/5894/1279

Subramanian, A. et.al. 2010. GM crops and gender issues. Nature Biotechnology, Vol.28 (No.5). pp. 404-406. May 2010.

Sunikumar, G. LM Campbell, L Puckhaber, RD Stipanovic and KS Rathore. 2006. Engineering cottonseed for use in human nutrition by tissue specific reduction of toxic gossypol. Proceedings of National Academy of Sciences (PNAS). 103(48) 18054-18059. http://www.pnas.org/content/103/48/18054.abstract

Swaminathan, M S. 2010 http://www.globalchange-discussion.org/interview/ms_swaminathan/full_interview

Tait, J and G Barker. 2011. Global food security and the governance of modern biotechnologies. EMBO Reports (2011) 12, 763 – 768. http://www.nature.com/embor/journal/v12/n8/full/embor2011135a.html

Takanori, K, H Nakanishi, M Takahashi, S Mori and N K Nishizawa. 2008. Generation and Field Trials of Transgenic Rice Tolerant to Iron Deficiency. 1 August, 2008.
http://www.springerlink.com/content/m412wx750257h33l/fulltext.pdf

Textile Commissioner. 2010. Memorandum-I, Procedural requirement for obtaining Export Authorisation Registration of raw cotton, No.1/162/2010/Cotton/Vol.VIII/14, Office of the Textile Commissioner, Ministry of Textile, 07 Sept, 2010.

The Age. 2008. Australian First GM grass trial to start. The Age, Melbourne, 28 October 2008.
http://www.theage.com.au/national/australianfirst-gm-grass-trials-to-start-in-victoria-20081028-5aai.html

The Daily Beast. 2011. US Politics: Obama's Organic Game. 15 October 2011.
http://www.thedailybeast.com/articles/2011/10/15/political-battle-over-genetically-modified-foods-should-they-be-labeled.html

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

The Economist. 8 July 2010. Great Wall Street.
http://www.economist.com/node/16541609?story_id=16541609

The Economist. 25 September 2010. Global targets, local ingenuity.
http://www.economist.com/node/17090934

The Economist. 26 February 2011. Feeding the World: The 9 billion-people question.
http://www.economist.com/node/18200618

The Economist. 2011 Hidden Hunger, 26 March 2011. http://www.economist.com/node/18438289

The Nation. 2010. Monsanto and Agriculture Ministry sign MoU for Bt tech, The Nation, 11 April, 2010, available at: http://www.nation.com.pk/pakistan-news-newspaper-daily-english-online/Business/11-Apr-2010/Monsanto-and-Agriculture-Ministry--sign-MoU-for-BT-tech

The News. 2011. Pakistan to approve commercially planting of GM corn, The News, 17 May 2011, available at: http://news.agropages.com/News/NewsDetail---4102.htm

Timmings, J. 2010. Stewards of the soil. http://www.croplife.org/files/documentspublished/1/en-us/CS/5255_CS_2010_01_21_Farmer_Profile_-_Canada_-_Timmings_-_Stewards_of_the_soil.pdf

Trigo E J. 2011. Quince Años de Cultivos Genéticamente Modificados en la Agricultura Argentina. (Fifteen Years of GM Crops in Argentine Agriculture). http://www.argenbio.org/adc/uploads/15_anos_Estudio_de_cultivos_GM_en_Argentina.pdf
English news release at http://www.argenbio.org/index.php?action=notas&note=5884

Toe, A. 2003. Limites maximales de résidus de pesticides dans les produits agricoles d'exportation dans trois pays du CILSS-Etude du Burkina Faso', FAO/CILLS, Rapports Techniques, Projet Gestion des pesticides au Sahel, Bamako, Mali.

Traoré, O, D Sanfo, K Traoré and B Koulibaly. 2006. 'The effect of Bt gene on cotton productivity, ginning rate and fiber characteristics under Burkina Faso cropping conditions', A Working Document Written by INERA Staff Members, Bobo Dialasso, Burkina Faso.

Tun, W. 2008. Cotton research in Myanmar – An overview, 4th Meeting of the Asian Cotton Research and Development Network, International Cotton Advisory Committee (ICAC), 10 Nov 2008.

UNEP GEF. 2006. National Biosafety Framework Myanmar, Ministry of Agriculture and Irrigation, Department of Agricultural Planning, Development of Biosafety Framework Project Myanmar, Nov 2006.

US Census Bureau. 2011. Income, Poverty and Health Insurance Coverage in the United States: 2010. Sept. 13, 2011. http://www.census.gov/newsroom/releases/archives/income_wealth/cb11-157.html

US EPA. 2011. Agriculture and Food Supply: Climate change, health and environmental effects. April 14, 2011. http://www.epa.gov/climatechange/effects/agriculture.html

USDA GAIN 2011. Pakistan-Cotton and Products Annual, Global Agricultural Information Network, USDA Foreign Agricultural Services, GAIN report nos. PK1102, 29 March 2011.

USDA NASS, 2011. Adoption of genetically engineered crops in the US. July 1, 2011. http://www.ers.usda.gov/Data/BiotechCrops/

United Nations. 1987. Global Issues – Environment. Excerpts from the Brundland Report. "Our Common Future" http://www.un.org/en/globalissues/environment/

United Nations. 2011. World Population Prospects: The 2010 Revision. http://www.unpopulation.org

US National Research Council. 2011. The impact of genetically engineered (GE) crops on farm sustainability in the United States. April 2010. http://www.nationalacademies.org/includes/genengcrops.pdf

University of New Castle Australia. 2009. Gene breakthrough secures crops' future. July 21, 2009.

University of Warwick. 2010. GM Crops produces massive gains for women's employment in India, press release, University of Warwick, 28 July 2010, available at: http://www2.warwick.ac.uk/newsandevents/pressreleases/gm_crop_produces

VIB, 2010. Sept. Scientific background report Phytophthora-resistant potatoes. http://www.vib.be/en/news/Documents/VIBdossierPipotatoes_ENG.pdf

VIB. 2011. Scientific field trial with GM potatoes started in Wetteren. 6 May 2011. http://www.vib.be/en/news/Pages/Scientific-field-trial-with-GM-potatoes-started-in-Wetteren.aspx

Vaissayre, M and J Cauquil. 2000. 'Principaux ravageurs et maladies du cotonnier en Afrique au Sud du Sahara', A Report Published by CIRAD.

Vitale, J, M Ouattara, G Vognan, and O Traore, 2010, Proceedings of ICABR Conference at Ravello Italy.

Vognan, G, M Ouédraogo and S Ouédraogo. 2002. Description de la filière cotonnière au Burkina Faso, Rapport intermédiaire, INERA, p.34.

von Braun, J. 2010 (http://www.globalchange-discussion.org/interview/joachim_von_braun/full_interview).

Wen, J. 2008. Chinese Premier says he supports developing transgenic engineering. People's Daily Online. October 18, 2008. http://english.peopledaily.com.cn/90001/90776/90785/6517152.html

Wu, K-M, Y-H Lu, H-Q Feng, Y Jiang and Z Z Jian. 2008. Suppression of cotton bollworm in multiple crops in China in areas with Bt toxin-containing cotton. Science. 321: 1676-1678.

Xinhua. 2009. China to raise grain output to 540 mln tonnes by 2020. 8 April 2009. http://id2.mofcom.gov.cn/aarticle/chinanews/200904/20090406159327.html

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

Zafar, Y. et al. 2007. Current status and prospects of biotech cotton in Pakistan, Proceedings of the Regional Consultation on Genetically Modified Cotton for Risk Assessment and Opportunities for Small-Scale Cotton Growers, National Institute for Biotechnology and Genetic Engineering, Faislabad, Pakistan, March 6-8, 2007, Technical paper No. 63, Common Fund for Commodity (CFC).

Zambrano, P, J H Maldonado, S L Mendoza, L Ruiz, L A Fonseca and I Cardona. 2011. Women cotton farmers: Their perceptions and experiences with transgenic varieties, A case study for Colombia. September 2011. http://www.ifpri.org/sites/default/files/publications/ifpridp01118.pdf

Zhang, T. 2010. Promote The Development Of The Seed Industry, Says China's Vice Minister Of Agriculture, Crop Biotech Update. 22 January 2010. http://www.isaaa.org; http://english.agri.gov.cn/ga/np/201001/t20100121_1614.htm for more information.

Zulauf, C and E. Hertzog. 2011a. Biotechnology and US Crop Yields. http://aede.osu.edu/biotechnology-and-us-crop-yield-trends.

Zulauf, C and E. Hertzog. 2011b. Biotechnology and Variation in Average U.S. Yields http://aede.osu.edu/sites/drupalaede.web/files/publications/Zulauf%20and%20Hertzog%20-%20Biotech%20and%20SD%20of%20Yield%20Trend.pdf

Appendix 1

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 2011. Regulatory approval processes for biotech products vary from country to country and therefore, countries should be consulted for specific details.

Appendix 1. Global Status of Regulatory Approvals

Compiled by M. Escaler, ISAAA 2006; RR Aldemita, ISAAA 2007, 2008, 2009, 2010, 2011

ARGENTINA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2001	2001		2001
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	1998	1998		1998
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2009	2009	2009	2009
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2001	2001		2001
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1998	1998		1996
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2009	2009		2011
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2011	2011	2011	2011
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2005	2005		2005
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2007	2007		
Maize	*Zea mays* L.	Lys + IR	LY038 × MON810	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2010	2010		2011
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1998	1998		1998
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2004	2004		2004
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2005	2005		2007
Maize	*Zea mays* L.	HT	T14	Bayer CropScience	1998	1998		1998
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	1998	1998		1998
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2005	2005		2005
Maize	Zea mays L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006	2008	2008
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2011	2011		2011
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2008	2008		2011
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1996	1996		1996

AUSTRALIA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101	Monsanto Company	2007	2007		
Alfalfa	*Medicago sativa*	HT	J163	Monsanto Company	2007	2007		
Argentine Canola	*Brassica napus*	HT	GT200 (RT200)	Monsanto Company	2010	2010		2010
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	2002	2002		2003
Argentine Canola	*Brassica napus*	HT	OXY-235	Aventis CropScience	2002			
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	2002	2002		2003
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	2002	2002		2003
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	2000			2003
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	2002	2002		2003
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	2002			2003
Carnation	*Dianthus caryophyllus*	FC + HT	123.2.2 (40619)	Florigene Pty Ltd.				2007

LEGEND

CPP	Cedar Pollen Peptide
DR	Delayed Ripening/Altered Shelf-Life
DS	Delayed Senescence
DT	Drought Tolerance
F	Fertility Restored
FC	Modified Flower Color
FC + HT	Modified Flower Color and Herbicide Tolerance
Flav Path	Flavonoid Biosynthetic Pathway
HC	High Cellulose
HPhy	High Phytase
HT	Herbicide Tolerance
HT + F	Herbicide Tolerance and Ferticility Restored
HT + HT	Stacked Herbicide Tolerant Traits
HT + IR	Herbicide Tolerance and Insect Resistance
IR	Insect Resistance
IR + HT	Insect Resistance and Herbicide Tolerance
IR + VR	Insect Resistance and Virus Resistance
Lys	Enhanced Lysine Content
Lys + IR	Enhanced Lysine Content and Insect Resistance
MS	Male Sterility
MS + HT	Male Sterility and Herbicide Tolerance
NIC	Nicotine Reduction
OC	Modified Oil Content
OC + HT	Modified Oil Content and Herbicide Tolerance
Plt Quality	Mod Amylase
VR	Virus Resistance
VR+IR+HT	Virus Resistance + Insect Resistance + Herbicide Tolerance

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

* The product has been approved for planting/cultivation but it is not necessarily in commercial production at present

AUSTRALIA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Carnation	*Dianthus caryophyllus*	FC + HT	123.2.38 (40644)	Florigene Pty Ltd.				2007
Carnation	*Dianthus caryophyllus*	FC + HT	123.8.8 (40685)	Florigene Pty Ltd.				2007
Carnation	*Dianthus caryophyllus*	FC	4, 11, 15, 16	Florigene Pty Ltd.				1995
Carnation	*Dianthus caryophyllus*	DS	66	Florigene Pty Ltd.				1995
Carnation	*Dianthus caryophyllus*	FC + HT	959A, 988A, 1226A, 1351A, 1363A, 1400A	Florigene Pty Ltd.				2007
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 × 3006-210-23	Dow AgroSciences LLC	2005	2009		2009
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2009			
Cotton	*Gossypium hirsutum* L.	HT	BXN	Calgene Inc.	2002	2002		
Cotton	*Gossypium hirsutum* L.	IR	COT102	Syngenta Seeds	2005			
Cotton	*Gossypium hirsutum* L.	IR	COT67B	Syngenta Seeds	2009			
Cotton	*Gossypium hirsutum* L.	IR + HT	GHB119	Bayer CropScience	2011		2011	
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2006			2006
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2000			2006
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2002			2006
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company				2006
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	1996	1996		2003
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company				2003
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	1996	1996		1996
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2006			2006
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company				2006
Cotton	*Gossypium hirsutum* L.	IR	T304-40	Bayer CropScience	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005			
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2001	2001		
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2001	2001		
Maize	*Zea mays* L.	IR + HT	Bt11 × DAS 59122-7 × MIR604 × TC1507 × GA21	Syngenta Seeds	2011	2011		
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006	2006	
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	2002			
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2008	2008		
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2000			
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2007	2007		
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2006			
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2009			
Maize	*Zea mays* L.	DT	MON 87460	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2000			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003			
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006			
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2002			
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2002	2002		
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2003			
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Potato	*Solanum tuberosum* L.	IR	ATBT04-6, ATBT04-27, ATBT04-30	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	2001	2001		

AUSTRALIA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Potato	*Solanum tuberosum* L.	IR	SPBT02-5	Monsanto Company	2001	2001		
Rice	*Oryza sativa* L.	HT	LLRICE06, LLRICE62	Aventis CropScience	2010	2010		
Rose	*Rosa hybrida*	Flav Path	IFD-524Ø1-4	Suntory Limited				2009
Soybean	*Glycine max* L.	OC	260-05 (G94-1, G94-19, G168)	DuPont Canada Agricultural Products	2000			
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2004			
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2004	2004		
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2010	2010		
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2010	2010	2010	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2000			
Soybean	*Glycine max* L.	OC + HT	MON 87705	Monsanto Company	2011			
Soybean	*Glycine max* L.	IR	MON87701	Monsanto Company	2010	2010	2010	
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2008	2008		
Sugarbeet	*Beta vulgaris*	HT	GTS B77	Monsanto Company	2002	2002		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2005			

BOLIVIA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2008	2008	2008	2008

BRAZIL

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Bean	*Phaseolus vulgaris*	GBMV	EMBRAPA 5.1	EMBRAPA	2011	2011		2011
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 × 3006-210-23	Dow AgroSciences LLC	2009	2009		2009
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2010	2010		2010
Cotton	*Gossypium hirsutum* L.	IR + HT	GHB 119 × T304-40	Bayer CropScience	2011	2011		2011
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2008	2008	2008	2008
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2008	2008	2008	2008
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2009	2009	2009	2009
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2009	2009		2009
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	2005	2005		2005
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2011	2011	2011	2011
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2008	2008	2008	2008
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2009	2009		2010
Maize	*Zea mays* L.	HT + IR	BT11 x MIR 162 × GA21	Syngenta Seeds	2009	2009	2009	2009
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2008	2008	2008	2008
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2009	2009		2009
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2009	2009	2009	2009
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2007	2007	2007	2008
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2009	2009		2009
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × NK603	Monsanto Company & Mycogen Seeds c/o Dow AgroSciences LLC	2010	2010		2010
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2008	2008	2008	2008
Maize	*Zea mays* L.	HT + IR	NK603 × Cry9C	Bayer CropScience		2005		
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2009	2009		2009
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2007	2007		2007
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2008	2008	2008	2008
Maize	*Zea mays* L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2011	2011	2011	2011
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2009	2009		2009
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2010	2010	2010	2010
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2010	2010	2010	2010
Soybean	*Glycine max* L.	HT	BPS-CV127-9	BASF and EMBRAPA	2009	2009		2009

BRAZIL

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1998	1998		1998
Soybean	*Glycine max* L.	IR + HT	MON 87701 × MON 89778	Monsanto Company	2010	2010	2010	2010

BURKINA FASO

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2008	2008	2008	2008

CANADA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101	Monsanto Company	2005	2005		2005
Alfalfa	*Medicago sativa*	HT	J163	Monsanto Company	2005	2005		2005
Argentine Canola	*Brassica napus*	OC	23-18-17, 23-198	Calgene Inc.	1996	1996		1996
Argentine Canola	*Brassica napus*	HT	GT200 (RT200)	Monsanto Company	1997	1997		1996
Argentine Canola	*Brassica napus*	HT	HCN10	Aventis CropScience	1995	1995		1995
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	1997	1996		1996
Argentine Canola	*Brassica napus*	HT	OXY-235	Aventis CropScience	1997	1997		1997
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	1995	1995		1995
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	1995	1995		1995
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	1994	1995		1995
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	1997	1996		1996
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	1995	1995		1995
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 + IR	31807/31808	Calgene Inc.	1998			
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2008	2008		
Cotton	*Gossypium hirsutum* L.	HT	BXN	Calgene Inc.	1996			
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2004	2004		
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	1996	1997		
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2003	2003		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2004	2004	2004	
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	1996	1996		
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2005	2005		
Flax, Linseed	*Linum usitatissumum* L.	HT	FP967	University of Saskatchewan	1998	1996		1996
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2005		2005
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	1996	1996		1996
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1995	1996		1996
Maize	*Zea mays* L.	IR + HT	Bt11 × DAS 59122-7 × MIR604 x TC1507 × GA21	Syngenta Seeds	2011	2011		
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2005	2005		2005
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2010	2010		
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2007	2007		2007
Maize	*Zea mays* L.	IR + HT	BT11 × MIR604 × GA21	Syngenta Seeds	2007	2007		2007
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2006	2006		2006
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2005		2005
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	1997	1997		1997
Maize	*Zea mays* L.	HT	DLL25 (B16)	DeKalb Genetics Corporation	1996	1996		1996
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2008	2008		2008
Maize	*Zea mays* L.	VR+IR+HT	Event 3272 × BT11 × MIR 604 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.	2009	2009		2009
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	1998	1998		1998
Maize	*Zea mays* L.	HT + IR	GA21 x MON810	Monsanto Company	2003	2003	2003	
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2006	2006		2006

CANADA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2007	2007		2007
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2010	2010		2010
Maize	*Zea mays* L.	DT	MON 87460	Monsanto Company	2011	2010		2010
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2009	2009	2009	
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.	IR	MON810	Monsanto Company	1997	1997		1997
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2006	2006		2006
Maize	*Zea mays* L.	HT	MON832	Monsanto Company	1997			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003	2003		2003
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2004	2004	2004	
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2004	2004		2004
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2004	2004	2004	
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006	2006		2006
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2008	2008		2008
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2009	2009		2009
Maize	*Zea mays* L.	HT + F	MS3	Bayer CropScience (Aventis CropScience(AgrEvo))	1997	1998		1996
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2001	2001		2001
Maize	*Zea mays* L.	HT + IR	NK603 x MON810	Monsanto Company	2001	2001		2001
Maize	*Zea mays* L.	HT	NK603 × T 25	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	T14	Bayer CropScience	1997	1996		1996
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	1997	1997		1996
Maize	*Zea mays* L.	IR + HT	TC 1507 × 59122 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2002	2002		2002
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		2006
Maize	*Zea mays* L.	IR + HT	TC6275	Dow AgroSciences LLC	2006	2006		2006
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	Monsanto Company	1996	1997		1997
Potato	*Solanum tuberosum* L.	IR	BT06 (RBBT06)	Monsanto Company	1995	1995		1995
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	1995	1996		1995
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	1999	1999		1999
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	1999	1999		1999
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	1999	1999		1999
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	1999	1999		2001
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	1999	1999		1999
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	1999	1999		1999
Potato	*Solanum tuberosum* L.	IR	SPBT02-5	Monsanto Company	1996	1997		1997
Rice	*Oryza sativa* L.	HT	LLRICE06, LLRICE62	Aventis CropScience	2006	2006		
Soybean	*Glycine max* L.	OC	260-05 (G94-1, G94-19, G168)	DuPont Canada Agricultural Products	2000	2000		2000
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2000	2000		1999
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2000	2000		2000
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2009	2009		2009
Soybean	*Glycine max* L.	OC + HT	DP305423 × GTS40-30-2	Pioneer Hi-Bred International Inc.	2009	2009		
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2009	2009		2009
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1996	1995		1995
Soybean	*Glycine max* L.	IR	MON87701	Monsanto Company	2010	2010		2010
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2007	2007		2007

CANADA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Squash	*Cucurbita pepo*	VR	CZW-3	Asgrow (USA) - Seminis Vegetable Inc. (Canada)	1998			
Squash	*Cucurbita pepo*	VR	ZW20	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	2000	2001		2001
Tomato	*Lycopersicon esculentum*	DR	1345-4	DNA Plant Technology Corporation	1995			
Tomato	*Lycopersicon esculentum*	IR	5345	Monsanto Company	2000			
Tomato	*Lycopersicon esculentum*	DR	B, Da, F	Zeneca Seeds	1996			
Tomato	*Lycopersicon esculentum*	DR	FLAVR-SAVR	Calgene Inc.	1995			

CHILE								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Argentine Canola	*Brassica napus*	HT	GT200 (RT200)	Monsanto Company				2007
Maize	*Zea mays* L.	IR	MON810	Monsanto Company				2007
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company				2007

CHINA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	2004	2004		
Argentine Canola	*Brassica napus*	HT	OXY-235	Aventis CropScience	2004	2004		
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	2004	2004		
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	2004	2004		
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	2004	2004		
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	2004	2004		
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	Cry1A + CpT1	Chinese Academy of Agricultural Sciences				1999
Cotton	*Gossypium hirsutum* L.	IR	GK12	Chinese Academy of Agricultural Sciences				1997
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2006	2006		
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2006	2006		
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	2004	2004		
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2007	2007	2007	
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2004	2004		
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2004	2004		
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2004	2004		
Maize	*Zea mays* L.	HT	High Phytase	Origin Agritech				2009
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2008	2008	2008	
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2004			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2004	2004		
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2005	2005		
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2004	2004		
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2004	2004		
Papaya	*Carica papaya*	VR	Huanong No. 1	South China Agricultural University				2006
Petunia	*Petunia*	FC	CHS gene	Beijing University				1998
Poplar	*Populus nigra*	IR	Bt Poplar	Research Institute of Forestry, Beijing, China			2003	2008
Rice	*Oryza sativa* L.	IR	cry1Ac Event	Huazhong Agricultural University	2009	2009		2009
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2007	2007		
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2004	2004		
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2008	2008		
Sweet pepper	*Capsicum annuum*	VR	PK-SP01	Beijing University	1998			1998

CHINA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Tomato	*Lycopersicon esculentum*	DR	Da Dong No. 9	Institute of Microbiology, CAS	2000	2000		2000
Tomato	*Lycopersicon esculentum*	DR	Huafan No. 1	Huazhong Agricultural University	1997	1997		1997
Tomato	*Lycopersicon esculentum*	DR	PK-TM8805R	Beijing University				1998

COLOMBIA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Carnation	*Dianthus caryophyllus*	FC + HT	959A, 988A, 1226A, 1351A, 1363A, 1400A	Florigene Pty Ltd.				2000
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience				2010
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2004	2004		2004
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2009			
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2006	2008		
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2003	2003		2003
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company				2007
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	2004		2004	
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2007	2007		2010
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company	2010	2007		2007
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2008	2008		2008
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds				
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2010	2010	2008	
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2010			
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2003	2006		
Maize	*Zea mays* L.	IR	MON863	Monsanto Company				
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company		2010		
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company		2008		
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2010			
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2004	2004		2008
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2008	2008		2008
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2006	2006		2006
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.				
Rice	*Oryza sativa* L.	HT	LLRICE601	Bayer CropScience	2008	2008		
Rose	*Rosa hybrida*	FC	Blue Rose pSPB130	International Flower Developments - PTY (Colombia)				2010
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2010	2010		
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2005	2005		2010
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2010	2010		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company		2010		
Wheat	*Triticum aestivum*	HT	MON-71800	Monsanto Company	2004	2004		

COSTA RICA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 × 3006-210-23	Dow AgroSciences LLC				2009
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON88913	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.				2009
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience				2009
Cotton	*Gossypium hirsutum* L.	IR	COT 102 × COT 67B	Syngenta Seeds				2009
Cotton	*Gossypium hirsutum* L.	IR	COT102	Syngenta Seeds				2009
Cotton	*Gossypium hirsutum* L.	IR + HT	COT102 × COT67B × MON88913	Syngenta Seeds				2009
Cotton	*Gossypium hirsutum* L.	IR	COT67B	Syngenta Seeds				2009
Cotton	*Gossypium hirsutum* L.	HT	Dicamba and Glufosinate	Monsanto Company				2009
Cotton	*Gossypium hirsutum* L.	IR	GEM1	Bayer SA, Costa Rica				2009
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience				2009

COSTA RICA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company				2008
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company				2008
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company				2008
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company				2008
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company				2008
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company				2008
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company				2008
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company				2008
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company				2009

CZECH REPUBLIC								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2005	2005		2005
Potato	*Solanum tuberosum* L.	Plt Quality	EH92-527-1	BASF Plant Science Company GmbH		2010	2010	2010
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2001	2001	2001	

EGYPT, ARAB REP.								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company				2008

EL SALVADOR								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2009	2009		

EUROPEAN UNION								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	1999	2000	2007	
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company		2007	2007	
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	2007	2007	2007	
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	1997	1998		
Carnation	*Dianthus caryophyllus*	FC + HT	123.2.38 (40644)	Florigene Pty Ltd.			2007	2007
Carnation	*Dianthus caryophyllus*	FC	4, 11, 15, 16	Florigene Pty Ltd.			1997	
Carnation	*Dianthus caryophyllus*	DS	66	Florigene Pty Ltd.			1998	1998
Carnation	*Dianthus caryophyllus*	FC + HT	959A, 988A, 1226A, 1351A, 1363A, 1400A	Florigene Pty Ltd.			1998	1998
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2011	2011	2011	
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2008	2008	2008	
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2002	1997		
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2005	2005		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2005	2005		
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2002	1997		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2005	2005		
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	1998	1998		
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1997	1997		1997
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2009	2009	2009	
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2006	2006	2008	
Maize	*Zea mays* L.	HT + IR	GA21 x MON810	Monsanto Company	2005	2007		

EUROPEAN UNION

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1998	1998		2004
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2006	2005		
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2010	2010		
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2007	2005	2007	
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2011	2011	2011	
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2004	2004		
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2005	2005		
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	1998	1998	1998	1998
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2006	2006		
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS-59122 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Potato	*Solanum tuberosum* L.	Plt Quality	EH92-527-1	BASF Plant Science Company GmbH		2010		2010
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2008	2008	2008	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2005	2005	1996	
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2008	2008	2008	
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2007	2007		
Tobacco	*Nicotiana tabacum* L.	HT	C/F/93/08-02	Societe National d Exploitation des Tabacs et Allumettesx			1994	

GERMANY

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Potato	*Solanum tuberosum* L.	Plt Quality	EH92-527-1	BASF Plant Science Company GmbH		2010	2010	2010

HONDURAS

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2002	2002		2002
Maize	*Zea mays* L.	HT	NK603	Monsanto Company			2008	2008
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2009	2009		2009
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010		2010

INDIA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	BNLA-601	CICR (ICAR) and UAS, Dharwad	2008	2008		2008
Cotton	*Gossypium hirsutum* L.	IR	Event-1	JK Agri Genetics Ltd (India)				2006
Cotton	*Gossypium hirsutum* L.	IR	GFM	Nath Seeds	2006	2006		2006
Cotton	*Gossypium hirsutum* L.	IR	MLS-9124	Metahelix Life Sciences				2009
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2006	2006		2006
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2002	2002		2002

IRAN

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Rice	*Oryza sativa* L.	IR	Tarom molaii + cry1ab	Agricultural Biotech Research Institute	2005	2005		2005

JAPAN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101	Monsanto Company	2005	2006		2006
Alfalfa	*Medicago sativa*	HT	J101 × J163	Monsanto Company	2005	2006		2006
Alfalfa	*Medicago sativa*	HT	J163	Monsanto Company	2005	2006		2006
Argentine Canola	*Brassica napus*	HT	GT200 (RT200)	Monsanto Company	2001	2001		2006
Argentine Canola	*Brassica napus*	HT	HCN10	Aventis CropScience	1997	1998		1997
Argentine Canola	*Brassica napus*	HT + F	MS8	Bayer CropScience	1997	1998		1998
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	1997	1998		1999
Argentine Canola	*Brassica napus*	HT	OXY-235	Aventis CropScience	1999	1999		1998
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	1996	1996		1996
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	1997	1997		1997
Argentine Canola	*Brassica napus*	HT	PHY14	Bayer CropScience	2001	1998		1997
Argentine Canola	*Brassica napus*	HT + F	PHY35	Bayer CropScience	2001	1998		1997
Argentine Canola	*Brassica napus*	HT + F	PHY36	Bayer CropScience	1997	1997		1997
Argentine Canola	*Brassica napus*	HT + F	RF3	Bayer CropScience	1997	1998		1998
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	1996	1996		1996
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	1997	1997		1997
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	2007	2007		
Carnation	*Dianthus caryophyllus*	FC + HT	123.2.2 (40619)	Florigene Pty Ltd.				2004
Carnation	*Dianthus caryophyllus*	FC + HT	123.2.38 (40644)	Florigene Pty Ltd.				2004
Carnation	*Dianthus caryophyllus*	FC + HT	123.8.8 (40685)	Florigene Pty Ltd.				2004
Carnation	*Dianthus caryophyllus*	FC + HT	959A, 988A, 1226A, 1351A, 1363A, 1400A	Florigene Pty Ltd.				2004
Carnation	*Dianthus caryophyllus*	HT	FLO-4Ø689-6	Suntory Limited			2007	2007
Cotton	*Gossypium hirsutum* L.	IR	281-24-236	Dow AgroSciences LLC	2005			
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 × 3006-210-23	Dow AgroSciences LLC	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	3006-210-23	Dow AgroSciences LLC	2005			
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON1445	Dow AgroSciences LLC	2006	2006		
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON88913	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006			
Cotton	*Gossypium hirsutum* L.	HT + IR	31807/31808	Calgene Inc.	1999	1999		1998
Cotton	*Gossypium hirsutum* L.	HT + HT	ACS-GH00103-3 × BCS-GH002-5	Bayer CropScience	2010	2010	2010	
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2010	2010	2010	
Cotton	*Gossypium hirsutum* L.	HT	BXN	Calgene Inc.	1997	1998		1997
Cotton	*Gossypium hirsutum* L.	IR	COT102	Syngenta Seeds				2007
Cotton	*Gossypium hirsutum* L.	IR	COT67B	Syngenta Seeds				2007
Cotton	*Gossypium hirsutum* L.	HT + IR	GHB614 × LL Cotton 25 × MON 15985	Bayer CropScience	2011	2011	2011	
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2004	2006		
Cotton	*Gossypium hirsutum* L.	HT + IR	LLCotton25 × MON15985	Bayer CropScience	2006	2007	2007	
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	1997	1998		1997
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2002	2003		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2005	2005		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2004	2003	2004	
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	1997	1997		1997
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2005	2006		
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company	2005	2006		
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		2006
Maize	*Zea mays* L.	HT + IR	ACS-ZMØØ3-2 (T25) × MON-ØØ81Ø-6	Bayer CropScience	2003	2003		
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds				1996
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1996	1996		1996
Maize	*Zea mays* L.	IR + HT	Bt11 × DAS 59122-7 × MIR604 × TC1507 × GA21	Syngenta Seeds	2011	2011	2011	2011
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2007			2007
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2010	2010	2010	2010
Maize	*Zea mays* L.	IR + HT	Bt11 × MIR 162 × TC1507 × GA21	Syngenta Seeds	2011	2011	2011	2011

JAPAN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR + HT	BT11 × MIR162 × MIR 604 × GA21	Syngenta Seeds	2010	2010	2010	2010
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2007			
Maize	*Zea mays* L.	IR + HT	BT11 × MIR604 × GA21	Syngenta Seeds	2007	2010	2010	2010
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2005	2006		2007
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2006		2006
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	1999			1999
Maize	*Zea mays* L.	HT	DLL25 (B16)	DeKalb Genetics Corporation	1999	2000		1999
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2010	2010	2010	2010
Maize	*Zea mays* L.	VR+IR+HT	Event 3272 × BT11 × MIR 604 × GA21	Syngenta Seeds	2010			
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.				2007
Maize	*Zea mays* L.	HT + IR	GA21 × MON810	Monsanto Company	2003	2003		
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2007	2007		
Maize	*Zea mays* L.	Lys + IR	LY038 × MON810	Monsanto Company	2007	2007		2007
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds			2007	2007
Maize	*Zea mays* L.	IR + HT	MIR 604 × GA21	Syngenta Seeds	2007	2007	2007	2007
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2010	2010	2010	2010
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	IR + HT	MON802	Monsanto Company				1997
Maize	*Zea mays* L.	IR + HT	MON809	Pioneer Hi-Bred International Inc.		1998		1997
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1997	1997		1996
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2005			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2002	2003		
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2004	2004		2004
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2004	2004		2004
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2004	2004		2004
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006	2006		2006
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2007	2008	2008	2008
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2008	2009		
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2009	2009		2009
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × NK603	Monsanto Company & Mycogen Seeds c/o Dow AgroSciences LLC	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2004	2004		2004
Maize	*Zea mays* L.	HT	NK603 × T 25	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	T14	Bayer CropScience	1997	2001		2006
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2001	2003		2004
Maize	*Zea mays* L.	IR + HT	TC 1507 × 59122 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2011	2011	2011	2011
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2002	2002		2002
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2005		
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS-59122 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2006		2006
Maize	*Zea mays* L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2011	2011	2011	
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2005		2005
Maize	*Zea mays* L.	IR + HT	TC6275	Dow AgroSciences LLC	2007	2008		
Papaya	*Carica papaya*	VR	55-1/63-1	Cornell University	2010			
Potato	*Solanum tuberosum* L.	IR	ATBT04-6, ATBT04-27, ATBT04-30	Monsanto Company	1997			
Potato	*Solanum tuberosum* L.	IR	BT06 (RBBT06)	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	1996			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	2003			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	2003			

JAPAN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	2003			
Potato	*Solanum tuberosum* L.	IR	SPBT02-5	Monsanto Company	2001			
Rice	*Oryza sativa* L.	CPP	10	National Institute of Agrobiological Sciences (NIAS)				2007
Rice	*Oryza sativa* L.	CPP	7Crp#242-95-7	National Institute of Agrobiological Sciences (NIAS)				2007
Rose	*Rosa hybrida*	Flav Path	IFD-524Ø1-4	Suntory Limited			2008	2008
Rose	*Rosa hybrida*	Flav Path	IFD-529Ø1-9	Suntory Limited			2008	2008
Soybean	*Glycine max* L.	OC	260-05 (G94-1, G94-19, G168)	DuPont Canada Agricultural Products	2007			
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2002	2003		1999
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2003	2006		2006
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2009	2009		2009
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2009	2009		2009
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1996	1996		1996
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2007	2008	2008	2008
Sugarbeet	*Beta vulgaris*	HT	GTS B77	Monsanto Company	2003			
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2003	2007	2007	
Sugarbeet	*Beta vulgaris*	HT	T120-7	Bayer CropScience	2001	2003		
Tomato	*Lycopersicon esculentum*	DR	FLAVR-SAVR	Calgene Inc.	1997			

KOREA, REP.								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	2005			2005
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	2005			
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	2005			
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	2003	2005		
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	2005			2005
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	2005			
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 × 3006-210-23	Dow AgroSciences LLC	2005	2008		
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON1445	Dow AgroSciences LLC	2006			
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON88913	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2008		
Cotton	*Gossypium hirsutum* L.	IR	757	Monsanto Company	2003			2004
Cotton	*Gossypium hirsutum* L.	HT + HT	ACS-GH00103-3 × BCS-GH002-5	Bayer CropScience		2011		
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience		2010		
Cotton	*Gossypium hirsutum* L.	HT + IR	GHB614 × LL Cotton 25 × MON 15985	Bayer CropScience		2011		
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2005	2006		
Cotton	*Gossypium hirsutum* L.	HT + IR	LLCotton25 × MON15985	Bayer CropScience	2007	2008		
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2003	2004		
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2003	2004		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2004	2008		
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2003			
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2008	2008		
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	2003	2004		
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2006			
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company	2006	2008		
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2005		
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2003	2006		
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2003	2006		
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2006	2008		
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2011			
Maize	*Zea mays* L.	IR + HT	BT11 × MIR162 × MIR 604 × GA21	Syngenta Seeds	2010	2011		
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR + HT	BT11 × MIR604 × GA21	Syngenta Seeds	2008			2008

KOREA, REP.								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2008	2008		
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006			
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	2004			
Maize	*Zea mays* L.	HT	DLL25 (B16)	DeKalb Genetics Corporation	2004			
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2011	2011		
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.		2010		
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2010	2005		
Maize	*Zea mays* L.	HT + IR	GA21 × MON810	Monsanto Company	2004			
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2007	2008		
Maize	*Zea mays* L.	IR + HT	MIR 604 × GA21	Syngenta Seeds	2007	2008		
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds		2010		
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2010	2009		
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2002			
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2006			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003			2004
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2004			
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2004			
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2004			
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006			
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2009	2009		
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × NK603	Monsanto Company & Mycogen Seeds c/o Dow AgroSciences LLC	2010	2011		
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2002			2004
Maize	*Zea mays* L.	HT + IR	NK603 x MON810	Monsanto Company	2004			
Maize	*Zea mays* L.	HT	NK603 × T 25	Monsanto Company	2010	2011	2010	
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2003			2004
Maize	*Zea mays* L.	IR + HT	TC 1507 × 59122 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.		2010		
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2002	2004		
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.		2010		
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2004			
Potato	*Solanum tuberosum* L.	IR	ATBT04-6, ATBT04-27, ATBT04-30	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR	BT06 (RBBT06)	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	2004			
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	2004			
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2009	2009		
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience		2011		
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2010	2009		
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2002	2004		
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2009	2009		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2006			

MALAYSIA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1998	1998	1998	

MALAYSIA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	1998	1998	1998	
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	1998	1998	1998	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1997	1997	1997	

MEXICO

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101	Monsanto Company	2005			
Alfalfa	*Medicago sativa*	HT	J101 × J163	Monsanto Company	2010	2010		
Alfalfa	*Medicago sativa*	HT	J163	Monsanto Company	2005	2005		
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	2004	2004		
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	1996	1996		
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	2001			
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	1999			
Cotton	*Gossypium hirsutum* L.	IR	281-24-236	Dow AgroSciences LLC	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 × 3006-210-23	Dow AgroSciences LLC	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	3006-210-23	Dow AgroSciences LLC	2004	2004		
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON1445	Dow AgroSciences LLC	2005	2005		
Cotton	*Gossypium hirsutum* L.	HT + IR	3006-210-23 × 281-24-236 × MON88913	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Cotton	*Gossypium hirsutum* L.	HT + HT	ACS-GH00103-3 × BCS-GH002-5	Bayer CropScience	2010	2010		
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2009	2009		
Cotton	*Gossypium hirsutum* L.	HT	BXN	Calgene Inc.	1996	1996		
Cotton	*Gossypium hirsutum* L.	IR	COT102	Syngenta Seeds	2010	2010		
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2006	2006		
Cotton	*Gossypium hirsutum* L.	HT + IR	LLCotton25 × MON15985	Bayer CropScience	2008	2008		
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2003	2003		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2006	2006		
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	1996	1996		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2002	2002		
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	1997	1997		1997
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2008	2008		2011
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2004	2004		
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR + HT	BT11 × MIR604 × GA21	Syngenta Seeds	2008	2008		
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2006	2006		
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2008	2008		
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.	2009	2009		
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2002	2002		
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2007			
Maize	*Zea mays* L.	Lys + IR	LY038 × MON810	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR + HT	MIR 604 × GA21	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2010	2010		
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2010	2010		
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2002			
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003			

MEXICO								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2004	2006		
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2004			
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2010	2010		
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2010	2010		
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2002			
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2004			
Maize	*Zea mays* L.	HT	T14	Bayer CropScience	2007	2007		
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2007	2007		
Maize	*Zea mays* L.	IR + HT	TC 1507 × 59122 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2003			
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006			
Maize	*Zea mays* L.	IR + HT	TC1507 × MON 810	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2004	2004		2011
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	1996	1996		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	2001	2001		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	2001	2001		
Rice	*Oryza sativa* L.	HT	LLRICE06, LLRICE62	Aventis CropScience	2007	2007		
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2003	2003		
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2003	2003		
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2009	2009		
Soybean	*Glycine max* L.	OC + HT	DP305423 × GTS40-30-2	Pioneer Hi-Bred International Inc.	2010	2010		
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2008	2008		
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1998	1998		1998
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2008	2008		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2006	2006		
Tomato	*Lycopersicon esculentum*	DR	1345-4	DNA Plant Technology Corporation	1998	1998		
Tomato	*Lycopersicon esculentum*	DR	B, Da, F	Zeneca Seeds	1996	1996		
Tomato	*Lycopersicon esculentum*	DR	FLAVR-SAVR	Calgene Inc.	1995	1995		1995

MYANMAR								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	Silver Six	Cotton and Sericulture Department	2006	2006		2006

NETHERLANDS								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1997	1997		

NEW ZEALAND								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101 × J163	Monsanto Company	2007			
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	2002			
Argentine Canola	*Brassica napus*	HT	OXY-235	Aventis CropScience	2002			
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	2002			

NEW ZEALAND								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	2002			
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	2002			
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	2002			
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	2002			
Cotton	*Gossypium hirsutum* L.	HT	BXN	Calgene Inc.	2002			
Cotton	*Gossypium hirsutum* L.	IR	COT102	Syngenta Seeds	2005			
Cotton	*Gossypium hirsutum* L.	IR + HT	GHB119	Bayer CropScience	2011		2011	
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2006			
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2000			
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2002			
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	2000			
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2006			
Cotton	*Gossypium hirsutum* L.	IR	T304-40	Bayer CropScience	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005			
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2001			
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2001			
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006	2006	
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	2002			
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2008	2008	2008	
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2000			
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2006			
Maize	*Zea mays* L.	DT	MON 87460	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2000			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003			
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006			
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2008	2008		
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2002			
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2002			
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2003			
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	2001			
Potato	*Solanum tuberosum* L.	IR	SPBT02-5	Monsanto Company	2001			
Rice	*Oryza sativa* L.	HT	LLRICE06, LLRICE62	Aventis CropScience	2010	2010		
Soybean	*Glycine max* L.	OC	260-05 (G94-1, G94-19, G168)	DuPont Canada Agricultural Products	2000			
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2004			
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2010	2010		
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2010	2010	2010	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2000			
Soybean	*Glycine max* L.	OC + HT	MON 87705	Monsanto Company	2011			
Soybean	*Glycine max* L.	IR	MON87701	Monsanto Company	2010	2010	2010	
Sugarbeet	*Beta vulgaris*	HT	GTS B77	Monsanto Company	2002			
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2005			

PAKISTAN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2010	2010	2010	2010

PARAGUAY								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2011	2011		2011
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2004	2004		2004

PHILIPPINES								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101	Monsanto Company	2006	2006		
Alfalfa	*Medicago sativa*	HT	J163	Monsanto Company	2006	2006		
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	2003	2003		
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2003	2003		
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2003	2003		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	MON531	Monsanto Company	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2004	2004		
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	2004	2004		
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2005	2005		2011
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2003	2003		2005
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2003	2003		
Maize	*Zea mays* L.	IR + HT	Bt11 × DAS 59122-7 × MIR604 × TC1507 × GA21	Syngenta Seeds	2011	2011		
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2007	2007		2010
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	IR + HT	BT11 × MIR162 × MIR 604 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR + HT	BT11 × MIR604 × GA21	Syngenta Seeds	2008	2008		
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2007	2007		
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	2003	2003		
Maize	*Zea mays* L.	HT	DLL25 (B16)	DeKalb Genetics Corporation	2003	2003		
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2008	2008		
Maize	*Zea mays* L.	VR+IR+HT	Event 3272 × BT11 × MIR 604 × GA21	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2009	2009		2009
Maize	*Zea mays* L.	HT + IR	GA21 × MON810	Monsanto Company	2004	2004		
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	Lys + IR	LY038 × MON810	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR + HT	MIR 604 × GA21	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2010	2010		
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2009	2009		2011
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2002	2002		2002
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003	2003		
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2004	2004		
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2005	2004		
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2004			
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2009	2009		2010

PHILIPPINES

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2009	2009		
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2010	2010	2010	
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2003	2003		2005
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	NK603 × T 25	Monsanto Company	2010	2010	2010	
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2003	2003		
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006		
Potato	*Solanum tuberosum* L.	IR	ATBT04-6, ATBT04-27, ATBT04-30	Monsanto Company	2003	2003		
Potato	*Solanum tuberosum* L.	IR	BT06 (RBBT06)	Monsanto Company	2003	2003		
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	2003	2003		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	2003	2003		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	2004	2004		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	2004	2004		
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	2004	2004		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	2003	2003		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	2003	2003		
Potato	*Solanum tuberosum* L.	IR	SPBT02-5	Monsanto Company	2003	2003		
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2009	2009		
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2011	2011	2011	
Soybean	*Glycine max* L.	HT	BPS-CV127-9	BASF and EMBRAPA	2010	2010	2010	
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2009	2009	2010	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2003	2003		
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2007	2007		
Sugarbeet	*Beta vulgaris*	HT	GTS B77	Monsanto Company	2004	2004		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2005	2005		

POLAND

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2007	2007		2007

PORTUGAL

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1999	1999		2007

ROMANIA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company				2007

RUSSIAN FEDERATION

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2003			
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2010			
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2000	2003		
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2007	2008		
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2011			
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2000	2003		
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003	2003		
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2007	2008		
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2002	2003		

RUSSIAN FEDERATION								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2001			
Potato	*Solanum tuberosum* L.	IR	1210 amk	Centre Bioengineering RAS, Russia	2006			
Potato	*Solanum tuberosum* L.	IR	2904/1 kgs	Centre Bioengineering RAS, Russia	2005			
Rice	*Oryza sativa* L.	HT	LLRICE06, LLRICE62	Aventis CropScience	2003			
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2002			
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2002			
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1999			
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2010			
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2006			

SINGAPORE								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2007			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2006	2006		
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2006	2006		
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2007	2007		

SLOVAK REPUBLIC								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2007	2007		2007

SOUTH AFRICA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	2001	2001		
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	2001			
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	2001	2001		
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	2001	2001		
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	2000	2000		2000
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2003	2003		2003
Cotton	*Gossypium hirsutum* L.	IR + HT	MON531 × MON1445	Monsanto Company	2005	2005	2005	
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	1997	1997		1997
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2007	2007		2007
Cotton	*Gossypium hirsutum* L.	HT + IR	MON88913 × MON15985	Monsanto Company	2007	2007		2007
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2002	2002		2003
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2001	2001		
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT + IR	GA21 × MON810	Monsanto Company	2003	2003		
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1997	1997		1997
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2002	2002		2002
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2004	2004		2007
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2002	2002		
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2001	2001		
Soybean	Glycine max L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2001	2001		2001

SPAIN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2003	2003		2003
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2004	2004	2004	

SWEDEN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Potato	*Solanum tuberosum* L.	Plt Quality	EH92-527-1	BASF Plant Science Company GmbH		2010	2010	2010

SWITZERLAND								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	1998	1998		
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1997	1997		
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2000	2000		
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1996	1996		

TAIWAN								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2005	2005	2005	
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2004	2004	2004	
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	2004		2004	
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2009	2009	2009	
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2011	2011	2011	
Maize	*Zea mays* L.	IR + HT	Bt11 × MIR 162 × TC1507 × GA21	Syngenta Seeds	2011	2011	2011	
Maize	*Zea mays* L.	IR + HT	BT11 × MIR162 × MIR 604 × GA21	Syngenta Seeds	2011	2011	2011	
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	BT11 × MIR604 × GA21	Syngenta Seeds	2009	2009	2009	
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	2003			
Maize	*Zea mays* L.	HT	DLL25 (B16)	DeKalb Genetics Corporation	2003			
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2010	2010	2010	
Maize	*Zea mays* L.	VR+IR+HT	Event 3272 × BT11 × MIR 604 × GA21	Syngenta Seeds	2011	2011	2011	
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	2003	2003	2003	
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds	2007	2007	2007	
Maize	*Zea mays* L.	IR + HT	MIR 604 × GA21	Syngenta Seeds	2009	2009	2009	
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2002	2002	2002	
Maize	*Zea mays* L.	HT + IR	MON810 x MON88017	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2003	2003	2003	
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	2006	2006	2006	
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2008	2008	2008	
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × x NK603	Monsanto Company & Mycogen Seeds c/o Dow AgroSciences LLC	2011	2011	2011	
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2003	2003	2003	
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	HT	NK603 × T 25	Monsanto Company	2011	2011	2011	
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	2002	2002	2002	
Maize	Zea mays L.	IR + HT	TC 1507 × 59122 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2011	2011	2011	
Maize	Zea mays L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2003	2003		
Maize	Zea mays L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2009	2009		
Maize	Zea mays L.	HT + IR	TC1507 × DAS-59122 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2009	2009		
Maize	Zea mays L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2011	2011	2011	
Maize	Zea mays L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2009	2009	2009	
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	2007	2007	2007	

TAIWAN

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	2010	2010	2010	
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2010	2010	2010	
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2009	2009	2009	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2002	2002	2002	
Soybean	*Glycine max* L.	IR	MON87701	Monsanto Company	2011	2011	2011	
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2007	2007	2007	

THAILAND

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2000	2000		
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	2000	2000		

TURKEY

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))		2011	2011	
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company		2011	2011	
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company		2011	2011	

UNITED KINGDOM

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	1998	1998		
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1997			
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1996	1996		

UNITED STATES OF AMERICA

Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Alfalfa	*Medicago sativa*	HT	J101	Monsanto Company	2004	2004		2005
Alfalfa	*Medicago sativa*	HT	J163	Monsanto Company	2004	2004		2005
Argentine Canola	*Brassica napus*	OC	23-18-17, 23-198	Calgene Inc.	1994	1994		1994
Argentine Canola	*Brassica napus*	HT	GT200 (RT200)	Monsanto Company	2002	2002		2003
Argentine Canola	*Brassica napus*	HT	HCN10	Aventis CropScience	1995	1995		1995
Argentine Canola	*Brassica napus*	HT + F	MS8 × RF3	Bayer CropScience (Aventis CropScience(AgrEvo))	1994	1994		1994
Argentine Canola	*Brassica napus*	HT	OXY-235	Aventis CropScience	1999			
Argentine Canola	*Brassica napus*	HT + F	PGS1 (MS1(B91-4) × RF1(B93-101))	Bayer CropScience (Aventis CropScience(AgrEvo))	1996	1996		2002
Argentine Canola	*Brassica napus*	HT + F	PGS2 (MS1 × RF2) (B91-4 × B94-2)	Aventis CropScience	1996	1996		2002
Argentine Canola	*Brassica napus*	HT	RT73 (GT73)	Monsanto Company	1995	1995		1999
Argentine Canola	*Brassica napus*	HT	T45 (HCN28)	Bayer CropScience	1998	1998		1998
Argentine Canola	*Brassica napus*	HT	Topas 19/2, HCN92	Bayer CropScience (Aventis CropScience(AgrEvo))	1995			2002
Chicory	*Cichorium intybus*	HT + F	RM3-3, RM3-4, RM3-6	Bejo Zaden BV	1997	1997		1997
Cotton	*Gossypium hirsutum* L.	HT	19-51A	DuPont Canada Agricultural Products	1996	1996		1996
Cotton	*Gossypium hirsutum* L.	IR	281-24-236	Dow AgroSciences LLC	2004	2004		2004
Cotton	*Gossypium hirsutum* L.	IR	281-24-236 x 3006-210-23	Dow AgroSciences LLC	2004	2004		2004
Cotton	*Gossypium hirsutum* L.	IR	3006-210-23	Dow AgroSciences LLC	2004	2004		2004
Cotton	*Gossypium hirsutum* L.	HT + IR	31807/31808	Calgene Inc.	1998	1998		1997
Cotton	*Gossypium hirsutum* L.	HT	BCS-GHØØ2-5 (GHB614)	Bayer CropScience	2009	2009		2009
Cotton	*Gossypium hirsutum* L.	HT	BXN	Calgene Inc.	1994	1994		1994
Cotton	*Gossypium hirsutum* L.	IR	COT102	Syngenta Seeds	2005	2005		2011
Cotton	*Gossypium hirsutum* L.	IR	COT67B	Syngenta Seeds	2009			2011
Cotton	*Gossypium hirsutum* L.	HT	LLCotton25	Bayer CropScience	2003	2003		2003
Cotton	*Gossypium hirsutum* L.	HT	MON1445	Monsanto Company	1995	1995		1995

UNITED STATES OF AMERICA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Cotton	*Gossypium hirsutum* L.	IR	MON15985	Monsanto Company	2002			2002
Cotton	*Gossypium hirsutum* L.	IR + HT	MON15985 × MON1445	Monsanto Company	2004	2004	2004	
Cotton	*Gossypium hirsutum* L.	IR	MON531/757/1076	Monsanto Company	1995	1995		1995
Cotton	*Gossypium hirsutum* L.	HT	MON88913	Monsanto Company	2005	2005		2004
Creeping Bentgrass	*Agrostis stolonifera*	HT	ASR368	Scotts Seeds		2003		
Flax, Linseed	*Linum usitatissumum* L.	HT	FP967	University of Saskatchewan	1998	1998		1999
Maize	*Zea mays* L.	HT + IR	59122	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2004	2004		2005
Maize	*Zea mays* L.	MS+HT	676, 678, 680	Pioneer Hi-Bred International Inc.	1998	1998		1998
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	1996	1996		1996
Maize	*Zea mays* L.	IR	BT 176	Syngenta Seeds	1995	1995		1995
Maize	*Zea mays* L.	IR + HT	Bt11 × DAS 59122-7 × MIR604 × TC1507 × GA21	Syngenta Seeds	2011	2011		
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds	2007	2007	2007	2007
Maize	*Zea mays* L.	HT + IR	BT11 × MIR 162 × GA21	Syngenta Seeds	2010	2010		
Maize	*Zea mays* L.	IR + HT	Bt11 × MIR 162 × MIR 604 × TC1507 × GA21	Syngenta Seeds				2011
Maize	*Zea mays* L.	IR + HT	BT11 × MIR162 × MIR 604 × GA21	Syngenta Seeds	2010	2010		
Maize	*Zea mays* L.	IR + HT	Bt11 × MIR162 × MIR604	Syngenta Seeds	2009	2009		2009
Maize	*Zea mays* L.	HT + IR	BT11 × MIR604	Syngenta Seeds	2007	2007	2007	
Maize	*Zea mays* L.	IR + HT	CBH-351	Aventis CropScience		1998		1998
Maize	*Zea mays* L.	HT + IR	DAS 59122 × TC1507 × NK603	Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	HT + IR	DAS-59122-7 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006	2006	
Maize	*Zea mays* L.	HT + IR	DBT418	DeKalb Genetics Corporation	1997	1997		1997
Maize	*Zea mays* L.	HT	DLL25 (B16)	DeKalb Genetics Corporation	1996	1996		1995
Maize	*Zea mays* L.	MS	DP32138-1/2	Pioneer Hi-Bred International Inc.				2011
Maize	*Zea mays* L.	Plt Quality	Event 3272	Syngenta Seeds	2007	2007		
Maize	*Zea mays* L.	VR+IR+HT	Event 3272 × BT11 × MIR 604 × GA21	Syngenta Seeds	2010	2010		
Maize	*Zea mays* L.	HT + HT	Event 98140	Pioneer Hi-Bred International Inc.	2008	2008		
Maize	*Zea mays* L.	HT	GA21	Monsanto Company	1996			1997
Maize	*Zea mays* L.	HT + IR	GA21 x MON810	Monsanto Company	2003	2003	2003	
Maize	*Zea mays* L.	Lys	LY038	Monsanto Company	2005	2005		2006
Maize	*Zea mays* L.	Lys + IR	LY038 x MON810	Monsanto Company	2006	2006	2006	
Maize	*Zea mays* L.	IR	MIR 604	Syngenta Seeds			2007	2007
Maize	*Zea mays* L.	IR	MIR162	Syngenta Seeds	2008	2008		
Maize	*Zea mays* L.	IR + HT	MON 89034 × DAS1507-1 × DAS 59122-7	Monsanto Company	2009	2009		2009
Maize	*Zea mays* L.	IR + HT	MON 89034 × NK603	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR	MON80100	Monsanto Company	1996	1996		1995
Maize	*Zea mays* L.	IR + HT	MON802	Monsanto Company	1996	1996		1997
Maize	*Zea mays* L.	IR + HT	MON809	Pioneer Hi-Bred International Inc.	1996	1996		1996
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	1996	1996		1995
Maize	*Zea mays* L.	HT + IR	MON810 × MON88017	Monsanto Company	2006	2006	2006	
Maize	*Zea mays* L.	HT	MON832	Monsanto Company	1996			
Maize	*Zea mays* L.	IR	MON863	Monsanto Company	2001	2001		
Maize	*Zea mays* L.	IR	MON863 × MON810	Monsanto Company	2004	2004	2004	2004
Maize	*Zea mays* L.	HT + IR	MON863 × MON810 × NK603	Monsanto Company	2004	2004	2004	
Maize	*Zea mays* L.	HT + IR	MON863 × NK603	Monsanto Company	2004	2004	2004	
Maize	*Zea mays* L.	HT + IR	MON88017	Monsanto Company	1996	1996		1995
Maize	*Zea mays* L.	IR	MON89034	Monsanto Company	2007	2008	2008	2008
Maize	*Zea mays* L.	IR + HT	MON89034 × MON88017	Monsanto Company	2009	2009	2009	
Maize	*Zea mays* L.	IR + HT	MON89034 × TC1507 × MON88017 × DAS-59122-7	Dow AgroSciences LLC	2009	2009		2009
Maize	*Zea mays* L.	HT + F	MS3	Bayer CropScience (Aventis CropScience(AgrEvo))	1996	1996		1996
Maize	*Zea mays* L.	HT + F	MS6	Bayer CropScience (Aventis CropScience(AgrEvo))	2000	2000		1999
Maize	*Zea mays* L.	HT	NK603	Monsanto Company	2000	2000		2000

UNITED STATES OF AMERICA								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company	2001	2001	2001	2001
Maize	*Zea mays* L.	HT	NK603 × T 25	Monsanto Company	2010	2010	2010	2010
Maize	*Zea mays* L.	HT	T14	Bayer CropScience	1995	1995		1995
Maize	*Zea mays* L.	HT	T25	Bayer CropScience (Aventis CropScience(AgrEvo))	1995	1995		1995
Maize	*Zea mays* L.	IR + HT	TC 1507 × 59122 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)	2001	2001		2001
Maize	*Zea mays* L.	HT + IR	TC1507 × DAS 59122-7	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2007	2007	2007	
Maize	*Zea mays* L.	IR + HT	TC1507 × MON 810	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010		
Maize	*Zea mays* L.	IR + HT	TC1507 × MON810 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2010	2010	2010	
Maize	*Zea mays* L.	HT + IR	TC1507 × NK603	Dow AgroSciences LLC and Pioneer Hi-Bred International Inc.	2006	2006	2006	
Maize	*Zea mays* L.	IR + HT	TC6275	Dow AgroSciences LLC	2004	2004		2004
Melon	*Cucumis melo*	DR	A, B	Agritope Inc.	1999			
Papaya	*Carica papaya*	VR	55-1/63-1	Cornell University	1997	1997		1996
Papaya	*Carica papaya*	VR	UFL-X17CP-6 (X17-2)	University of Florida	2008	2008		2009
Plum	*Prunus domestica*	VR	ARS-PLMC5-6	United States Department of Agriculture - Agricultural Research Service	2009	2009	2007	2007
Potato	*Solanum tuberosum* L.	IR	ATBT04-6, ATBT04-27, ATBT04-30	Monsanto Company	1996	1996		1996
Potato	*Solanum tuberosum* L.	IR	BT06 (RBBT06)	Monsanto Company	1994			1995
Potato	*Solanum tuberosum* L.	IR	BT6, BT10, BT12, BT16, BT17, BT18, BT23	Monsanto Company	1994	1994		1995
Potato	*Solanum tuberosum* L.	IR + VR	RBMT15-101	Monsanto Company	1998	1998		1999
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-129	Monsanto Company	1998	1998		1998
Potato	*Solanum tuberosum* L.	IR + VR	RBMT21-350	Monsanto Company	1998	1998		1998
Potato	*Solanum tuberosum* L.	IR + VR	RBMT22-82	Monsanto Company	1998	1998		1998
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-02	Monsanto Company	1998	1998		1999
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-07	Monsanto Company	2000	2000		
Potato	*Solanum tuberosum* L.	IR + VR	SEMT15-15	Monsanto Company	1998	1998		1999
Potato	*Solanum tuberosum* L.	IR	SPBT02-5	Monsanto Company	1996	1996		1996
Rice	*Oryza sativa* L.	HT	LLRICE06, LLRICE62	Aventis CropScience	2000	2000		1999
Rice	*Oryza sativa* L.	HT	LLRICE601	Bayer CropScience				2006
Soybean	*Glycine max* L.	OC	260-05 (G94-1, G94-19, G168)	DuPont Canada Agricultural Products	1997	1997		1997
Soybean	*Glycine max* L.	HT	A2704-12	Bayer CropScience (Aventis CropScience(AgrEvo))	1998	1998		1996
Soybean	*Glycine max* L.	HT	A5547-127	Bayer CropScience	1998	1998		1998
Soybean	*Glycine max* L.	OC + HT	DP-305423	DuPont Canada Agricultural Products	2009	2009		2010
Soybean	*Glycine max* L.	HT	DP356043	Pioneer Hi-Bred International Inc.	2007	2007	2008	2008
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1994	1994		1994
Soybean	*Glycine max* L.	HT	GU262	Bayer CropScience	1998	1998		1998
Soybean	*Glycine max* L.	OC + HT	MON 87705	Monsanto Company	2011	2011		
Soybean	*Glycine max* L.	IR	MON87701	Monsanto Company	2010	2010	2010	2011
Soybean	*Glycine max* L.	HT	MON89788	Monsanto Company	2007	2007	2007	2007
Soybean	*Glycine max* L.	HT	W62, W98	Bayer CropScience	1998	1998		1996
Squash	*Cucurbita pepo*	VR	CZW-3	Asgrow (USA) - Seminis Vegetable Inc. (Canada)	1994	1994		1996
Squash	*Cucurbita pepo*	VR	ZW20	Asgrow (USA) - Seminis Vegetable Inc. (Canada)	1997	1997		1994
Sugarbeet	*Beta vulgaris*	HT	GTS B77	Monsanto Company	1998	1998		1998
Sugarbeet	*Beta vulgaris*	HT	H7-1	Monsanto Company	2004	2004		2005
Sugarbeet	*Beta vulgaris*	HT	T120-7	Bayer CropScience	1998	1998		1998
Tobacco	*Nicotiana tabacum* L.	NIC	Vector 21-41	Vector Tobacco Inc.				2002
Tomato	*Lycopersicon esculentum*	DR	1345-4	DNA Plant Technology Corporation	1994	1994		1995
Tomato	*Lycopersicon esculentum*	DR	35-1-N	Agritope Inc.	1996	1996		1996
Tomato	*Lycopersicon esculentum*	IR	5345	Monsanto Company	1998	1998		1998
Tomato	*Lycopersicon esculentum*	DR	8338	Monsanto Company	1994	1994		1995
Tomato	*Lycopersicon esculentum*	DR	B, Da, F	Zeneca Seeds	1994	1994		1995
Wheat	*Triticum aestivum*	HT	MON-71800	Monsanto Company	2004	2004		

URUGUAY								
Crop	Latin Name	Trait	Event	Developer	Food	Feed	Direct Use	Planting
Maize	*Zea mays* L.	HT + IR	BT 11 (X4334CBR, X4734CBR)	Syngenta Seeds	2004	2004		2004
Maize	*Zea mays* L.	HT + IR	BT11 × GA21	Syngenta Seeds				2011
Maize	*Zea mays* L.	HT	GA21	Monsanto Company				2011
Maize	*Zea mays* L.	IR	MON810	Monsanto Company	2003	2003		2003
Maize	*Zea mays* L.	HT	NK603	Monsanto Company				2011
Maize	*Zea mays* L.	HT + IR	NK603 × MON810	Monsanto Company				2011
Maize	*Zea mays* L.	HT + IR	TC1507	Mycogen (Dow AgroSciences) - Pioneer (DuPont)				2011
Soybean	*Glycine max* L.	HT	GTS 40-3-2 (40-3-2)	Monsanto Company	1996	1996		1996

Appendix 2

Global Crop Protection Market

Table 1. Global Crop Protection Market, 2010

$M	Herbicides	Inscticides	Fungicides	Others	Biotech	Total
North America	5,915	1,694	1,142	440	9,281	18,472
West Europe	3,106	1,170	3,080	649	21	8,026
East Europe	653	442	407	89	3	1,594
Japan	1,207	1,317	1,049	125	0	3,698
Industrial Countries	**10,881**	**4,623**	**5,678**	**1,303**	**9,305**	**31,790**
Latin America	4,003	2,639	2,689	376	1,516	11,223
Rest of Far East	2,066	2,281	1,689	181	380	6,597
Rest of World	647	1,499	509	96	579	3,330
Developing Countries	**6,716**	**6,419**	**4,887**	**653**	**2,475**	**21,150**
Total	**17,597**	**11,042**	**10,565**	**1,956**	**11,780**	**52,940**

Appendix 3

Useful Tables and Charts on the International Seed Trade

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Table 1. Seed Exports (FOB) of Selected Countries, 2009 (with over 100 Million US$ Market)*

Country	Field Crops	Vegetable Crops	Total
Netherlands	241	1,058	1,299
USA	746	432	1,178
France	884	278	1,162
Germany	458	48	506
Chile	261	109	370
Canada	273	82	355
Mexico	244	11	255
Hungary	221	14	235
Denmark	168	55	223
Italy	123	94	217
Argentina	163	9	172
Belgium	160	4	164
China	72	68	140
Austria	115	3	118
Japan	30	87	117
Spain	62	47	109
Others	699	351	1,050
Total	**4,920**	**2,750**	**7,670**

Table 2. Seed Imports (FOB) of Selected Countries, 2009 (with over 100 Million US$ Market)**

Country	Field Crops	Vegetable Crops	Total
USA	447	300	747
France	590	107	697
Netherlands	282	310	592
Germany	457	72	529
Mexico	270	173	443
Spain	198	198	396
Italy	186	162	348
Canada	223	59	282
Russian Federation	210	45	255
Ukraine	182	24	206
United Kingdom	126	73	199
Belgium	160	31	191
Japan	92	78	170
China	76	73	149
Romania	124	14	138
Turkey	53	72	125
Poland	78	44	122
Austria	91	14	105
Hungary	84	17	101
Others	1,096	742	1,838
Total	**5,025**	**2,608**	**7,633**

Source: International Seed Federation, 2010
*http://www.worldseed.org/cms/medias/file/ResourceCenter/SeedStatistics/SeedExports/Seed_Exports_2009.pdf
**http://www.worldseed.org/cms/medias/file/ResourceCenter/SeedStatistics/SeedImports/Seed_Imports_2009.pdf

Appendix 4

Deployment of Approved Bt Cotton Events/Hybrids/Variety by Companies/Institutions in India

Table 1. Deployment of Approved Bt Cotton Events/Hybrids/Variety by Companies/Institutions in India, 2002 to 2011

Event	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
NORTH ZONE Haryana Punjab Rajasthan				6 Hybrids 1 Event 3 Companies	14 Hybrids 3 Events 6 Companies	32 Hybrids 4 Events 14 Companies	62 Hybrids 4 Events 15 Companies	64 Hybrids 5 Events 26 Companies	271 Hybrids 5 Events 31 Companies	279 Hybrids 5 Events 34 Companies
CENTRAL ZONE Gujarat Madhya Pradesh Maharashtra	3 Hybrids	3 Hybrids	4 Hybrids	12 hybrids 1 Event 4 Companies	36 Hybrids 4 Events 15 Companies	84 Hybrids 4 Events 23 Companies	148 Hybrids 4 Events 27 Companies	296 Hybrids 6 Events 35 Companies	459 Hybrids 6 Events 35 Companies	549 Hybrids 6 Events 40 Companies
SOUTH ZONE Andhra Pradesh Karnataka Tamil Nadu	3 Hybrids	3 Hybrids	4 Hybrids	9 Hybrids 1 Event 3 Companies	31 hybrids 4 Events 13 Companies	70 Hybrids 4 Events 22 Companies	149 Hybrids 4 Events 27 Companies	294 Hybrids 6 Events 35 Companies	444 Hybrids 6 Events 35 Companies	488 Hybrids 6 Events 37 Companies
Summary										
Total no. of hybrids	3	3	4	20	62	131	274	522*	780	884*
Total no. of events	1	1	1	1	4	4	4	6	6	6
Total no. of companies	1	1	1	3	15	24	30	35	35	40

* Some of the 884 hybrids including a variety are being grown in multiple regions (see Figure 5)
Source: Compiled by ISAAA, 2011.

Appendix 5

Listing of Events, Bt Cotton Variety and Hybrids in India

Table 1. Listing of events, Bt cotton variety and hybrids in India, 2011

Zone	BG-I Hybrids	BG-II Hybrids	GFM/Event-I/MLS-9124/BNLA-601
North Zone (279 Hybrids 5 Events, 34 Companies)	ABCH 223 Bt, ABCH 224 Bt, ABCH 225Bt, ABCH 226Bt, ABCH 227Bt, ABCH 228 Bt, ABCH 229Bt, ABCH 230Bt, ABCH 231Bt, ABCH-232 Bt, ABCH-235 Bt, ABCH-3083 Bt, ABCH-3483 Bt, ABCH-1857 Bt, ABCH-172 Bt, ABCH-173 Bt, ABCH-174 Bt, ABCH-177 Bt, ABCH-178 Bt, Ankur 3028 Bt, Ankur 8120 Bt, Ankur-651, Ankur-2226, Ankur-2534, GK-206, IT-905, Jai Bt, KDCHH-553 BGI, KSCH-201 Bt, KSCH-204 Bt, KDCHH-507 BG-I, KDCHH-9810, MRC-6025, MRC-6029, MRC-6301, MRC-6304, NAMCOT-402, NCS-138, NCS-913, NCS-950, NCS-901 Bt, NCS-902 Bt, NCS-903 Bt, NCS-904 Bt, NCS-905 Bt, Ole, SP504B1 BGI, NCS 1915 Bt, NCS 1916 Bt, PCH-1414 Bt, PRCH-721Bt, PRCH-722 Bt, PCH 401 Bt, PCH 402 Bt, PCH 403 Bt, PCH-406 Bt, RCH-134, RCH-308, RCH-314, RCH-317, SDS-9, SDS-1368, Shakti-9 Bt, Sigma, SP 7007 B1, VBCH-1006 BG, VBCH-1008 BG, VICH-11 BG, 6317 Bt, 6488 Bt	ABCH 243 Bt, ABCH 244 Bt, ABCH 245Bt, ABCH 246Bt, ABCH 247Bt, ABCH 248 Bt, ABCH 251Bt, ABCH 252Bt, ABCH 254Bt, ABCH-256 Bt, ABCH-1299 Bt (BG-II), ABCH-2099 Bt (BG-II), ABCH-4899 Bt (BG-II), ABCH-7399 Bt (BG-II), ABCH-143 Bt (BG-II), ABCH-146 Bt (BG-II), ABCH-181 Bt (BG-II), ABCH-182 Bt (BG-II), ABCH-191 Bt (BG-II), ABCH-192 Bt (BG-II), ACH-155-2, ACH177-2, ACH133-2, ACH 33-2, ANKUR 3224 BGII, ANKUR 3244 BGII, ANKUR 3228 BGII, Ankur 3028 BG-II, ANKUR-5642, ANKUR-8120, GK-228 BGII,GK-239 BGII, GK-212, GOLDSTAR BGII, Jai BG-II, Jassi, JKCH 0109 BGII, KCH-36 BG-II, KCH999 BG-II, KCH-14K59 BGII, KCH-15K39 BGII, KCH-100 BG-II, KCH-172 BG-II, KCH-189 BG-II, KCH-311 BG-II, KCH-707 Bt, KDCHH-541BGII, KDCHH-441, KCH-100BGII, KCH-172BGII, KCH-189BGII, KCH-311BGII, KDCHH-516 BGII, KDCHH-621 BGII, KDCHH-641 BGII, KDCHH-9810 BGII, KSCH-207 Bt, MRC-7301 BGII, MRC-7347 BGII, MRC-7351 BGII, MRC-7361 BG II, MRC-7365 BG-II, MRC-7017, MRC-7031, MRC-7041, MRC-7045, NCS 9002Bt2, NCS 9011 Bt2, NAMCOT-616 BGII, NAMCOT-617 BGII, NCS 9012 Bt2, NCS 9013 Bt2, NCS 9024 Bt2, NCS-855 Bt2, NCS-856 Bt2, NCS-857 Bt2, NCS-858 Bt2, NCS-145 (Bunny), NCS 459 BGII, NCS 950 BGII, NCS 4455 BGII, NSPL 252 BG II, NSPL 531 BG II, NSPL 2223BGII, PCH-9602 Bt2, PCH-9604 Bt2, PCH-9605 Bt2, PCH- 9609 Bt2, PCH-9611 Bt2, PCH-876 Bt2, PCH-877 Bt2, PCH-878 Bt2, PCH-879 Bt2, PRCH 732 BGII, PRCH 711 BGII, RCH650 BGII, RCH 653 BGII, RCH-602 BGII, RCH-605 BGII, RCH-314 BGII, RCH-134, PRCH-708 Bt2, PRCH-302, PRCH-333, SDS-27 BG II, SDS-6003 BGII, SDS-234 BGII, SDS-9, SDS-36, SOLAR-56 BG-II, SOLAR-64 BG-II, SOLAR-65 BG-II, SOLAR-72 BG II, SOLAR-75 BG-II, SOLAR-76 BG-II, SOLAR-77 BG-II, Shakthi 9 BGII, SP7007B2, SP7114B2 BGII, SP504B2 BGII, SO7H878 BGII, SP1169B2, SP 7010B2, SWCH-4735 BGII, SWCH-4744 BGII, SWCH-4748 BGII, SWCH-4750 BGII, SWCH-4755 BGII, SWCH- 4757 BGII, SWCH-4768 BGII, SWCH-4770 BGII, SWCH-4707 BG-II, SWCH-4711 BG-II, SWCH-2 BG-II, SWCH-4704 BG-II, SWCH-4713 BG-II, Super-721BGII, Super-931BGII, Super-965BGII,Super-971BGII, Super-5BGII, Super-511BGII, Super-544BGII, TULASI-9 BGII, TULASI 118 BGII, TULASI 252BGII, TULASI 135BGII, TULASI 171BGII, Tulasi-162 BG II, Tulasi-225 BG-II, Tulasi-4, Tulasi-45, VBCH-1532 BGII, VBCH-1533BGII, VBCH-1534BGII, VBCH-1544BGII, VBCH 1515 BGII,	MH 5270 Bt, Navkar-5 Bt, NCEH-6R, NCEH-26 Bt, NCEH-31 Bt, NCH-1005 Bt, NCH-1085 Bt, NCH-1163 Bt, NCH-1177 Bt, NCEH-51, NCEH-145, SBCH-278 Bt, SBCH-290Bt, YRCH-18Bt, UPLHH-12 Bt, UPLHH-271 Bt, UPLHH-342 Bt, UPLHH-350 Bt, ZCH-193 Bt, UPLHH-1, YRCH-22Bt,YRCH-36Bt,YRCH-40Bt, ***JKCH-109 Bt, JKCH-104 Bt, JKCH-1950 Bt, JKCH-99 Bt, JKCH-1145 Bt, JKCH-1923 Bt, JKCH-1945 Bt, JKCH-1947, JK-1050, JKCH-226 Bt, BNBt (Variety)***

Table 1. Listing of events, Bt cotton variety and hybrids in India, 2011

Zone	BG-I Hybrids	BG-II Hybrids	GFM/Event-I/MLS-9124/BNLA-601
		VBCH-1504, VICH-307 BG-II, VICH-308 BG-II, VICH-309 BG-II, VICH-310 BG-II, VICH-9, VICH-11, 569, 6488-2, 2510-2, 2113-2, 841 2(BGII), 846-2(BGII), 311-2 (BGII)	
Central Zone (549 Hybrids 6 Events, 40 Companies)	ABCH 223Bt, ABCH 224Bt, ABCH 225Bt, ABCH 226Bt, ABCH 227Bt, ABCH 228Bt, ABCH 229Bt, ABCH 230Bt, ABCH 231Bt, ABCH 236Bt, ABCH 237Bt, ABCH-3083 Bt, ABCH-3483 Bt, ABCH-1857 Bt, ABCH-172 Bt, ABCH-173 Bt, ABCH-174 Bt, ABCH-177 Bt, ABCH-178 Bt, ABCH-1165, ABCH-1220, ACH 33-1, ACH 155-1, ACH-177-1, Akka, Ankur 3042 Bt, Ankur-9, Ankur-651, Ankur-3032 Bt, Ankur HxB-1950 Bt, Brahma, Dyna, GK-204, GK-205, Jai Bt, KCH-135, KCH-707, KDCHB-407 BG-I, KDCHH-507 BG-I, KDCHH-786, KDCHH-9632, KDCHH-9810, KDCHH-9821, KDCHH-553 BGI, KSCH 201 BGI, KSCH 204 BGI, Mahasangram BG, MECH-12, MECH-162, MECH-184, MRC-6301, NCS-906 Bt, NCS-907 Bt, NCS-908 Bt, NCS-909 Bt, NCS-910 Bt, NCS-138, NCS-145 (Bunny), NCS-207 (Mallika), NCS-913, NCS-929, NCS-950, NCS-954, NCS-955, NCS 1911 BG-I, NCS 1914 BG-I, NCHB-991, NCHB-992, NPH-2171, NSPL-36, NSPL-405, NSPL-999, PCH-404 Bt, PCH-405 Bt, PCH-407 Bt, PCH-408 Bt, PCH-409 Bt, PCH-115, PCH-207 (PCH-205), PCH-923, PCH-930, PCH 1412 BG-I, PCH 1411BG-I, PCH 2270 BG-I, PRCH-724Bt, PRCH-725 Bt, PRCHB-405 BG-I, PRCH-102, PRCH-31, Rudra, RCH-134 Bt, RCH-2, RCH-118, RCH-138, RCH-144, RCH-377, RCH-386, RCH-395 Bt, Sarju-BG, Sigma, SP 1136 B1, SP-499, SP-503, SP-504 (Dhanno), SP-904, SP-923, SWCH-4428 Bt, SWCH-4531 Bt, SWCH-4314 Bt, Tulasi-4, Tulasi-5 Bt, Tulasi-9, Tulasi-117, VBCHB-1201BG, VBCHB-1202BG, VBCHB-1203BG, VBCH-101, VBCH-1006,VBCH-1009, VBCH-1010, VBCH-1016, VBCH-1017,VCH-111, VICH-5,	VBCH 1516 BGII, VBCH 1517 BGII, VBCH 1518 BGII, VBCH-1501, ABCH-1299 Bt (BG-II), ABCH-2099 Bt (BG-II), ABCH-4899 Bt (BG-II), ABCH-7399 Bt (BG-II), ABCH-1020 Bt (BG-II), ABCH-143 Bt (BG-II), ABCH-146 Bt (BG-II), ABCH-181 Bt (BG-II), ABCH-182 Bt (BG-II), ABCH-191 Bt (BG-II), ABCH-192 Bt (BG-II), ABCH 243Bt, ABCH 244Bt, ABCH 245Bt, ABCH 246Bt, ABCH 247Bt, ABCH 248Bt, ABCH 252Bt, ABCH 254Bt, ABCH 256Bt, ABCH 240Bt, ABCH 241Bt, ACH-5 BGII, ACH-6 BGII, Paramveer (ACH-12-2 BGII), ACH-52-2 BGII, ACH-111-2, ACH-177-2, Ajeet-11-2, Ajeet-155-2, Ajeet 199 BGII, Akka, Amar-1065 Bt, ANKUR 3224 BGII, ANKUR 3244 BGII, ANKUR 3228 BGII, ANKUR 5642 BGII, ANKUR 3066 BGII, Ankur-3028 BG-II, Ankur-3034 BG II, Ankur-216 BG II, Ankur-257 BG II, Ankur-3070 BG II, Ankur HB 2104 BG-II, Ankur 651 BGII, Atal, BAT HH 201 BGII, BAT HH 210 BGII, BAT HH 214 BGII, Brahma BGII, CTH 2 BGII, DPC 9066 BGII, DPC 7064 BGII, DPC 7065 BGII, EGCH 1447 BGII, GK 220 BGII, GK 249 BGII, GK-228 BGII, GK-238 BGII, GK-244 BGII, GK-218 BGII, GK-221 BGII, GK-224 BGII, GK-231 BGII , GK-235 BGII , GK-205, Jai BG-II, JKCH 99 DOUBLE Bt (JKCH99 BG II), JKCH 2245 DOUBLE Bt (JKCH 2245 BGII), JK DURGA DOUBLE Bt (JKDURGABGII), INDRA VAJRA DOUBLE Bt (INDRA VAJRA BGII), KCH 100 BGII, KCH-172BGII, KCH-189BGII, KCH 311BGII, KCH-14K59 BG-II, KCH-15K39 BG-II, KCH-36 BG-II, KCH-999 BGII, KCH-707, KCH-135, KDCHH-9810 BGII, KDCHH-641 BGII, KDCHH-541 BGII, KDCHB-407 BG-II, KDCHH-441, KDCHH-621, KDCHH-9632, KCHH-8152 BGII, KCHH-932 BGII, KCHH-904 BGII, KDCHH 02 BGII, KDCHH 202 BGII, KDCHH 065 BGII, KDCHH 722 BGII, KDCHH 532 BGII, KSCH 212 BGII, KSCH 207 BG II, Krishna BGII, MLBCH6 BGII, MLCH-317, MRC-7373 BG II, MRC-7383 BGII, MRC-7301, MRC-7326, MRC-7347, MRC-7351, MRC- 7918, MRC-7361 BGII, MRC-7375 BGII, MRC-7377 BGII, MRC-7385BGII, MRC-7387 BGII, Mahasangram BGII, NAMCOT 621 BGII, NAMCOT 627 BGII, NCS 9014Bt2, NAMCOT 614 BGII, NAMCOT 615 BGII, NAMCOT 603 BGII, NAMCOT 605 BGII, NCS 9015 Bt2, NCS 9025 Bt2, NCS 9028 Bt2, NCS 9030 Bt2, NCS 950Bt2, NCS 954 Bt2, NCS 955 Bt2, NCS 929 Bt2, NCS 138 Bt2, NCS 856Bt2, NCS 858Bt2, NCS 865 Bt2, NCS 866Bt2,	ACH-1575 Bt, ACH 1050 Bt, ACH 1151 Bt, ACH 1171 Bt, ACH-1019, Dhruv Bt, Kashinath, GBCH-07 Bt, GBCH-09 Bt, GBCH-01, MH 5225 Bt, MH 5234 Bt, MH 5243 Bt, MH 5274 Bt, Monsoon Bt, Navkar-5, NCEH-29, NCEH-24, NCEH-210, NCEH-2R, NCEH-3R, NCEH-21, NCEH-23, NCEH-14, NCEH-34 Bt, SBCH-310Bt(Gazab Bt), SBCH-286 Bt (Raka Bt), SBCH-311Bt, SSB-71Bt, SSB-72Bt, TPHCN07-015 Bt, TPHCN07-005 Bt, TPHCN07-009 Bt, UPLHH-271 Bt, UPLHH-17 Bt, UPLHH-12 Bt, UPLHH-189 Bt, UPLHH-352 Bt, UPLHH-13 Bt, UPLHH-1Bt, UPLHH-10 Bt, UPLHH-2Bt, YRCH-18Bt,YRCH-22Bt,YRCH-36Bt, YRCH-40Bt, YRCH-4 Bt, YRCH-9 Bt, YRCH-13 Bt, YRCH-31 Bt, YRCH-45 Bt, YRCH-54 Bt, ZCH-50005, ZCH-50072 Bt, YRCH 18 Bt, YRCH 22 Bt, YRCH 36 Bt, YRCH 40 Bt, *JK INDRA VAJRA Bt, JK SUPER VARUN Bt, JK SHIKHAR Bt (JKCH-1305 Bt), JK AGNI Bt(JKCH-2022 Bt), JK RUBY Bt(JKCH-2246 Bt), JK-Chamundi Bt, JK-Gowri Bt, JKCH-2245 Bt, JKCHB-229 Bt, JK-Ishwar (JKCH-634 Bt), JKCH-99, JKCH-226, JKCH-666, JK-Durga Bt, JK-Indra Bt, JK-Varuna, PCH-66Bt, PCH-55Bt, PCH- 44Bt, PCH-22Bt, PCH-99 Bt, PCH-77 Bt, PRCH-712 Bt, PRCH-713 Bt, PRCH-714 Bt, PRCH-715 Bt,* **MH-5125Bt, MH-5174Bt, BN Bt (Variety)**

Table 1. Listing of events, Bt cotton variety and hybrids in India, 2011

Zone	BG-I Hybrids	BG-II Hybrids	GFM/Event-I/MLS-9124/BNLA-601
	VICH-9, VICH-15, 322 Bt, 110 Bt, 6188 Bt, 563 Bt, 311 Bt	NCS-859 Bt2, NCS-860 Bt2, NCS-861 Bt2, NCS-862Bt2, NCS-853Bt2, NCS-145 Bt 2, NCS-207 (Mallika), NCS-854 Bt 2, NCS 459 BGII, NCS 852 BGII, NCS 855 BGII, NCS 857 BGII, NCS 864 Bt2 BGII, NCS 867 BGII, NCS 908 BGII, NCS 909 BGII, NCS 913 BGII, NCS 1122 BGII, NCS 2244 BGII, NCS 8899 BGII, NCS 9011 BGII, NCS 9012 BGII, NCS 9024 BGII, NCHB-9901 Bt2, NCHB-9902 Bt2, NCHB-9903 Bt2, NCHB-9904 Bt2, NCHB-9905 Bt2, NSPL 252 BG II, NSPL 531 BGII, NSPL 2223BGII, NCHB-945 Bt, NSPL-333 BGII, NSPL-432 BGII, NSPL-666 BGII, NSPL-36, NSPL-405, NSPL-999, PCHB-9969 Bt2, PCH-9613 Bt2, PCH-9614 Bt2, PCH-9616 Bt2, PCH-9619 Bt2, PCH-9620 Bt2, Paras Lakshmi, PCH-115 Bt2, PCH-881 Bt2, PCH-882 Bt2, PCH-2171 Bt 2, PCH-205 Bt 2, PCH 105 BGII, PCH 404 BGII, PCH 360 BGII, PCH 789 BGII, PCH 884 BGII, PCH 885 BGII, PCH 887 BGII, PCH 888 BGII, PCH 9605 BGII, PCH 1411 BGII, PRCH 731 BGII, PRCH 737 BGII, PRCH 739 Bt 2 BGII, PRCH 745 BGII, PRCH 746 BGII, PRCH 31 BGII, PRCH 733 BGII, PRCH 732 BGII, PRCH 710 BGII, PRCH-331 Bt II, PRCH-333 Bt II, PRCH-504, PRCH-505, PRCH-701Bt2, PRCH-703 Bt2, PRCH-704 Bt2, PRCH-709 Bt2, PRCHB-601Bt2, PRCHB-602 Bt2, RCH 668 BGII, RCH386 BGII, RCH 656 BGII, RCH 659BGII, RCH-608 BGII, RCH-377 BGII, RCH-530 BG-II, RCH-2, RCH-515, RCH-578, RCH-584, Sarju BG II, Senapati BGII, SO7H878 BGII , Solar 77 BGII, Solar 72 BGII, Solar 65 BGII, Solar 56 BGII, Solar 66 BGII, Solar 60 BG II, Solar 76 BGII, Solar 75 BGII, SP 499 BGII, SP 7149BGII, SP7147B2, SP7157B2, SP7196B2 BGII , SP1171B2, SP904 B2, SP1016 B2, SP1170 B2, SP504 B2, SRCH 99 BGII, SRCH 55 BGII, SRCH 33 BGII, SSCH 555BGII, SSCH 444 BGII, SSCH 333 BGII, Super-721BGII, Super-931BGII, Super-965BGII, Super-971BGII, Super-511BGII, Super-544BGII , Super 5 BGII, SWCH-4823 BGII, SWCH-4746 BGII, SWCH-4753 BGII, SWCH- 4765 BGII, SWCH-4790 BGII, SWCH-4800 BGII, SWCH-4776 BGII, SWCH-4749 BGII, SWCH- 4731BGII, SWCH-4751 BGII, SWCH-4754 BGII, SWCH-4769 BGII, SWCH-2 BG-II, SWCH-4708 BG-II, SWCH-4715 BG-II, SWCH-1 BG-II, SWCH-5017, SWCH-5011, Sudarshan BG II, TULASI-252 BGII, TULASI 171 BGII, TULASI 45BGII,TULASI 333 BGII, Tulasi-135 BG-II, Tulasi-144 BG-II, Tulasi-162 BG-II, Tulasi-117 BG-II, Tulasi-4, Tulasi-9, Tulasi-118, VBCH-1533BGII, VBCH-1537BGII, VBCH-1539BGII, VBCH-1542BGII, VBCH-1543BGII,VBCH-1544BGII, 841-2(BGII), VBCH- 1511, VBCH-1516, VBCH- 1519,	

Table 1. Listing of events, Bt cotton variety and hybrids in India, 2011

Zone	BG-I Hybrids	BG-II Hybrids	GFM/Event-I/MLS-9124/BNLA-601
		VBCH- 1520, VBCH- 1521, VBCHB-1525, VBCHB-1526, VICH-311 BG-II, VBCH-1501, VBCH-1503, VBCH-1505, VICH-312 BG-II, VICH-313 BG-II, VICH-314 BG-II, VICH-5 Bt, VICH-15, ZCH 501 Dhruv Gold BGII, ZCH 502 Super King BGII, ZCH 503 President Gold BGII, ZCH 504 Champion BGII, ZCH 508 Polaris BGII, ZCH 511 BGII, ZCH 541 BGII, ZCH 545 BGII 846-2(BGII), 844-2(BGII), 563-2 (BGII), 842-2 (BGII), 847-2 (BGII), 7213-2 (BGII), 7215-2 (BGII), 311-2, 557-2, 110-2, 111-2, 195-2	
South Zone (488 Hybrids, 6 Events, 37 Companies)	ABCH 231 Bt, ABCH-172 Bt, ABCH-173 Bt, ABCH-174 Bt, ABCH-177 Bt, ABCH-178 Bt, ABCH-3083 Bt, ABCH-3483 Bt, ABCH-1165, ABCH-1220, ACHB-901-1 Bt, ACH-1 Bt, ACH 21-1, ACH 33-1, ACH 155-1, Akka, Ankur-238 Bt, Ankur-3082 Bt, Ankur HB 1024 Bt, Ankur-3042 Bt, Ankur HB-1902 Bt, Ankur HB-1976 Bt, Brahma, Dyna, GK-207, GK-209, Jai Bt, KCH-135, KCH-707, Mahasangram BG, KDCHH 553 BGI, KDCHH-507 BG-I, KDCHB-407, KDCHH-9632, KDCHH-9810, KSCH 201, KSCH 204, MECH-162*, MECH-184*, MRC-6322, MRC-6918, NCS-1911 Bt, NCS-1912 Bt, NCS-1913, NCS-1914 Bt, NCS-145 (Bunny), NCS-207 (Mallika), NCS-913, NCS-929, NCS-950, NCS-954, NCS-906 Bt, NCS-907 Bt, NCS-908 Bt, NCS-909 Bt, NCS-910 Bt, NCHB-940 Bt, NCHB-945 Bt, NCHB-990, NCHB-992, NPH-2171, NSPL-9, NSPL-36, NSPL-603, NSPL-666, NSPL-405, NSPL-999, Ole, PCH-1410 Bt, PCH 1411 Bt, PCH 1412 Bt, PCH-1413 Bt, PCH-115, PCH-207 (PCH 205), PCH-409 Bt, PCH-930, PCH-2270, PRCHB-405, PRCH-31 Bt, PRCH 724 Bt, PRCH 725 Bt, RCH-2, RCH-20, SP1136 BI (BGI), RCH-111, RCH-371, RCH-368, RCHB-708, Rudra, Sigma, SP 1170 B1, SP1016 B1, SP911B1, SP-503, SP-504 (Dhanno), SP-700, SWCH-4428 Bt, SWCH-4531 Bt, SWCH-4314 Bt, Tulasi-9 Bt, Tulasi-4, Tulasi-45 Bt,Tulasi-117, Tulasi-118 Bt, VBCHB-1010 BG, VBCH-1016 Bt, VBCH-1018 Bt,	ABCH 224 Bt, ABCH 225 Bt, ABCH 227 Bt, ABCH 229 Bt, ABCH 230 Bt, ABCH 240 Bt, ABCH 241 Bt, ABCH 243 Bt, ABCH 244 Bt, ABCH 245 Bt, ABCH 246 Bt, ABCH 247 Bt, ABCH 248 Bt, ABCH 252 Bt, ABCH 254 Bt, ABCH 256 Bt , ABCH-143 Bt BG-II, ABCH-146 Bt BG-II, ABCH-147 Bt BG-II, ABCH-148 Bt BG-II, ABCH-1299 Bt BG-II, ABCH-7399 Bt BG-II, ABCH-181 Bt BG-II, ABCH-182 Bt BG-II, ABCH-191 Bt BG-II, ABCH-192 Bt BG-II, ABCH-1065 Bt, ABCH-1020 Bt, ACH-5 (Ajeet 5) BGII, ACH-6 (Ajeet 6) BGII, Paramveer (ACH-12-2 BGII), ACH-33-2, ACH-177-2, ACH-155-2, ANKUR 3224 BGII, ANKUR 3244 BGII, ANKUR 3228 BGII, Akka, Ankur-3028 BG-II, Ankur-3034 BG-II, Ankur-257 BG-II, Ankur-356 BG-II, Ankur-3066 BG-II, Ankur HB 2110 BG-II, Ankur-5642, Ankur-10122, Atal BGII, BAT HH 210 BGII, BAT HH 218 BGII, Brahma, DPC 7064 BGII, DPC 7065 BGII, EGCH 1513 BGII, GK 220 BGII, GK 228 BGII, GK 238 BGII, GK 239 BGII, GK 241 BGII , GK-218 BGII, GK-221 BGII, GK-223 BGII, GK-224 BGII, GK-231 BGII, GK-235 BGII, GK-217, Jai BG-II, JKCH 99 DOUBLE Bt (JKCH 99 BG II), JKCH 2245 DOUBLE Bt (JKCH 2245 BG II), JK DURGA DOUBLE Bt (JK Durga BG II) , INDRA VAJRA DOUBLE Bt (Indra Vajra BG II) , KCH-108 BGII, KCH-111 BGII, KCH-144 BGII, KCH-711 BGII, KCH- 100BGII, KCH-172BGII, KCH-189BGII, KCH-311BGII , KCH-707 BGII, KCH-14K59 BGII, KCH-15K39 BGII, KCH-36 BGII, KCH-999 BGII, KCH-135 Bt, KDCHH-541 BGII, KDCHB-407 BG-II, KDCHH-441, KDCHH-621, KDCHH-9632, KDCHH 641 BG II, KDCHH 9810 BG II, KDCHH 02 BGII, KDCHH 532 BGII, KDCHH 018 BGII, KDCHH 065 BGII, KDCHH 202 BGII, KDCHH 722 BGII, KDCHH 850 BGII, KSCH 207, Mahasangram BGII, MRC-7361 BGII, MRC-7375 BGII, MRC-7377 BGII, MRC-7385BGII, MRC-7387 BGII , MLBCH6 BGII, MLCH-318, MRC-7373 BGII, MRC-7383 BGII, MRC-7160, MRC-7918, MRC-7201, MRC-7347, MRC-7351, MRC-7929, NAMCOT 610 BGII,	Dhruv Bt, GBCH-04Bt, GBCH-07 Bt, Kashinath, MH 5225 Bt, MH 5234 Bt, MH 5243 Bt, MH 5274 Bt, Monsoon Bt, NCEH-2R, NCEH-3R, NCEH-13 Bt, NCEH-34 Bt, SSB-71Bt, SSB-72Bt, SBCH-311Bt, SBCH-310 Bt, SBCH-292 Bt, TPHCN07-015 Bt, TPHCN07-005 Bt, TPHCN07-009 Bt, UPLHH-189 Bt, UPLHH-7 Bt, UPLHH-295 Bt, UPLHH-355 Bt, UPLHH-358 Bt, UPLHH-360 Bt, UPLHH-347 Bt, UPLHH-265 Bt, UPLHH-271 Bt, UPLHH-10 Bt, YRCH- 4 Bt, YRCH-9 Bt, YRCH- 13 Bt, YRCH-31 Bt, YRCH-45 Bt,YRCH- 54 Bt, YRCH 18 Bt, YRCH 22 Bt, YRCH 36 Bt, YRCH 40 Bt, UPLHH-12 Bt, UPLHH-5 Bt, ZCH-50072 Bt, JK COMMANDER Bt(JKCH-2253 Bt), JK KANAKADURGA Bt (JKCH-2004 Bt), JK SUPER STAR Bt (JKCH-2247 Bt), INDRA VAJRA, JK SUPER VARUN Bt, JKCH-1305 Bt, JKCHB-229 Bt, JK-Durga, JKCH-99, JKCH-634 (JK-Iswar), JKCH-2245 Bt, JK Chamundi Bt, JK-Indra Bt, JK- Gowri Bt, PCH-66Bt, PCH-55Bt, PCH-44Bt, PCH-22Bt, PCH-99 Bt, PCH-77 Bt, PRCH-712 Bt, PRCH-713 Bt, PRCH-714 Bt, PRCH-715 Bt, **MH-5125Bt, MH- 5174Bt, BN Bt (Variety)**

Table 1. Listing of events, Bt cotton variety and hybrids in India, 2011

Zone	BG-I Hybrids	BG-II Hybrids	GFM/Event-I/MLS-9124/BNLA-601
	VBCHB-1203,VICH-5, VICH-9, VCH-111, 118 Bt, 340 Bt, 6188 Bt	NAMCOT 622 BGII, NAMCOT 803 (HB) BG II , NAMCOT-612, NAMCOT-607, NAMCOT-604 BG-II, NAMCOT-605 BG-II, NAMCOT-614 BG-II, NAMCOT-615 BG-II, NCS 9014 Bt 2, NCS 9015 Bt 2, NCS 9025 Bt2, NCS 9028 Bt2, NCS 9030 Bt2, NCS 950 Bt2, NCS 954 Bt2, NCS 955 Bt2, NCS 929 Bt2, NCS 138 Bt2, NCS 856 Bt2, NCS 858 Bt2, NCS-854, NCS-207, NCS-145 (Bunny), NCS 567 BGII, NCS 9012 BGII, NCHB 9901 Bt 2, NCHB 9902 Bt2, NCHB 9903 Bt2, NCHB 9904 Bt2, NCHB 9905 Bt 2, NCHB 990 Bt 2, NCHB 991 Bt 2, NSPL 252 BG II, NSPL 531 BG II, NSPL 2223BGII , NSPL-432 BGII, NSPL-333 BGII, NSPL-405, NSPL-999, Paras Laxmi BGII, PCH 9605 BGII, PCH 789 BGII, PCH 9613 Bt 2, PCH 9614 Bt 2, PCH 9616, PCH 9619 Bt 2, PCH 9620 Bt2, PCH-884 Bt2, PCH-887 Bt2, PCH-888 Bt2, PCH-115 Bt2, PCH-881 Bt2, PCH-882 Bt2, PCH-885 Bt2, PCH-886 Bt2, PCH-205 Bt2, PCH-2171 Bt2, PCH-2270, PCH-105, PCHB 9969 Bt2 , PRCH 731 BGII, PRCH 701 Bt2, PRCH 703 Bt2, PRCH 704 Bt2, PRCH 709 Bt2, PRCH 710 Bt2, PRCHB 601 Bt2, PRCHB 602 Bt2, PRCH-331 BG-II, PRCH-333 BG-II, PRCH-504, PRCH-505, RCH 665 BGII, RCH 668 BGII, RCH 578BGII, RCH-20 BG-II, RCH-656 BGII, RCH-659 BGII, RCHB- 625 BGII, RCH-111BGII, RCH-2, RCH-530, RCH-533, RCH-596, SARJU BG-II, SP 7149 BGII, SP-1171 B2, SP 504 B2 (Dhanno) BG II, SP911B2, SP904B2, SP-1037, SP1170 B2, SP7147 B2, SP7157 B2, SP7196 B2 (BGII), SRCH 99 BGII, SRCH 55 BGII, SRCH 33 BGII, SSCH 333 BGII, SSCH 444 BGII, SSCH 555 BGII, SWCH 4776 BGII, SWCH 4823 BGII, SWCH 4746 BGII, SWCH 4753 BG II, SWCH 4765 BG II, SWCH 4790 BGII, SWCH 4800 BGII, SWCH 4749 BG II, SWCH 4731 BGII, SWCH 4751 BGII, SWCH 4754 BG II, SWCH 4769 BG II , SWCH-2 BG-II, SWCH-4708 BG-II, SWCH-4703 BG-II, SWCH-4715 BG-II, SWCH-4720 BG-II, SWCH-5017 BG-II, SWCH-5011 BG-II, Senapati BGII, Solar 76 BGII, Solar 75 BGII, SOLAR-66 BG-II, SOLAR 72 BGII, SOLAR-60 BG-II, Sudarshan BGII, Super -721BGII, Super -931BGII, Super -965BGII,Super -971BGII, Super- 511BGII, Super -544BGII, Super-5 BG-II, TULASI-162 BGII, TULASI 171 BGII, TULASI 216 BGII, TULASI 234 BGII, TULASI 243 BGII, Tulasi-135 BG-II, Tulasi-144 BG-II, Tulasi-252 BG-II, Tulasi-4 BG-II, Tulasi-45 BG-II, Tulasi-117 BG-II, Tulasi-333 BG-II, Tulasi-7, Tulasi-9, Tulasi-118, VBCH 1533 BGII, VBCH 1537 BGII, VBCH 1539 BGII, VBCH 1542 BG II, VBCH 1543 BG II, VBCH 1544 BGII , VBCHB-1525 BG-II, VBCHB-1526 BG-II, VBCH-1511 BG-II,	

Table 1. Listing of events, Bt cotton variety and hybrids in India, 2011

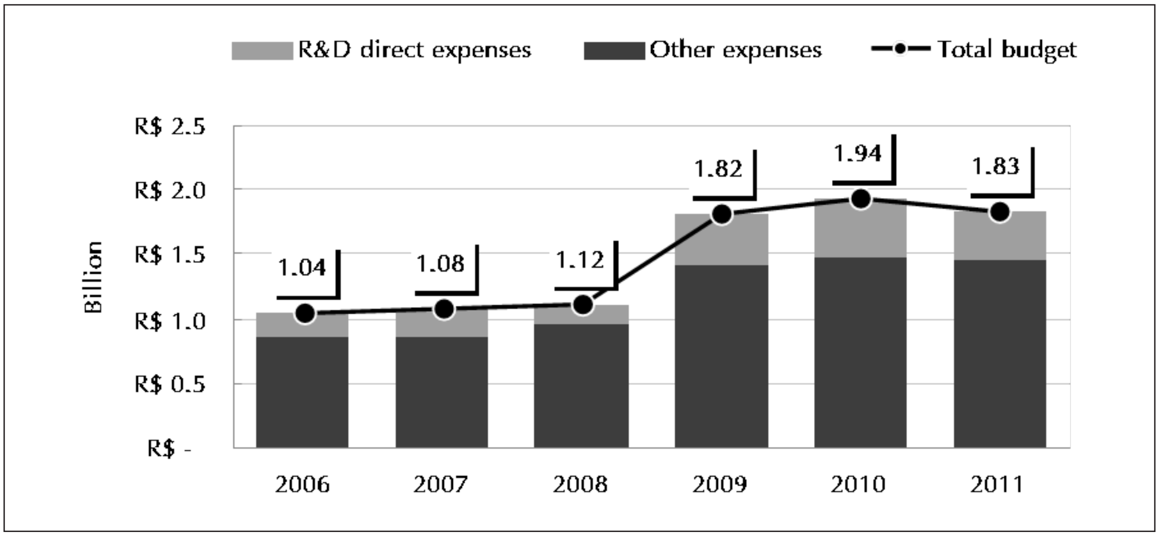
Zone	BG-I Hybrids	BG-II Hybrids	GFM/Event-I/MLS-9124/BNLA-601
		VBCH-1516 BG-II, VBCH-1519 BG-II, VBCH-1520 BG-II, VBCH-1521 BG-II, VBCH-1501, VBCH-1505, VBCH-1506, VICH-301 BG-II, VICH-303 BG-II, VICH-304 BG-II, VICH-311 BG-II, VICH-312 BG-II, VICH-313 BG-II, VICH-314 BG-II, VICH-5 Bt,VICH-15 Bt, ZCH 501 Dhruv Gold BGII, ZCH 502 Super King BGII, ZCH 503 President Gold BGII, ZCH 504 Champion BGII, ZCH 508 Polaris BGII, ZCH 541 Robo BGII, 563-2, 7211-2, 7213-2, 7215-2 BG II, 110-2, 118-2, 61888-2, 322-2, 113-2, 340-2.	

Source: Compiled by ISAAA, 2011.

Appendix 6

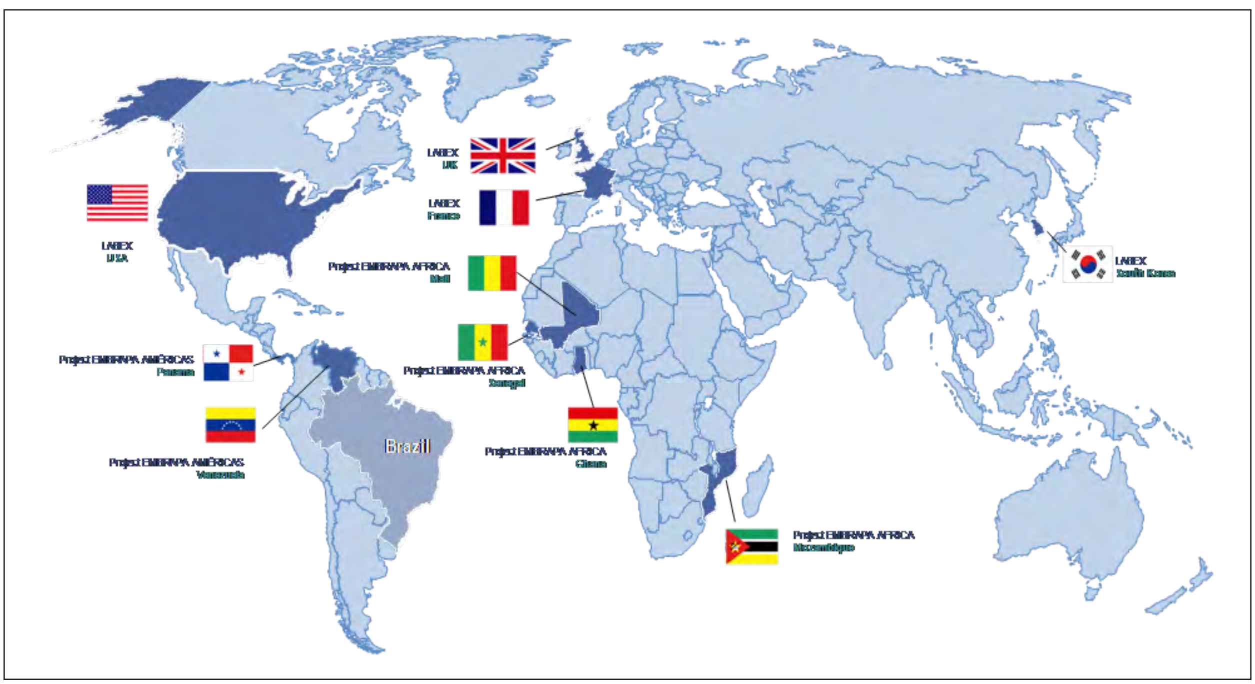
The EMBRAPA: Brazilian Agricultural Research Cooperation

Figure 1. EMBRAPA* Annual Budget Since 2006 (R$ Billion)



Source: EMBRAPA | Elaboration: CÉLERES® 2011.

Figure 2. EMBRAPA* Projects Around the World



Source: EMBRAPA | Elaboration: CÉLERES® 2011.

*EMBRAPA is the Brazilian organization responsible for agricultural research and development in Brazil. Embrapa's annual budget (based on average annual exchange rates) grew from US$478 million in 2006 to US$1.1 billion in 2010 and 2011; In 2008/2009, Embrapa launched a governmental plan called "PAC Embrapa" to promote Embrapa activities in Brazil and overseas including several programs in Africa.

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