ISAAA
INTERNATIONAL SERVICE
FOR THE ACQUISITION
OF AGRI-BIOTECH
APPLICATIONS

EXECUTIVE SUMMARY

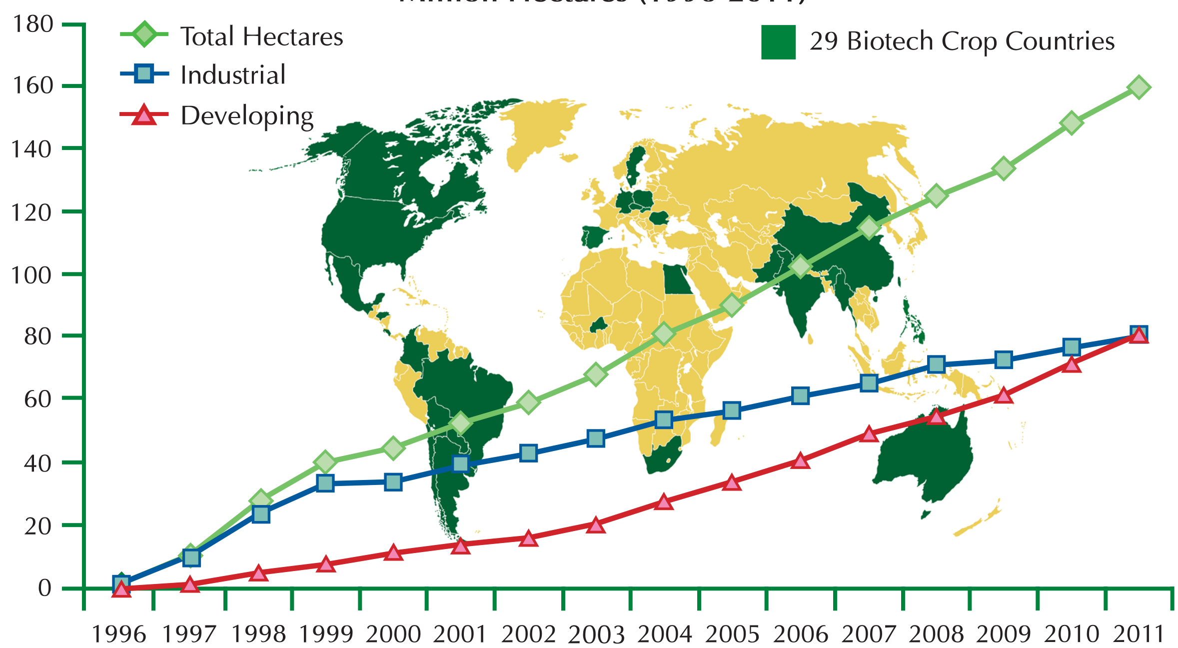
BRIEF 43
Global Status of Commercialized Biotech/GM Crops: 2011

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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Co-sponsors: Fondazione Bussolera-Branca, Italy
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ISAAA

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EXECUTIVE SUMMARY

Global Status of Commercialized Biotech/GM Crops: 2011

Table of Contents

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Global Status of Commercialized Biotech/GM Crops: 2011

By

Clive James, Founder and Chair of ISAAA

Introduction

This Executive Summary focuses on the 2011 biotech crop highlights, which are presented and discussed in detail in ISAAA Brief 43, Global Status of Commercialized Biotech/GM Crops: 2011.

Biotech crops reached 160 million hectares, up 12 million hectares on 8% growth, from 2010, as the global population reached a historical milestone of 7 billion on 31 October 2011

2011 was the 16th year of commercialization of biotech crops, 1996-2011, when growth continued after a remarkable 15 consecutive years of increases; a double-digit increase of 12 million hectares, at a growth rate of 8%, reaching a record 160 million hectares.

Biotech crops, fastest adopted crop technology

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

Millions of farmers globally elect to adopt biotech crops due to the benefits they offer

The most compelling and credible testimony to biotech crops is that during the 16 year period 1996 to 2011, millions of farmers in 29 countries worldwide, elected to make more than 100 million independent decisions to plant and replant an accumulated hectarage of more than 1.25 billion hectares – an area 25% larger than the total land mass of the US or China – there is one principal and overwhelming reason that underpins the trust and confidence of risk-averse farmers in biotechnology – biotech crops deliver substantial, and sustainable, socio-economic and environmental benefits. The 2011 study conducted in Europe confirmed that biotech crops are safe as animal feed.

Top ten countries each grew more than 1 million hectares of biotech crops

Of the 29 countries planting biotech crops in 2011, it is noteworthy that 19 were developing and 10 were industrial countries (see Table 1 and Figure 1). The top 10 countries each grew more than 1 million hectares providing a broad-based worldwide foundation for diversified growth in the future; in fact, the top nine each grew more than 2 million hectares. More than half the world's population, 60% or ~4 billion people, live in the 29 countries planting biotech crops.

Table 1. Global Area of Biotech Crops in 2011: by Country (Million Hectares)**

Rank	Country	Area (million hectares)	Biotech Crops
1	USA*	69.0	Maize, soybean, cotton, canola, sugarbeet, alfalfa, papaya, squash
2	Brazil*	30.3	Soybean, maize, cotton
3	Argentina*	23.7	Soybean, maize, cotton
4	India*	10.6	Cotton
5	Canada*	10.4	Canola, maize, soybean, sugarbeet
6	China*	3.9	Cotton, papaya, poplar, tomato, sweet pepper
7	Paraguay*	2.8	Soybean
8	Pakistan *	2.6	Cotton
9	South Africa*	2.3	Maize, soybean, cotton
10	Uruguay*	1.3	Soybean, maize
11	Bolivia*	0.9	Soybean
12	Australia*	0.7	Cotton, canola
13	Philippines*	0.6	Maize
14	Myanmar*	0.3	Cotton
15	Burkina Faso*	0.3	Cotton
16	Mexico*	0.2	Cotton, soybean
17	Spain*	0.1	Maize
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
23	Poland	<0.1	Maize
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize
26	Romania	<0.1	Maize
27	Sweden	<0.1	Potato
28	Costa Rica	<0.1	Cotton, soybean
29	Germany	<0.1	Potato
	Total	**160.0**	

* 17 biotech mega-countries growing 50,000 hectares, or more, of biotech crops
** Rounded off to the nearest hundred thousand

Source: Clive James, 2011.

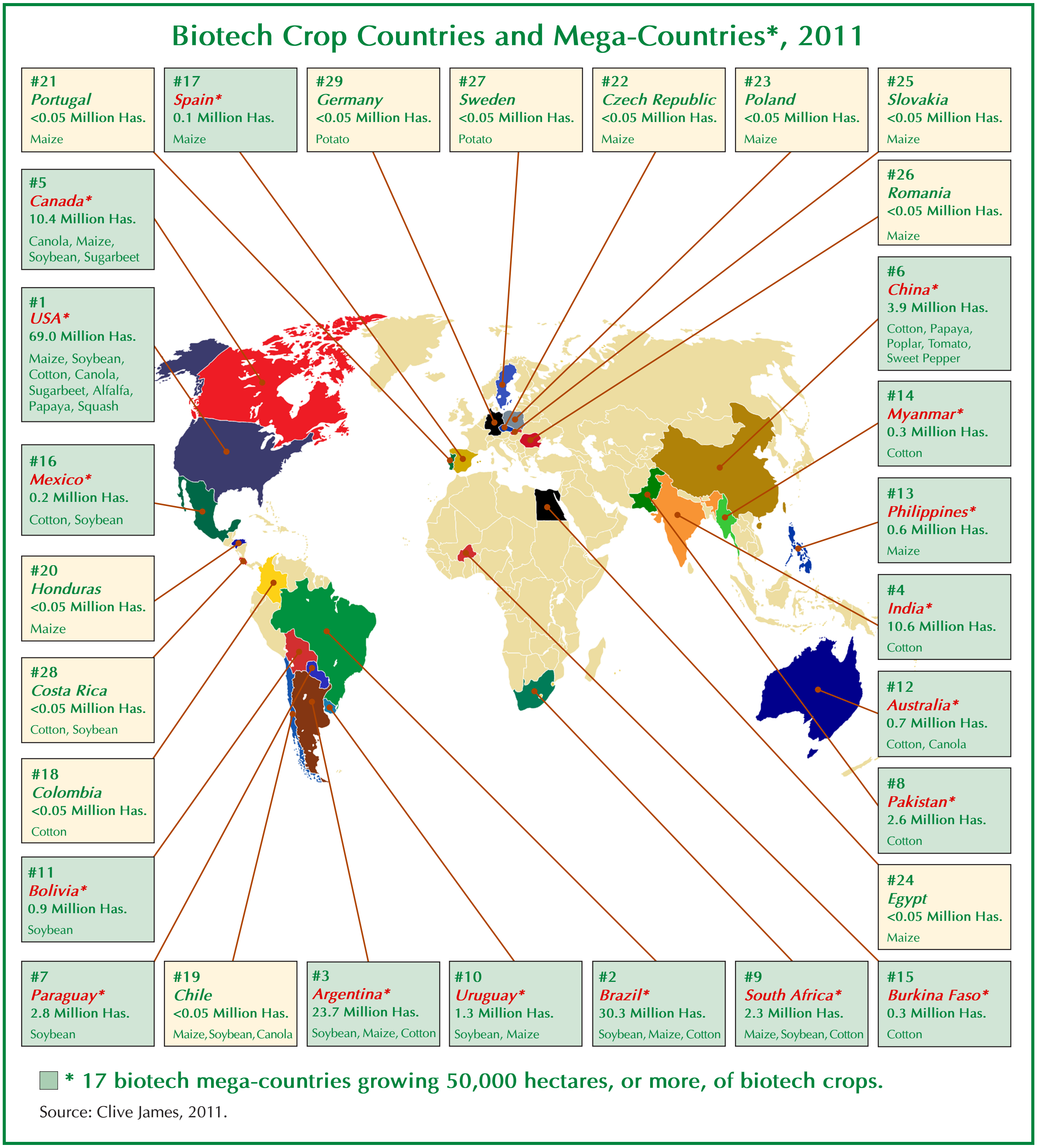

Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2011

A total of 16.7 million farmers grew biotech crops in 2011, up 1.3 million from 2010 – notably, 15 million or 90% were small resource-poor farmers from developing countries

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, 7 million small farmers in China and another 7 million small farmers in India, collectively planted a record 14.5 million hectares of biotech crops. Bt cotton increased the income of farmers significantly by up to US$250 per hectare and also halved the number of insecticide sprays, thus reducing farmer exposure to pesticides.

Developing countries grew close to 50% of global biotech crops

Developing countries grew close to 50% (49.875%) of global biotech crops in 2011 and for the first time are expected to exceed industrial countries hectarage in 2012; this is contrary to the prediction of critics who, prior to the commercialization of the technology in 1996, prematurely declared that biotech crops were only for industrial countries and would never be accepted and adopted by developing countries. In 2011, the 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. During the period 1996-2010 cummulative economic benefits were the same for developing and developed countries (US$39 billion). For 2010 alone, economic benefits for developing countries were higher at US$7.7 billion compared with US$6.3 billion for developed countries.

Stacked traits occupied ~25% of the global 160 million hectares

Stacked traits are an important feature of biotech crops – 12 countries planted biotech crops with two or more traits in 2011, and encouragingly 9 were developing countries – 42.2 million hectares or 26% of the 160 million hectares were stacked in 2011, up from 32.2 million hectares or 22% of the 148 million hectares in 2010.

The 5 lead biotech developing countries are China, India, Brazil, Argentina and South Africa – they grew 44% of global biotech crops, and have ~40% of world population

The five lead developing countries in biotech crops are China and India in Asia, Brazil and Argentina in Latin America, and South Africa on the continent of Africa, collectively grew 71.4 million hectares (44% of global) and together represent ~40% of the global population of 7 billion, which could reach 10.1 billion by 2100. Remarkably, Africa alone could escalate from 1 billion today (~15% of global) to a possible high of 3.6 billion (~35% of global) by the end of this century in 2100 – global food security, exacerbated by high and unaffordable food prices, is a formidable challenge to which biotech crops can contribute but are not a panacea.

Brazil, the engine of biotech crop growth

Brazil ranks second only to the USA in biotech crop hectarage in the world, with 30.3 million hectares, and is emerging as a global leader in biotech crops. For the third consecutive year, Brazil was the engine of growth globally in 2011, increasing its hectarage of biotech crops more than any other country in the world – a record 4.9 million hectare increase, equivalent to an impressive year-over-year increase of 20%. Brazil grows 19% of the global hectarage of 160 million hectares and is consolidating its position by consistently closing the gap with the US. A fast track approval system allowed Brazil to approve 8 events in 2010, and as of 15 October 2011, an additional 6 events were approved in 2011. Brazil approved the first stacked soybean with insect resistance and herbicide tolerance for commercialization in 2012. Notably, EMBRAPA, a public sector institution, with an annual budget of ~US$1 billion, gained approval to commercialize a home-grown biotech virus resistant bean, (rice and beans are the staples of Latin America) developed entirely with its own resources, thus demonstrating its impressive technical capacity to **develop, deliver and approve** a new state-of-the art biotech crop.

The US is the lead producer of biotech crops with 69.0 million hectares (43% of global)

The US continued to be the lead producer of biotech crops globally with 69.0 million hectares, (an average adoption rate of ~90% across its principal biotech crops) with particularly strong growth in maize and cotton in 2011 and the resumption of the planting of RR®alfalfa – alfalfa is the fourth largest hectarage crop in the US (~8 million hectares) after maize, soybean and wheat; RR®alfalfa currently occupies ~200,000 hectares and strong farmer-demand augers well for the future. Adoption could reach as high as 35% to 50% by around 2015 and higher thereafter. RR®sugarbeet, the fastest adopted biotech crop, continues to have a 95% adoption equivalent to ~475,000 hectares. Resistance to corn rootworm was reported in the US and collaborative studies to assess the event are underway. It is timely, to again stress that adherence to good farming practices including rotations and resistance management, are a must for biotech crops as they are for conventional crops. Finally, and importantly, from a regulatory viewpoint, virus resistant papaya from the US was approved for consumption as a fresh fruit/food in Japan effective 1 December 2011.

Bt cotton has transformed cotton production in India

In 2011, India celebrated a decade of successful cultivation of Bt cotton, which has achieved phenomenal success in transforming the cotton crop into the most productive and profitable crop in the country. India's Bt cottons are unique in that they are hybrids and not varieties, as used by all other countries planting Bt cotton. In 2011, plantings of Bt cotton in India surpassed the historical milestone of 10 million hectares (10.6) for the first time, and occupied 88% of the record 12.1 million hectare cotton crop. The principal beneficiaries were 7 million farmers growing, on average, 1.5 hectares of 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 10 years. 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 (Brookes and Barfoot, 2012, Forthcoming)[1]. Thus, Bt cotton has transformed cotton production in India by increasing yield substantially, decreasing insecticide applications by ~50%, and through welfare benefits, contributed to the alleviation of poverty of 7 million small resource-poor farmers and their families in 2011 alone. Approval of Bt brinjal (eggplant) is pending in India whilst the Philippines is planning for an approval in

[1] Brookes, G. and Barfoot, P. 2012. Forthcoming. GM Crops: Global socio-economic and environmental impacts 1996-2010, PG Economics Ltd, Dorchester, UK.

2012/13 with a view to benefiting from the substantial reductions in pesticide applied to this very pest-prone but popular vegetable, referred to as the "queen of the vegetables" in India.

In China, seven million small farmers benefit from 3.9 million hectares of Bt cotton

In China, 7 million small resource-poor farmers (average of ~0.5 hectare of cotton) grew a record 3.9 million hectares of Bt cotton at the highest adoption rate to-date of 71.5%. Government has reconfirmed the national importance of biotech crops, to be developed under strict biosafety standards. Biotech phytase maize and Bt rice, approved for biosafety in 2009, are undergoing routine field testing. Maize has been accorded priority for commercialization to meet a rapidly growing demand for domestically produced biotech maize as an animal feed in response to a demand for more meat. Higher productivity from domestic biotech maize could serve to offset increasing imports of maize. The expected commercial approval of biotech Golden Rice in the Philippines in 2013/14 will be of significance to China, and also to Vietnam and Bangladesh which are evaluating the product with a view to deployment.

Mexico seeks self sufficiency with biotech cotton; biotech maize has the potential to partially offset growing maize imports

In 2011, Mexico planted 161,500 hectares of biotech cotton, equivalent to an adoption rate of 87% and 14,000 hectares of biotech RR®soybean for a country total of 175,500 hectares, compared to 71,000 hectares in 2010; this 146% increase is an impressive performance by any standard. The aim is self-sufficiency in cotton during the next few years. 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 (Bollgard II/Flex and RR Flex) to be planted annually in specific northern states of Mexico. The most significant recent development was the planting of the first biotech maize trials in the country in 2009 and continued in 2010/11. Mexico grows over 7 million hectares of maize but imports about 10 million tons per annum at a foreign exchange cost of US$2.5 billion, which could be partially offset with higher yielding home-grown biotech maize hybrid cultivated in Mexico's northern states. 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 are US$19 million; the potential for the future is substantial (Brookes and Barfoot, 2012, Forthcoming).

Progress in Africa with three countries planting, and another three conducting field trials

Africa made steady progress in 2011 in planting, regulatory and research activities on biotech crops. The three countries already commercializing biotech crops (South Africa, Burkina Faso and Egypt), together planted a record 2.5 million hectares. An additional three countries (Kenya, Nigeria, and Uganda), conducted field trials, with others like Malawi have already approved pending trials. Trials focusing on Africa's pro-poor priority staple crops including maize, cassava, banana and sweetpotato are making good progress. Examples include drought tolerant maize through the WEMA – Water Efficient Maize for Africa project, with on-going second season trials in three countries, Kenya, South Africa and Uganda.

Argentina and Canada, ranked 3rd and 5th in the world, continue to post gains

Argentina ranked 3rd, and Canada ranked 5th, retained their world rankings and both posted record hectarage of biotech crops at 23.7 million hectares and 10.4 million hectares, respectively. The largest gain in Argentina was biotech maize increasing by ~900,000 hectares, and in Canada herbicide tolerant canola increased by ~1.6 million hectares after Canada reported its largest ever canola crop.

Australia planted its largest ever hectarage of cotton of which 99.5% was biotech

Following an unprecedented drought for three years and then floods, Australia planted its largest ever hectarage of cotton of which 99.5% was biotech, equivalent to 597,000 hectares of which 95% was the stacked trait for insect resistance and herbicide tolerance. In addition, Australia grew ~140,000 hectares of herbicide tolerant canola for a total of over ~700,000 hectares for the two biotech crops cotton and canola. There is also significant R & D effort in Australia on biotech wheat and sugarcane.

EU plants record 114,490 hectares of Bt maize, up 26% or 23,297 hectares from 2010

Six EU countries (Spain, Portugal, Czechia, Poland, Slovakia and Romania) planted a record 114,490 hectares of biotech Bt maize, a substantial 26% or 23,297 hectares higher than 2010, with Spain growing 85% of the total in the EU with a record adoption rate of 28%. An additional two countries (Sweden and Germany) planted a token 17 hectares of the new biotech quality starch potato named “Amflora” for “seed” production for a total of 114,507 hectares of biotech crops planted in the EU. 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, both growing less than 1,000 hectares, was associated with several factors, including disincentives for some farmers due to bureaucratic and onerous reporting of intended plantings of Bt maize. The planned release in 2014, subject to approval, of a new biotech potato named “Fortuna” resistant to late blight, (the most important disease of potatoes), is potentially an important product, that can meet EU policy and environmental needs to make potato production more sustainable by reducing heavy fungicide applications and decreasing production losses estimated at up to US$1.5 billion annually in the EU alone, and US$7.5 billon worldwide.

A change of heart in Europe – a strongly-worded open letter from 41 Swedish scientists in support of biotech/GM crops – a petition endorsed by UK scientists; Member of African Biotechnology Stakeholders Forum criticizes EU of *“hypocrisy and arrogance”* in relation to GM crops

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 using science-based assessments of the technology. A contingent of scientists from the United Kingdom endorsed the Swedish petition. **Dr. Felix M’mboyi, A Kenyan national and a member of the African Biotechnology Stakeholders Forum, accused 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, stated 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, the 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.

France's Council of State, the nation's highest administrative court of appeal, upheld the September European Court of Justice ruling which found that France's 2008 prohibition of Monsanto MON810 variety was out of line on procedural grounds. The Council ruled that France's agriculture minister "has not provided the proof (that can) present a major risk to human or animal health to the environment."

A University of Reading study in 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 (US$575) and €929 million (US$1.2 billion) 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."

Contribution of biotech crops to Food Security

From 1996 to 2010, this was achieved by: increasing crop production and value by US$78 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 (Brookes and Barfoot, 2012, Forthcoming).

Adoption by crop – biotech soybean remains the dominant crop

Biotech soybean continued to be the principal biotech crop in 2011, occupying 75.4 million hectares or 47% of global biotech area, followed by biotech maize (51.00 million hectares at 32%), biotech cotton (24.7 million hectares at 15%) and biotech canola (8.2 million hectares at 5%) of the global biotech crop area.

Adoption by trait – herbicide tolerance remains the dominant trait

From the genesis of commercialization in 1996 to 2011, herbicide tolerance has consistently been the dominant trait. In 2011, herbicide tolerance deployed in soybean, maize, canola, cotton, sugarbeet and alfalfa, occupied 59% or 93.9 million hectares of the global biotech area of 160 million hectares. In 2011, the stacked double and triple traits occupied a larger area (42.2 million hectares, or 26% of global biotech crop area) than insect resistant varieties (23.9 million hectares) at 15%. The stacked genes were the fastest growing trait group between 2010 and 2011 at 31% growth, compared with 5% for herbicide tolerance and –10% for insect resistance, this reflects farmer preference for stacked traits. Stacked traits are an increasingly important feature of biotech crops – 12 countries planted biotech crops with stacked traits in 2011, 9 were developing countries.

Need for appropriate, science-based and cost/time-effective regulatory systems that are responsible, and rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries

There is an urgent need for appropriate, science-based and cost/time-effective regulatory systems that are responsible, rigorous but not onerous, for small and poor developing countries. Lack of appropriate regulation is the major constraint that denies poor countries timely access to biotech crops which can contribute, but are not a panacea, to urgent food security needs, in countries such as those in the Horn of Africa where up to 10 million were at risk from famine triggered by drought in 2011, and exacerbated by many other factors.

Global value of the biotech seed market alone was US$13.2 billion in 2011 with commercial biotech maize, soybean grain and cotton valued at ~US$160 billion, or more for 2011

Global value of biotech seed alone was US$13.2 billion in 2011, with the end product of commercial grain from biotech maize, soybean grain and cotton valued at ~US$160 billion or more per year. A 2011 study estimated that the cost of discovery, development and authorization of a new biotech crop/trait is ~US$135 million.

In 2011, the global market value of biotech crops, estimated by Cropnosis, was US$13.2 billion, (up from US$11.7 billion in 2010); this represents 22% of the US$59.6 billion global crop protection market in 2011, and 36% of the US$37 billion commercial seed market. The estimated global farm-gate 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$13.2 billion) – extrapolating from 2008 data, biotech crop harvested products would be valued at approximately US$160 billion globally in 2010, and projected to increase at up to 10 - 15% annually.

Status of Approved Events for Biotech Crops

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 had 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. 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. 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 in1996, are reviewed as well as their potential contribution to feeding the world in the future, within the context of the Challenges and Opportunities for biotech crops globally.

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.

Population, Poverty and Hunger

The 31st of October 2011 was the world's birthday, when the 7th billion living person was born. The most recent study by the Population Division of the United Nations (UN) has increased its projection of global population from 9.2 to 9.3 billion for 2050.[2] More importantly and unlike previous estimates which predicted plateauing in 2050, continuing global growth is now projected until the end of this century to

[2] United Nations, 2011 World Population Prospects: The 2010 Revision (www.unpopulation.org)

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 representing 15% of global to an extraordinary high of 3.6 billion, representing ~35% of global by 2100. "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.

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. 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 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. Ten years ago, in 2001, global society made a pledge, The Millennium Development Goal (MDG), to cut poverty by 50% by 2015, with 1990 as the starting benchmark. 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.

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 other Asian mega varieties including the variety PSBRc82 in the

Philippines, and BRRI dhan 29, a Bangladesh variety. In 2010, IRRI completed one season of confined field tests of IR64-GR and in 2011, 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). 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 a similar cost as current conventional varieties. Golden Rice is expected to be first released in the Philippines in 2013/14.

Contribution of biotech crops to Sustainability

Biotech crops are contributing to sustainability 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**

  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 276 million tons. The corresponding figures for 2010 alone was 76% of the total gain due to increased yield (equivalent to 44.1 million tons), and 24% due to lower cost of production (Brookes and Barfoot, 2012, 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 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 (Brookes and Barfoot, 2012, Forthcoming) 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.

- **Contributing to the alleviation of poverty and hunger**

  To-date, biotech cotton in developing countries such as China, India, Pakistan, Myanmar, Bolivia, Burkina Faso and South Africa have already made a significant contribution to the income of ~15 million small resource-poor farmers in 2011; 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.

- **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. 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 7.9 million cars off the road. Thus in 2010, the combined permanent and additional savings through sequestration was equivalent to a saving of 19 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.

Climate change and crop production

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 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 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.

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, who are already vulnerable and food insecure, are likely to be the most seriously affected. IFPRI estimated that 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; World Bank, 2010).

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 an increase of 20% in child malnutrition. To remedy these negative effects, IFPRI is recommending aggressive annual 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.

Contribution of biotech crops to 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 growing 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, have been 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." The supportive views of climate change specialists have in turn positively influenced the views of some environmentalists. 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. 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.

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.

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 Forester 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 over 150 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 13 countries where they have been commercialized, growing from less than one million hectares globally in 1996 to ~25 million hectares in 2011. 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 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.

Of the 13 countries which grew biotech cotton in 2011 four grew more than 1 million hectares viz –: India 10.6 million hectares, USA (4.0), China (3.9), 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. 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 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 billion and US$5 billion for 2010 alone (Brookes and Barfoot, 2012, Forthcoming).

Unmet needs for biotech cotton

The largest group 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 (which just 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 family of 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 the global lead in the development of an innovative technology and its timely deregulation

The deployment of multiple resistance genes from wild potatoes into commercial varieties (cisgenes) offers potato farmers globally the best opportunity for achieving durable resistance to late blight of potato, the cause of the 1845 Irish famine in which 1 million people perished; remarkably, 150 years later it is still the most devastating disease of potatoes (Haverkort et al, 2008)[3]. 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. Over 50 years of conventional potato breeding has failed to result in durable resistance to this devastating disease which became more aggressive in the 1980s when more virulent strains of the disease evolved. Public and private institutions have joined together, led by EU science, to create a network (Euroblight) dedicated to sharing knowledge and technology, to hasten the demise of late blight in potatoes. Incorporating multigenic resistance into commercially important potato varieties through cisgene transformation is now possible as a practical solution. This is a near term prospect, facilitated by several EU research institutions using innovative technology to develop durable resistance based on cisgenes. However, the value of this unique innovation to farmers in the EU and globally, estimated at up to US$7.5 billion annually, cannot be realized unless the barrier imposed by the implementation of onerous EU regulation can be resolved. This is a unique opportunity for the EU to take the lead globally to develop a workable regulatory framework that will enable commercial production of cisgene crop varieties in a cost/time efficient manner so this technology can reach its full global potential. In brief, the rationale for the EU taking the global lead in this innovative technology, and importantly, the implementation of responsible, science-based and cost/time effective GM crop deregulation, is summarized below:

- **It is an <u>innovative technology</u> espoused by the EU in its science policy directives,** and it is EU scientists that are exerting global leadership in its development. EU countries which support active R & D programs in biotech potatoes include the Netherlands, United Kingdom, Denmark and Germany;

- **It will confer, for the first time, a sustainable and durable level of resistance to potato late blight, a devastating disease that has plagued the world for over 150 years,** which today costs global society up to US$7.5 billion each year and US$1.5 billion in EU countries;

- **Success will result in decreased use of pesticides and contribute to a safer and more sustainable environment.** 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;

- **Increased potato yield with this technology will contribute to world food security – potato is the fourth most important food crop in the world.** Productivity increases will be higher in countries with less intensive cropping systems where fungicide applications are too costly, such as Poland, where current yields are significantly constrained by late blight. Know-how on increasing productivity and controlling late blight could be shared with potato-growing developing countries, (which grow more than half the potatoes in the world) through EU international development projects with food security and alleviation of poverty, as humanitarian goals;

[3] Haverkort AJ, PM Boonekamp, R Hutten, E. Jacobsen, LAP Lotz, GJT Kessel, RGF Visser, and EAG 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/

- **Conventional breeding of potato is very expensive in time and resources, and alone, has not, and will not, result in durable resistance to late blight.** The use of biotechnology in conjunction with a conventional breeding program, has the potential to significantly reduce costs and time;

- **Biotech/GM crops, modified with cisgenes technology to incorporate essential multiple marker-free R genes, can confer durable resistance, and is entirely compatible with co-existence.** In the EU, there are no wild relatives that can cross-breed with potatoes, and unlike a crop like canola, gene flow due to cross pollination is not an issue in vegetatively-propagated potatoes;

- **The new and urgent challenges associated with climate change, demand faster delivery of improved crops from breeding programs and the new biotechnologies are a tool to meet this need.** Climate change results in more pressure and urgency, to counter, for example, more frequent and more severe epidemics, pest infestations, and drought;

- **A unique opportunity exists to rapidly broaden the benefits** by building on a successful late blight initiative through the addition/pyramiding of already developed transgenes that code for virus disease and insect resistance;

- **Internationally recognized institutions/companies from the public and private sector in the EU 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 urgently needed now is political will and support from the EU to implement a science-based approval system that would provide a cost/time effective deregulation process for commercialization of a technology which can benefit 500 million EU citizens; importantly EU support would also encourage EU public institutions and companies to practice innovation in food technology and exert global leadership in food security initiatives, consistent with EU policy;

- **Unlike transgenics, cisgenics do not involve cross genera genes and hence regulatory bodies can justifiably apply less onerous science-based requirements that would expedite responsible deregulation.** Such appropriate regulations would have enormous impact for a myriad of institutions in the public sector in the EU, and globally, particularly resource-poor developing countries, which are urgently in need of new technologies to ensure food security but are unable to engage in either cisgenics or transgenics because of the prohibitive and long-term cost of gaining deregulation and also import approval to lucrative markets such as the EU.

Several groups in Europe have recently called for a review of GM regulation. In October 2011, 41 leading Swedish biological scientists, submitted a letter to politicians and environmentalists, 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.

A recent publication from Europe (Tait and Barker, 2011)[4] 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."

A full version of the above proposal on potato late blight is included in the full Brief 43, available from ISAAA.

Public-Private Sector Partnerships and the three streams of technology products: private, public-private, and public

Understandably, public–private sector partnerships is a subject that has evoked 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.

[4] 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)

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 benefits (substantially less pesticides applied on a food crop), 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 up to 3.6 billion in 2010, 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 assessed as 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 a new country 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 may 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 adoption rate of the four current large hectarage biotech crops (maize, soybean, cotton, and canola), which collectively represented 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 consumer-friendly 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 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 an 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 is 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, Portugese 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).*[5]

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;

[5] 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

- 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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