ISAAA Brief 42-2010: Executive Summary

Global Status of Commercialized Biotech/GM Crops: 2010

Introduction

This Executive Summary focuses on the 2010 biotech crop highlights, which are presented and discussed in detail in ISAAA Brief 42, Global Status of Commercialized Biotech/GM Crops: 2010.

2010 is the 15th Anniversary of the commercialization of biotech crops.

2010 is the fifteenth anniversary of the commercialization of biotech crops, first planted in 1996. As a result of the consistent and substantial economic, environmental and welfare benefits offered by biotech crops, millions of large, small and resource-poor farmers around the world continued to plant significantly more hectares of biotech crops in 2010. **Progress was made on several major fronts: accumulated hectares from 1996 to 2010 reached an historic global milestone; a significant double-digit year-over-year increase in biotech crop hectarage was posted, as well as a record number of biotech crop countries; the number of farmers planting biotech crops globally increased substantially; across-the-globe growth, reflected increased stability of adoption and that biotech crops are here to stay.** These are very important developments given that biotech crops already contribute to some of the major challenges facing global society, including: **food security and self-sufficiency, sustainability, alleviation of poverty and hunger, help in mitigating some of the challenges associated with climate change and global warming; and the potential of biotech crops for the future is enormous.**

Accumulated hectarage from 1996 to 2010 exceeded an unprecedented 1 billion hectares for the first time, signifying that biotech crops are here to stay.

Remarkably, in 2010, the accumulated hectarage planted during the 15 years, 1996 to 2010, **exceeded for the first time, 1 billion hectares, which is** equivalent to more than 10% of the enormous total land area of the USA (937 million hectares) or China (956 million hectares). **It took 10 years to reach the first 500 million hectares in 2005, but only half that time, 5 years, to plant the second 500 million hectares to reach a total of 1 billion hectares in 2010.**

A record 87-fold increase in hectarage between 1996 and 2010, making biotech crops the fastest adopted crop technology in the history of modern agriculture

The growth from 1.7 million hectares of biotech crops in 1996 to 148 million hectares in 2010 is an unprecedented 87-fold increase, making biotech crops the fastest adopted crop technology in the history of modern agriculture. Importantly, this reflects the trust and confidence of millions of farmers worldwide, who have consistently benefited from the significant and multiple benefits that biotech crops offered over the last 15 years, and has provided farmers with the strong motivation and incentive to plant more hectares of biotech crops every single year since 1996, mostly with double-digit percentage annual growth. **Over the last fifteen years, farmers, who are the masters of risk aversion, have consciously made approximately 100 million individual decisions to plant an increasing hectarage of biotech crops year after year, because of the significant benefits they offer.** Surveys confirm that close to 100% of farmers decided to continue to plant, after their first experience with biotech crops because of the benefits they offer.

Strong double digit-growth of 10% in hectarage in the 15th year of commercialization – notably, the 14 million hectare increase was the second largest increase in 15 years.

Global hectarage of biotech crops continued its strong growth in 2010 for the fifteenth consecutive year – **a 10%, or 14 million hectare increase, notably the second largest increase in 15 years, reaching 148 million hectares,** – up significantly from a 7% growth or 9 million hectares increase and a total of 134 million hectares in 2009. Measured more precisely, in 2010 adoption of biotech crops increased to 205 million "trait hectares", equivalent to a 14% growth or 25 million "trait hectares", up from 180 million "trait hectares" in 2009. Measuring in "trait hectares" is similar to measuring air travel (where there is more than one passenger per plane) more accurately in "passenger miles" rather than "miles".

Number of countries planting biotech crops soared to a record 29, up from 25 in 2009 – for the first time, the top ten countries each grew more than 1 million hectares.

It is noteworthy that in 2010, the number of biotech countries planting biotech crops reached 29, up from 25 in 2009 (Table 1 and Figure 1). Thus, the number of countries electing to grow biotech crops has increased consistently from 6 in 1996, the first year of commercialization, to 18 in 2003, 25 in 2008 and 29 in 2010. **For the first time the top ten countries each grew more than 1 million hectares;** in decreasing order of hectarage they were; **USA (66.8 million hectares), Brazil (25.4), Argentina (22.9), India (9.4), Canada (8.8), China (3.5), Paraguay (2.6), Pakistan (2.4), South Africa (2.2) and Uruguay with 1.1 million hectares.** The remaining 19 countries which grew biotech crops in 2010 in decreasing order of hectarage were: **Bolivia, Australia, Philippines, Burkina Faso, Myanmar, Spain, Mexico, Colombia, Chile, Honduras, Portugal, Czech Republic, Poland, Egypt, Slovakia, Costa Rica, Romania, Sweden and Germany. The number of biotech crop mega-countries (countries growing 50,000 hectares, or more) increased to 17 in 2010 from 15 in 2009. The strong growth in 2010 provides a very broad and stable foundation for future global growth of biotech crops.**

Table 1. Global Area of Biotech Crops in 2010: by Country (Million Hectares)

Rank	Country	Area (million hectares)	Biotech Crops
1	USA*	66.8	Maize, soybean, cotton, canola, sugarbeet, alfalfa, papaya, squash
2	Brazil*	25.4	Soybean, maize, cotton
3	Argentina*	22.9	Soybean, maize, cotton
4	India*	9.4	Cotton
5	Canada*	8.8	Canola, maize, soybean, sugarbeet
6	China*	3.5	Cotton, papaya, poplar, tomato, sweet pepper
7	Paraguay*	2.6	Soybean
8	Pakistan *	2.4	Cotton
9	South Africa*	2.2	Maize, soybean, cotton
10	Uruguay*	1.1	Soybean, maize
11	Bolivia*	0.9	Soybean
12	Australia*	0.7	Cotton, canola
13	Philippines*	0.5	Maize
14	Myanmar*	0.3	Cotton
15	Burkina Faso*	0.3	Cotton
16	Spain*	0.1	Maize
17	Mexico*	0.1	Cotton, soybean
18	Colombia	<0.1	Cotton
19	Chile	<0.1	Maize, soybean, canola
20	Honduras	<0.1	Maize
21	Portugal	<0.1	Maize
22	Czech Republic	<0.1	Maize, potato
23	Poland	<0.1	Maize
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize
26	Costa Rica	<0.1	Cotton, soybean
27	Romania	<0.1	Maize
28	Sweden	<0.1	Potato
29	Germany	<0.1	Potato
	Total	**148.0**	

* 17 biotech mega-countries growing 50,000 hectares, or more, of biotech crops

Source: Clive James, 2010.

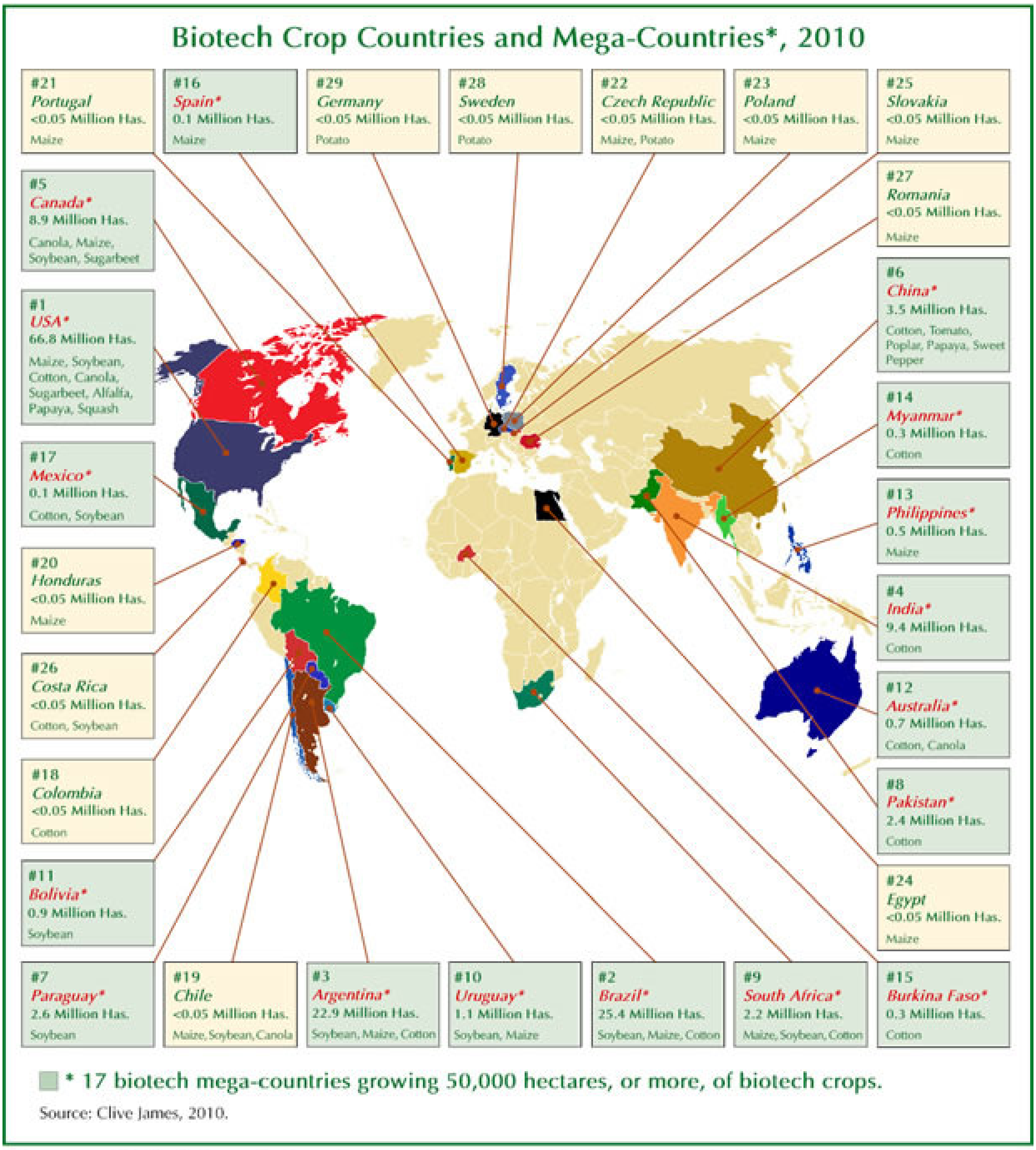

Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2010

Three new countries planted approved biotech crops for the first time in 2010 and Germany resumed planting.

Pakistan planted Bt cotton, as did **Myanmar**, and notably **Sweden**, the first Scandinavian country to plant a biotech crop, planted **"Amflora"**, a potato with high quality starch. Germany also resumed adoption of biotech crops by planting "Amflora" , for a net gain of four countries in 2010.

Of the 29 biotech crop countries in 2010, 19 were developing countries compared with only 10 industrial countries.

The strong trend for more developing countries than industrial countries to adopt biotech crops is expected to continue in the future with about **40 countries expected to adopt biotech crops by 2015,** the final year of the second decade of commercialization. By coincidence, 2015 also happens to be the Millennium Development Goals year, when global society has pledged to cut poverty and hunger in half – a noble humanitarian goal that biotech crops can contribute to, in an appropriate and significant way.

In 2010, the 15th year of commercialization, a record 15.4 million farmers grew biotech crops – notably, over 90% or 14.4 million were small resource-poor farmers in developing countries; estimates of number of beneficiary farmers are conservative due to a spill-over of indirect benefits to neighboring farmers cultivating conventional crops.

It is a historical coincidence that 2010, the 15th consecutive year of planting biotech crops, was also the year when a record 15.4 million small and large farmers from both developing and industrial countries planted biotech crops, up by 1.4 million from 2009. Notably, over 90%, or 14.4 million, were small and resource-poor farmers in developing countries. This is contrary to the predictions of some critics, who speculated, prior to the commercialization of biotech crops, that biotech crops were only for the rich and large farmers in industrial countries. However, experience has proven that to-date, by far, the largest number of beneficiary farmers, are small and resource-poor farmers in developing countries; this trend is likely to even strengthen in the future as most of the growth will be in developing countries. In 2010, the total number of small resource-poor farmers growing biotech crops were mainly in the following countries: **6.5 million in China cultivating an average of only 0.6 hectares of Bt cotton; 6.3 million in India; 0.6 million in Pakistan; 0.4 million in Myanmar; over a quarter million in the Philippines; almost 100,000 in Burkina Faso, and the balance of 0.2 million in the other 13 developing countries cultivating biotech crops.** Moreover, these estimates of the number of beneficiary farmers are conservative because studies in China indicate that an **additional 10 million farmers, planting crops other than Bt cotton but infested by the same cotton bollworm pest, are deriving indirect or spill-over benefits due to Bt cotton suppressing pest infestation levels of cotton bollworm (up to 90% lower)** on conventional crops such as maize and soybean. **Thus, up to 10 million more small and resource-poor farmers are secondary beneficiaries of Bt cotton in China. This spill-over effect in China is consistent with the results of a US study where farmers planting Bt maize for the period 1996 to 2009 derived benefits of US$2.6 billion but farmers planting conventional maize in the same region benefited 65% more, at US$4.3 billion in indirect benefits due to the suppression of pest infestations effected by Bt maize.**

Developing countries grew 48% of global biotech crops in 2010 – they will exceed industrial countries before 2015 – growth rates are also faster in developing countries than industrial countries.

The percentage of global biotech crops grown by developing countries has increased consistently every year over the last decade, from 14% in 1997, to 30% in 2003, 43% in 2007 and 48% in 2010. **Developing countries are almost certain to plant more biotech crops than industrial countries, well before the MDG year of 2015. Rate of hectarage growth in biotech crops between 2009 and 2010 was much higher in developing countries, 17% and 10.2 million hectares, compared with industrial countries at 5% and 3.8 million hectares.**

The lead developing countries are China, India, Brazil, Argentina and South Africa.

There are five principal developing countries growing biotech crops, China and India in Asia, Brazil and Argentina in Latin America, and South Africa in the continent of Africa, with a combined population of 2.7 billion (40% of global), which are exerting leadership with biotech crops. Collectively, the five countries planted 63 million hectares in 2010, equivalent to 43% of the global total and are driving adoption in the developing countries. Furthermore, benefits from biotech crops are spurring strong political will and substantial new R&D investments in biotech crops in both the public and private sectors, particularly in China, Brazil and India.

Brazil increased its hectarage of biotech crops, more than any other country in the world, an impressive 4 million hectare increase.

For the second year running Brazil, the engine of biotech crop growth in Latin America had the largest absolute year-over-year increase, **an impressive 4 million hectare increase over 2009.**

In Australia, biotech crops recovered after a multi-year drought with the largest proportional year-on-year increase of 184%.

Following a multi year drought which was the worst in the history of the country, the total hectarage of **biotech crops in 2010 increased significantly to over 650,000 hectares from approximately 250,000 hectares in 2009** (a 184% increase). Increases were recorded for both biotech cotton and canola.

Burkina Faso had the second largest proportional increase of biotech hectarage of any country in the world, an increase of 126%.

For the second consecutive year, Burkina Faso in West Africa had a very high proportional increase which was the second highest percentage increase in the world in 2010. **Bt cotton hectarage in 2010 increased by 126% to reach 260,000 hectares (65% adoption) farmed by 80,000 farmers, compared with 115,000 hectares in 2009.**

In India, stellar growth continued with 6.3 million farmers growing 9.4 million hectares of Bt cotton, equivalent to 86% adoption rate.

Mexico, the center of biodiversity for maize, successfully conducted the first field trials of Bt and herbicide tolerant maize.

After an eleven year moratorium, which precluded field trials of biotech maize in Mexico, the first experimental field trials were successfully conducted in 2010, which demonstrated the effectiveness of biotech crops for the control of insect pests and weeds. This is consistent with international experience with commercializing biotech maize in more than 10 countries around the world for about 15 years. Further trials planned for 2011 will evaluate biotech maize semi-commercially. 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 first permits for biotech maize trials to be conducted semi-commercially in 2011 were requested in the last quarter of 2010.

EU biotech crop adoption grows to a record of eight countries following approval of "Amflora" potato – the first approval for planting in 13 years in the EU. Six countries grew Bt maize, three grew Amflora, and one country grew both.

A record number of eight EU countries planted biotech crops in 2010; six countries continued to plant 91,193 hectares of Bt maize (compared with 94,750 hectares in 2009), led by Spain; **three countries, the Czech Republic, Sweden (the first Scandinavian country to plant a biotech crop), and Germany planted small hectarages of "Amflora" potato totaling 450 hectares in the three countries for seed multiplication and initial commercial production. "Amflora",** approved in 2010, is the first biotech crop to be approved by the EU for planting in thirteen years. Other biotech potatoes, including one that is resistant to the important disease "late blight", the cause of the Irish famine of 1845, are under development in EU countries and expected to be released before 2015, subject to regulatory approval.

In 2010, more than half the world's population (59% or 4 billion people) lived in the 29 countries, which planted 148 million hectares of biotech crops.

More than half (59% or 4.0 billion people) of the global population of 6.7 billion live in the 29 countries where biotech crops were grown in 2010 and generated significant and multiple benefits worth over US$10 billion (10.7) globally in 2009. Notably, more than half (52% or 775 million hectares) of the ~ 1.5 billion hectares of cropland in the world is in the 29 countries where approved biotech crops were grown in 2010.

For the first time, biotech crops occupied a significant 10% of ~1.5 billion hectares of all cropland in the world, providing a stable base for future growth.

The 148 million hectares of biotech crops in 2010 occupied for the first time, a significant 10% of all 1.5 billion hectares of cropland in the world.

Adoption by crop – herbicide tolerant soybean remains the dominant crop.

Biotech soybean continued to be the principal biotech crop in 2010, occupying 73.3 million hectares or 50% of global biotech area, followed by biotech maize (46.8 million hectares at 31%), biotech cotton (21.0 million hectares at 14%) and biotech canola (7.0 million hectares at 5%) of the global biotech crop area. After entering the EU, Romania was denied the opportunity of continuing to benefit from successful production of RR®soybean. Romania's Minister of Agriculture estimates that the EU ban is costing Romania US$131 million annually – he is requesting urgent approval for resumption of planting RR®soybean in Romania.

Adoption by trait – herbicide tolerance remains the dominant trait.

From the genesis of commercialization in 1996 to 2010, herbicide tolerance has consistently been the dominant trait. **In 2010, herbicide tolerance deployed in soybean, maize, canola, cotton, sugarbeet and alfalfa, occupied 61% or 89.3 million hectares of the global biotech area of 148 million hectares.** In 2010, the stacked double and triple traits occupied a larger area (32.3 million hectares, or 22% of global biotech crop area) than insect resistant varieties (26.3 million hectares) at 17%. **The insect resistance trait products were the fastest growing trait group between 2009 and 2010 at 21% growth, compared with 13% for stacked traits and 7% for herbicide tolerance.**

Stacked traits are an increasingly important feature of biotech crops – 11 countries planted biotech crops with stacked traits in 2010, 8 were developing countries.

Stacked products are a very important feature and future trend, which meets the multiple needs of farmers and consumers and these are now increasingly deployed by eleven countries listed in descending order of hectarage – USA, Argentina, Canada, South Africa, Australia, the Philippines, Brazil, Mexico, Chile, Honduras, and Colombia, (8 of the 11 are developing countries), with more countries expected to adopt stacked traits in the future. A total of 32.3 million hectares of stacked biotech crops were planted in 2010 compared with 28.7 million hectares in 2009. In 2010, the USA led the way with 41% of its total 66.8 million hectares of biotech crops stacked, including 78% of maize, and 67% of cotton; the fastest growing component of stacked maize in the USA was the triple stacks conferring resistance to two insect pests plus herbicide tolerance. Double stacks with pest resistance and herbicide tolerance in maize were also the fastest growing component in 2010 in the Philippines, increasing from 338,000 in 2009 to 411,000 in 2010, up by a substantial 22%. Biotech maize with eight genes, named SmartstaxTM, was released in the USA and Canada in 2010 with eight different genes coding for several pest resistant and herbicide tolerant traits. Future stacked crop products will comprise both agronomic input traits for pest resistance, tolerance to herbicides and drought plus output traits such as high omega-3 oil in soybean or enhanced pro-Vitamin A in Golden Rice.

Contribution of biotech crops to Sustainability – the multiple contributions of biotech crops are already being realized in the following ways and have enormous potential for the future.

The World Commission on Environment and Development defined sustainable development as follows: ***"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:

- ***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$65 billion were generated globally by biotech crops during the period 1996 to 2009, of which just less than half, 44%, were due to reduced production costs (less ploughing, fewer pesticide sprays and less labor) and just over half, 56%, due to substantial yield gains of 229 million tons. The 229 million tons comprised 83.5 million tons of soybean, 130.5 million tons of maize, 10.5 million tons of cotton lint, and 4.8 million tons of canola over the period 1996 to 2009. For 2009 alone, economic gains at the farm level were ~ US$10.7 billion, of which approximately 25%, were due to reduced production costs (less ploughing, fewer pesticide sprays and less labor) and approximately 75%, due to substantial yield gains of 41.7 million tons. The 41.67 million tons comprised 9.7 million tons of soybean, 29.4 million tons of maize, 1.9 million tons of cotton lint, and 0.67 million tons of canola in 2009. 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 (Brookes and Barfoot, 2011, forthcoming).

- ***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 229 million tons of additional food, feed and fiber produced by biotech crops during the period 1996 to 2009 had not been produced by biotech crops, an additional 75 million hectares of conventional crops would have been required to produce the same tonnage. Some of the additional 75 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 2009 alone, if the 42 million tons of additional food, feed and fiber produced by biotech crops during 2009 had not been produced by biotech crops, an additional 12 million hectares of conventional crops would have been required to produce the same tonnage for 2009 alone (Brookes and Barfoot, 2011, 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, Philippines, Burkina Faso and South Africa have already made a significant contribution to the income of 14.4 million poor farmers in 2010, and this can be enhanced significantly in the remaining 5 years of the second decade of commercialization, 2011 to 2015.** Of special significance is biotech rice which has the potential to benefit 250 million poor rice 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 CO2 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 2009 was estimated at 393 million kilograms (kgs) of active ingredient (a.i.), a saving of 8.8% in pesticides, which is equivalent to a 17.1% 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 2009 alone was a reduction of 39.1 million kgs a.i. (equivalent to a saving of 10.2% in pesticides) and a reduction of 21.8% in EIQ (Brookes and Barfoot, 2011, 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 9.2 billion by 2050. The first biotech maize hybrids with a degree of drought tolerance are expected to be commercialized by 2012 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 (CO2) emissions through reduced use of fossil-based fuels, associated with fewer insecticide and herbicide sprays; in 2009, this was an estimated saving of 1.36 billion kg of CO2, equivalent to reducing the number of cars on the roads by 0.6 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 2009 to16.3 billion kg of CO2, or removing 7.2 million cars off the road. Thus in 2009, the combined permanent and additional savings through sequestration was equivalent to a saving of 17.6 billion kg of CO2 (~18 billion kg) or removing 7.8 million cars (~8 million cars) from the road (Brookes and Barfoot, 2011, 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 CO2 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 CO2.

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.

There is an urgent need for appropriate cost/time-effective regulatory systems that are responsible, rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries

The most important constraint to the adoption of biotech crops in most developing countries, that deserves highlighting, is the lack of appropriate cost/time-effective and responsible regulatory systems that incorporate all the knowledge and experience of 15 years of regulation. **Current regulatory systems in most developing countries are usually unnecessarily cumbersome and in many cases it is impossible to implement the system to approve products which costs US$1 million or more to deregulate – this is beyond the means of most developing countries.** The current regulatory systems were designed more than 15years ago to meet the initial needs of industrial countries dealing with a new technology and with access to significant resources for regulation which developing countries simply do not have – t**he challenge for developing countries is "how to do a lot with little."** With the accumulated knowledge of the last fifteen years it is now possible to design appropriate regulatory systems that are responsible, rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries – **this should be assigned top priority. This is a moral dilemma, where the demands of regulatory systems have become "the end and not the means."**

Conclusions of the Study Week on Biotech Crops and Food Security hosted by the Pontifical Academy of Sciences

The Pontifical Academy of Sciences, (PAS) Study Week from 15-19 May 2009, organized by Dr. Ingo Potrykus addressed the important issue of **"Transgenic Plants for Food Security in the Context of Development."** The following were some of the principal conclusions endorsed by the participants, in which the Vatican was not involved:

- enhance the provision of reliable information to regulators, and producers to facilitate sound decision-making based on current knowledge;
- standardize and rationalize the principles involved in the evaluation and approval of new crop varieties, irrespective of the breeding process (Genetically Engineered [GE] or conventional) so that they are scientific, risk-based, predictable and transparent;
- re-evaluate the application of the precautionary principle to GE crops using scientific prediction as a basis for action;
- evaluate the Cartagena Protocol, to ensure that it is consistent with current scientific understanding;
- free GE techniques from excessive, unscientific regulation, to facilitate the enhancement of crop productivity and nutrition;
- promote technology to assist small farmers to optimize crop productivity;
- encourage the wide adoption of sustainable productive practices to improve the lives of the poor and needy;
- ensure that appropriate GE and molecular marker-assisted breeding are used to improve crops grown in food-insecure, poor nations;
- encourage international aid agencies and charities to take urgent action to provide support and exercise moral responsibility to guarantee food security;
- facilitate private-public cooperative relationships to ensure the cost-free exploitation of GE technologies for the common good in the developing world where they will have the greatest impact.

These very important conclusions along with more information from 31 scientific contributions, including the conference statement have been published in all the major languages. For further information see (New Biotechnology, 2010, http://www.askforce.org/web/Vatican-PAS-Studyweek-Elsevier-publ-20101130/Press-Release-PAS-Studyweek-20101127.pdf;

Participants:http://www.ask-force.org/web/Vatican-Studyweek-Elsevier/Participants-List-english-email.pdf).

Status of Approved Events for Biotech Crops

While **29** countries planted commercialized biotech crops in 2009, an additional **30** countries, totaling **59** have granted regulatory approvals for biotech crops for import for food and feed use and for release into the environment since 1996. It is noteworthy that 75% of the world's population live in the 59 countries that have approved biotech crops for planting or import. A total of 964 approvals have been granted for 184 events for 24 crops. Thus, biotech crops are accepted for import for food and feed use, and for release into the environment in 59 countries, including major food importing countries like **Japan, which do not plant biotech crops. Of the 59 countries that have granted approvals for biotech crops, USA tops the list followed by Japan, Canada, Mexico, Australia, South Korea, the Philippines, New Zealand, the European Union, and China.** Maize has the most events approved (60) followed by cotton (35), 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 23 approvals (EU=27 counted as 1 approval only), followed by herbicide tolerant maize (NK603) and insect resistant maize (MON810) with 20 approvals each, and insect resistant cotton (MON531/757/1076) with 16 approvals worldwide.

Global value of the biotech seed market alone was valued at US$11.2 billion in 2010 with commercial biotech maize, soybean grain and cotton valued at ~US$150 billion for 2010.

In 2010, the global market value of biotech crops, estimated by Cropnosis, was US$11.2 billion, (up from US$10.6 billion in 2009); this represents 22% of the US$51.8 billion global crop protection market in 2010, and 33% of the US$34 billion commercial seed market. The estimated global farm-scale revenues of the harvested commercial "end product", (the biotech grain and other harvested products) is much greater than the value of the biotech seed alone (US$11.2 billion) – extrapolating from 2008 data, biotech crop harvested products would be valued at approximately US$150 billion globally in 2010, and projected to increase at up to 10 - 15% annually.

Future Prospects

Outlook for the remaining five years, 2011 to 2015, of the second decade of commercialization of biotech crops, 2006 to 2015

The adoption of biotech crops in the five year period 2011 to 2015 will be dependent mainly on three factors: first, the timely implementation of appropriate, responsible and cost/time-effective regulatory systems; second, strong political will and support; a continuing wave of improved biotech crops that will meet the priorities of industrial and developing countries in Asia, Latin America and Africa.

The outlook for biotech crops in the remaining 5 years of the second decade of commercialization, 2011 to 2015, looks encouraging. From 2011 to 2015, about 12 countries are projected to adopt biotech crops for the first time, bringing the total number of biotech crop countries globally to approximately 40 in 2015. These new countries are likely to include up to three to four in each of the regions of Asia, West Africa and East/Southern Africa with fewer in Latin/Central America and Western/Eastern Europe. Western Europe is by far the more 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. The potato crop may offer new and appropriate opportunities for the EU.

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 almost 150 million hectares of biotech crops in 2010 from a total global potential of 315 million hectares; thus, there are approximately 150 million hectares for potential adoption. In the next five years the timing of the deployment of biotech rice, as a crop, 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 further increasing yield. Quality traits, such as omega-3, will become more prevalent providing a much richer mix of traits for deployment in conjunction with a growing number of input traits.

Four years ago in North America, a decision was made to delay the introduction of biotech herbicide tolerant wheat, but this decision has recently been revisited as it becomes evident that wheat is failing to compete with the relative advantages conferred on biotech maize and soybean which are more profitable for farmers to grow as a result of higher yields and lower production costs. In the US, the three-year average yield of wheat over the previous eight years increased from 41.6 bushels in 1999-01 to 43.2 bushels in 2007-09, a 3.8 percent increase. Over that same time period, the US three-year average maize yields increased by 14.7 percent and soybeans by 9.7 percent. 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 by about 2017.

Between now and 2015, there will also be several important new biotech crops that will occupy small, medium and large hectarages globally, featuring both agronomic and quality traits as single and stacked trait products. By far, the most important of the new biotech crops that are now nearing commercial approval and adoption is biotech rice. Golden Rice is expected to be available in 2013 in the Philippines and probably followed by Bangladesh, Indonesia and Vietnam (IRRI, 2010). Subject to commercial approval, Bt rice in China could be available in about three years from now. Rice is unique even amongst the three major staples (rice, wheat and maize) in that it is the most important food crop in the world and more importantly, it is the most important food crop of the poor in the world. Over 90% of the world's rice is grown and consumed in Asia by some of the poorest people in the world – the 250 million Asian households/families whose resource-poor rice farmers cultivate on average a meager half a hectare of rice.

Maize with Bt and herbicide tolerance, which has been well tested globally, is likely to be introduced in several developing countries in all three continents. Phytase maize is also likely to be available in China in about three years. Several other medium hectarage crops are expected to be approved before 2015 including: biotech potatoes, already approved in the EU for high quality starch, are being field tested for "late blight" disease resistance in the EU and in other developing countries; sugarcane with quality and agronomic traits; and disease resistant bananas. Some biotech orphan crops are also expected to become available: Bt eggplant approval is pending in India, and is in advance field testing in the Philippines and Bangladesh. Vegetable crops, such as biotech tomato, broccoli, cabbage and okra, which require heavy applications of insecticides (biotech can effect significant pesticide savings) are also under development. Pro-poor biotech crops such as biotech cassava, sweet potato, pulses and groundnut are also candidates. Several of these products are being developed by public sector national or international institutions in the developing countries. The development of this broad portfolio of new biotech crops augurs well for the continued global growth of biotech crops in the next five years.

The second decade of commercialization, 2006-2015, is likely to feature significantly more growth in Asia and Africa compared with the first decade, which was the decade of the Americas, where there will be continued strong growth in North and South America, and particularly strong growth in Brazil. Adoption of biotech soybean, maize and cotton in Brazil is expected to continue to climb as well as the introduction of new biotech crops such as sugarcane and beans. Brazil is emerging as the engine of growth in biotech crops in Latin America. As adoption of biotech crops advances globally, adherence to good farming practices with biotech crops, such as rotations and resistance management, is a must, as it has been during the first decade. Continued responsible stewardship must be practiced, particularly by the countries of the South, which are certain to be the major new deployers of biotech crops in the second decade of commercialization of biotech crops, 2006 to 2015.

The use of biotechnology to increase efficiency of first generation food/feed crops and second-generation energy crops for biofuels presents both opportunities and challenges. **Whereas biofuel strategies must be developed on a country-by-country basis, food security should always be assigned the first priority and should never be jeopardized by a competing need to use food and feed crops for biofuel.** Injudicious use of food/feed crops – sugarcane, cassava and maize for biofuels in food insecure developing countries could jeopardize food security goals if the efficiency of these crops cannot be increased through biotechnology and other means, so that food, feed and fuel goals can all be adequately met. The key role of crop biotechnology in the production of biofuels is to cost-effectively optimize the yield of biomass/biofuel per hectare, which in turn will provide more affordable fuel. However, by far, the most important potential role of biotech crops will be their contribution to the humanitarian Millennium Development Goals (MDG) of ensuring a secure supply of affordable food and the reduction of poverty and hunger by 50% by 2015.

The 2008 World Bank Development Report emphasized that, ***"Agriculture is a vital development tool for achieving the Millennium Development Goals"*** (World Bank, 2008) given that three out of every four peoplein developing countries live in rural areas, the majority of whom are dependent on agriculture. The report also**"recognizes that overcoming abject poverty cannot be achieved in Sub Saharan Africa without a revolutionin agricultural productivity for the millions of suffering subsistence farmers in Africa, most of them women."**Africa is home to over 900 million people representing 14% of the world population and is the only continentin the world where food production per capita is decreasing and where hunger and malnutrition afflicts at leastone in three Africans. Africa is recognized as the continent that represents by far the biggest challenge in termsof adoption and acceptance. It is noteworthy that there are now three countries (South Africa, Egypt and BurkinaFaso) benefiting from biotech crops in Africa, and that growth was registered in all three in 2010. The impressiveincrease of over 100% in Bt cotton from 115,000 hectares in 2009 to 260,000 hectares farmed by 80,000 farmersin 2010 in Burkina Faso is of strategic importance in neighboring countries and for the African continent. **There isnow a lead country commercializing biotech crops in each of the three principal regions of the continent:South Africa in southern and eastern Africa; Burkina Faso in west Africa; and Egypt in north Africa.** Thisbroad geographical coverage in Africa is of strategic importance in that it allows the three adopting countriesto become role models in their respective regions and for **more African farmers to become practitioners ofbiotech crops and to be able to benefit directly from "learning by doing", which has proven to be such an important feature in the success of Bt cotton in China and India.**

The President of Burkina Faso, Blaise Compaore offered the following guidance on biotech crops, duringNational 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 tonnes."***

The Minister of Science and Environment, Ghana. Hon. Ms. Sherry Ayittey said ***"Africa may not be able to meet its 2015 Millennium Development Goals (MDG) for human poverty reduction if the application of biotechnology is not considered seriously. My personal vision for the application of biotechnology is to improve the economy, create jobs, reduce hunger and improve health delivery especially for the rural poor."***

The World Bank Report (World Bank, 2008) also highlights the fact that Asia is home to 600 million rural people (compared with the 800 million total population of Sub Saharan Africa) living in extreme poverty. It is a stark fact of life that poverty today is a rural phenomenon where 70%, of the world's poorest people are small and resource-poor farmers and the rural landless labor that live and toil on the land. The big challenge is to transform this problem of a concentration of poverty in agriculture into an opportunity for alleviating poverty by sharing with resource-poor farmers the knowledge and experience of those from industrial and developing countries who have successfully employed biotech crops to increase crop productivity, and in turn, income. **It is**

encouraging to witness the growing "political will" for biotech crops at the G8 and G20 international level and at the national level in developing countries. This growing political will and conviction of visionaries and lead farmers for biotech crops, is particularly evident in several of the lead developing countries highlighted in this Brief. Failure to provide the necessary political will and support for biotech crops at this time will risk many developing countries missing out on a one-time window of opportunity and as a result become permanently disadvantaged and non-competitive in crop productivity. This has dire implications for the hope of alleviating poverty for up to 1 billion resource-poor farmers and the rural landless whose livelihoods, and indeed survival, is largely dependent on improved yields of crops which are the principal source of food and sustenance for over 5 billon people in the developing world, a significant proportion of whom are extremely poor and desperately hungry – a situation that is morally unacceptable in a just society.

Challenges and Opportunities

The importance of innovation

The word **innovation** comes from the Latin "Innovatus" and is defined as **"the ability to manage change as an opportunity, not as a threat."**

The future of global crop production will, to a significant extent, depend on **innovation** and how successful developers of biotech crops will be in pursuing innovation through a sequential **Three I Strategy** – **Ingenuity, Innovation and Implementation.** Innovation applies generically to all strategies and thus has implications for food security, food self-sufficiency and the alleviation of poverty of small resource-poor farmers and the landless poor. It is useful to take an example from a completely different sector to demonstrate the critical importance of innovation. A century ago, innovation allowed mass production of affordable cars in the USA and made it the number one country in the world in the car industry. Thirty years ago, the Japanese car industry overtook the American car industry to become the number one country in the world because it employed "frugal innovation" to redesign cars using a "lean manufacturing" approach that was successfully implemented to satisfy the changing needs and priorities of customers globally (The Economist, 15 April 2010).

Biotech crops are one of the most innovative approaches to crop technology and have resulted in the successful and unprecedented adoption of biotech crops, on one billion hectares in the last fifteen years, despite a politically and ideologically motivated opposition from the EU. **The unqualified success of biotech crops, which are the fastest adopted crop technology in the history of agriculture, was entirely due to innovation.** Similarly, the continued development and success of biotech crops on a global basis by current and future developers of biotech crops will also depend on the ability of the different developers **to innovate. Failure to innovate will result in diminished growth rates of crop productivity. The most recent OECD-FAO Outlook (FAO-OECD, 2010) projects that, for the period 2010 to 2019, net agricultural productivity in the EU will be "stagnant" growing at only 4%, compared with other countries, (such as the USA, Canada, Australia, China, India and countries in Latin America) practicing innovation with technologies like biotech crops, which are projected to grow at much higher rates of 15% to 40% over the same period. Mr. George Lyon, Member of the European Parliament (MEP), speaking at the January 2011 Oxford Conference on agriculture, cautioned that "*politicians were exploiting people's fears about GM for their own political advantage and advised a change in tack*" (Surman, 2011). In an impassioned speech Mr. Lyon, who is leading the European Parliament response to the Commission's proposal to reform the EU agricultural policy (CAP), said *"European farmers were being left behind as GM becomes the norm around the rest of the world."* While recognizing that GM crops were not a silver bullet, Mr. Lyon said that "*GM crops were an essential technology… and that the impasse in Europe must be broken if we are not to fall further behind."* He noted that *"organic and low input, low output farming had a role, but were certainly not the answer to meeting the challenges of doubling food production by 2050"* (Surman, 2011).**

It is evident that the world's economic axis is shifting in favor of the emerging nations of the world, and this has implications for the development of all products, including biotech crops. Increased participation in innovative approaches in plant biotechnology is already evident in the lead developing countries of BRIC – Brazil in Latin America, and India and China in Asia. Emerging countries are no longer satisfied to have only low labor costs as their only comparative advantage, but operate dynamic incubators of innovation, producing new and competing products and employing innovation to redesign products for customers at significantly lower cost, to meet fast growing domestic and international demands. **Thus, "frugal innovation" is not only an issue of cheap labor but increasingly will apply to the designing and redesigning of more affordable products and processes which will require both technological and business innovation.**

All this implies that the western world may be losing out to the emerging countries, but this is not necessarily so. Of the Fortune 500 companies, 98 have R&D activities in China and 63 in India, and these include collaborative efforts on biotech crops with both public and private partners in their respective host countries. The philosophy underlying these investments by the multinationals in the developing country BRICs is that they will retain a comparative advantage in innovation, in addition to being well placed to participate in the new markets that will be developed to meet the needs of an increasingly wealthy population of more than 2.5 billion in their home countries. This compares with only 303 million in the US and 494 million in the 27 EU countries. **Given that the nature of innovation is to feed upon itself, "innovation in the emerging world will encourage rather than undermine innovation in the western world"** (The Economist, 15 April 2010).

The current unprecedented explosive growth and change occurring in the emerging countries will have enormous implications for the rest of the world, and will demand more innovative solutions from successful developers. The global share of the emerging world's GDP increased from 36% in 1980 to 45% in 2008 and is predicted to reach 51% by 2014. In 2009, productivity in China grew by 8.2% compared with 1.0% in the US and a decline of 2.8% in the UK. Emerging country consumers have outspent the US since 2007 and are currently at 34% of global spending versus 27% in the USA. Thus, emerging country consumers are, and will continue to demand a better quality of life including a better diet, with significantly more meat, which in turn drives increased demand for the principal biotech feed stocks, maize and soybean.

Consistent with other lead countries of the world, the policy guidelines of the EU strongly promote innovation as a general policy in science but it has chosen not to practice what it preaches when it is applied to biotech crops – one of the most innovative approaches to crop technology. If innovation is the key to success with crop technology this could seriously disadvantage the EU. Some multinationals involved in crop biotechnology have already reduced R&D activities in some EU countries and, where possible, are relocating activities to outside the EU because it does not provide a congenial environment for the development of biotech crops which are viewed in the EU as a threat and not as an opportunity.

Climate change and the role of biotech crops

Given that 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, 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 9.2 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)."

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 CO2 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 CO2 emissions – a major bonus for climate change.
- Herbicide tolerant biotech crops encourage zero or no-till, which in turn significantly reduces the loss of soil carbon and CO2 emissions.
- Herbicide tolerant biotech crops reduce ploughing, which enhances the conservation of water substantially, reduces soil erosion significantly, and builds up organic matter which locks up soil carbon and reduces CO2 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 and water level 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.

Whereas in general environmentalists have been opposed to biotech crops, climate change specialists, tasked with cutting CO2 levels as the only remedy to avoid a future catastrophe, are becoming increasingly supportive of biotech crops because they 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 colleagues, now acknowledge that the green movement opposition to biotech crops is out of sync with current knowledge and this has precluded biotech crops from optimizing contributions for the benefit of society in the strategic areas of food security and climate change (Ecologist, 15 Nov 2010). Lynas 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 CO2 generators and polluters, thereby exacerbating, rather than solving, the problems associated with climate change.

One of the few successes of the Copenhagen Summit on Climate Change was the initiative known as REDD (Reducing Emissions from Deforestation and Forest Degradation) which, as the name suggests, aims to reduce deforestation. Whereas agriculture is a cause of deforestation, emitting about 14% of global GHG, crops also absorb CO2 with soils acting as a carbon sink. The Global Research Alliance on Agriculture Greenhouse Gases was established on 16 December 2009 with US$150 billion in pledges to investigate and develop potential opportunities which could reward farmers in poor countries for locking up carbon in their crops and soils under the aegis of the Clean Development Mechanism discussed in Copenhagen (The Economist, 30 December 2009).

Golden Rice and the humanitarian price of overregulation

Golden Rice is expected to be approved for release in 2013 (IRRI, 2010) after an unnecessarily long and costly process during which victims of VAD have been denied a remedy that would have relieved their suffering. **In a recent article, Ingo Potrykus (2010) concluded that biotech crops (GM) *"could save millions from starvation and malnutrition, if they can be freed from excessive regulation."*** 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). Golden Rice contains two genes (phytoene synthase and phytoene double-desaturase) that produce up to 35 micrograms of Vitamin A precursor (beta carotene) per gram of edible rice. For Vitamin A deficient rice eating populations in the developing countries, Golden Rice can provide sufficient Vitamin A to reduce substantially the 6,000 deaths a day due to Vitamin A deficiency, and save the eyesight of hundreds of thousands of people per year, unnecessarily suffering from this disease. Conventional breeding cannot increase Vitamin A, so 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. Golden Rice will probably reach the market in 2013, but it was ready in the laboratory in 1999. Potrykus concluded that the lag was entirely due to unjustified regulatory processes discriminating against biotech crops versus conventional crops. Hence, Potrykus holds 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. However, biotech crops have enormous potential to alleviate poverty and hunger and contribute to food security in the developing countries of the world.

Countless international agencies and national academies have endorsed the science underpinning biotech crops and have challenged the subjective and scientifically unsubstantiated views of critics, recognizing that new conventional crops created by traditional breeding methods are also genetically modified. Ironically, these conventional crops require no safety data, only evidence that they perform as well, or better, than current commercial conventionally bred crops. It is evident that with about one billion people suffering from hunger and poverty, which is morally unacceptable, it is more just to utilize public support to feeding the world's growing population than on unnecessary and unjustified bureaucratic regulations. **ISAAA Brief 41 for 2009 (James, 2009b) drew similar conclusions to Potrykus and highlighted that inappropriate over-regulation was the major constraint to more widespread adoption of biotech crops in developing countries.** The challenge for a lead developing country with first-hand experience and political will for adopting biotech crops is to appropriately reduce the current regulatory burden and implement a model system that is both responsible and time- and cost-effective. It is important to note that this can be achieved without in any way compromising biosafety. Importantly, it would also allow that lead nation to exercise leadership and become a model for other developing countries to embark on a humanitarian mission, growing biotech crops to become more self-sufficient in food, feed and fiber and contribute to the alleviation of poverty which currently pervasively pollutes the lives of approximately one billion people – this is morally unacceptable.

Technological advances in crop biotechnology – some of which pose regulatory dilemmas

Some new advances in molecular biotechnology pose challenges to regulators as to whether they fall within the scope of their regulatory authority. **"Targeted mutation"**, also referred to as **"zinc fingers"**, or **"meganucleases"**, is one such technique; it does not involve a **"transgene"** or foreign gene but induces errors in DNA repair and hence is quite different to regulated GM technology, and is more akin to conventional radiation and chemical-based mutation breeding which is not regulated. Cibus LLC from the USA has used meganucleases to develop a herbicide tolerant canola which it plans to release in 2011, subject to APHIS classifying it as a non-regulated technology. At this time it is uncertain how regulatory agencies will classify meganucleases. **Given that no foreign gene is involved, there is logic in the view that zinc fingers should not be regulated, consistent with traditional mutations.** Scientists hope that zinc fingers could be the catalyst that will allow global society to practice what it preaches about embracing innovation in science, by not classifying meganucleases as regulated technology. USDA/APHIS is currently considering its regulatory authority over zinc fingers and judgment is expected in 2011 when the first product is due for release (New York Times, 11 November 2010).

Novel ways to control bacterial phytopathogens in crops are being developed to reduce the significant annual losses due to plant diseases – estimated at 16% of global crop production (Oerke, 2006). Innovative crop biotechnology strategies could result in a significant and humanitarian contribution to food security in a world that has almost one billion people suffering from hunger, malnutrition and poverty – all three of which are inextricably linked. Pattern recognition receptors (PRRs) are capable of detecting pathogens by recognizing pathogen associated molecular patterns (PAMPs), which up until now have not been demonstrated to confer resistance to bacterial plant pathogens. Lacombe et al, (2010) report progress in detecting PRR activity after its transfer from a cruciferous plant *Arabidopsis thaliana* to two Solanaceous species, *Nicotiana benthamiana* and tomato, which conferred resistance to several phytopathogenic bacteria from different genera. The study suggests that expression of PAMPs could be used to confer broad-based disease resistance to bacterial pathogens of crops that cause significant productivity losses in crops globally.

The Millennium Development Goals (MDG) – cut poverty by 50% by 2015, optimizing the contribution of biotech crops in honor of the legacy of ISAAA's founding patron and Nobel Peace Laureate, Norman Borlaug

The MDG targets were set 10 years ago in 2000, with 1990 as the starting benchmark and 2015 as the target year. Given that two-thirds of the 15 year period has already expired, it is appropriate to take stock of progress (The Economist, September 2010). World leaders met in New York in late September 2010 to discuss what progress has been made to-date. Analysis by the UN shows that progress has been made regarding the major goal of alleviating poverty by cutting the percentage of poor in developing countries by 50%. **In 1990 on a global basis, poverty, expressed on a percent basis in the developing countries was 46% (World Bank estimate), and by 2005 had decreased to 27% – thus, 23% seems feasible by 2015, five years from now.** However, whereas the percentage of poor (poverty is defined as earnings under US$1.25 per day at PPP) has decreased, the absolute number of poor, hungry and malnourished, (in contrast to percentage) remains at an unacceptably high level of 925 million globally. It is noteworthy that 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, October 2010; Summer, 2010). A significant increase in poverty resulted from the price hikes of food commodities in 2008, which in turn led to riots in 30 developing countries and the fall of two governments. Many economists are predicting further price hikes of food in the near future. In addition to alleviating poverty by 50% the MDG also calls for malnutrition to be cut by half from 20% in 1990 to 10% in 2015 – it had reached 16% by 2008.

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 in smaller countries; this is exacerbated by the lack of data on poverty in many small poor countries. For example, 28 of the poorest countries have only recorded poverty levels once between 1990 and 2008. Nevertheless, it is estimated that 15 poor countries have already cut poverty in half, and of the top 10 achievers (listed in descending order, according to annual decline in poverty), encouragingly, six are African countries that include Gambia, Mali, Senegal, Ethiopia, the Central African Republic and Guinea.

It is noteworthy that the major reason for success, notably in China, but also to a lesser extent in Africa, is not due to an increase in public spending but to faster national economic growth which has become the engine of economic growth in the rural areas, where most of the world's poor reside. However, taking India as an example, it is evident that economic growth alone is not a panacea for poverty. Almost half (48%) of all under 5 children in India suffer from malnutrition, and they number over 60 million. This is one of the highest rates in the world and is the highest absolute number for any country in the world, equivalent to over a third of the 150 million malnourished under 5s in the world. India at a rate of 48% compares with the following countries which have the most chronically malnourished children under 5: Ethiopia at 51%, Congo 46%, Tanzania 44%, Bangladesh 43%, Pakistan 42%, Nigeria 41%, Indonesia 37%, Philippines 34%, and notably, by contrast, China at only 15%.

The international community involved with biotech crops from the public and private sector in the North and the South, as well as the donor community has not taken full advantage of the MDG in 2015 to demonstrate to the world at large the important contribution that biotech crops can make to food security and the alleviation of poverty. Given Norman Borlaug's strong advocacy of biotech crops this initiative would be the most appropriate and noble way to honor his rich and unique legacy in a global program entitled **"Knowledge, Biotechnology and the Alleviation of Poverty"– A partnership that would engage the North, South, East and West, embracing both public and private sectors, in a collective and noble effort to optimize the contribution of biotech crops to productivity, 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 2015, which coincidentally marks the end of the second decade of the commercialization of biotech crops, 2006 to 2015 – Norm Borlaug would approve.