Biotech Crops *in* Africa

the Final Frontier

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Background

Over five decades ago, the world experienced a striking breakthrough in Agriculture, the Green Revolution, which saved at least a billion lives from starvation in Asia and Latin America. Africa, then largely fed through subsistence farming, missed that boat and the consequences have been felt for years since. With the new era of advanced agricultural technologies, more specifically modern biotechnology, Asia, Latin America and the West are leading the way again, yet Africa, with over 200 million starving people, is certainly in greater need. What's more, up to 80 percent of Africa's population depends on agriculture, but per capita productivity remains the lowest in the world as a result of, among other factors, minimum application of modern scientific and agricultural technologies.

Challenged by this reality and in a bold move to make a quick turnaround on the continent's most important socio-economic lifeline, African governments have been setting targets towards improving productivity and efficiency in the agricultural sector. In 2003, for example, under the Comprehensive Africa Agriculture Development Programme (CAADP), the Heads of State and governments' meeting in Mozambique endorsed the Maputo Declaration, in which signatories committed to allocating at least 10 percent of their national budgets to agriculture.

At the 2009 Africa Union (AU) summit, which focused on "Investing in modern agriculture technologies for economic growth and food security," Kenya's President Mwai Kibaki challenged African governments to go beyond upholding the Maputo Declaration, to raise their annual budgetary allocation to the sector to at least 13 percent by 2012.

At the global level, it is becoming increasingly apparent that enhancing crop yields, instead of increasing cultivated area, will be required to bring about the necessary increases in the food production needed to meet the demands of a rapidly growing and more sophisticated society.

One area believed to hold great promise towards this endeavour is the adoption of new and emerging technologies, including modern biotechnology (Juma and Serageldin 2007). Consequently, there has been considerable effort towards setting up special governance and capacity building mechanisms to advance the application of biotechnology in agriculture.

Several African countries have put in place policies and regulatory frameworks to support the responsible and safe use of biotechnology. The signs of progress have not been limited to regulation; African scientists are gaining recognition the world over for their breakthrough innovations in modern agriculture. For instance, Professor Gebisa Ejeta an African scientist, was awarded the 2009 World Food Prize for his work on sorghum, one of Africa's most important staples. In 2008, Burkina Faso and Egypt joined South Africa which was the only country on the continent growing commercial biotech crops raising the number of African countries benefiting from the technology to three in just one year.

These developments, together with increased political will and emerging vibrant biosciences research platforms, are indicators that Africa is coming of age in embracing science to revolutionalise her agricultural sector, contrary to the widely held belief that the continent is not ready for new technologies.

Introduction

Agriculture continues to be a fundamental instrument for sustainable development and poverty reduction in sub-Saharan Africa (SSA), accounting for about 29 percent of the region's gross domestic product (GDP). The sector's dominant role as a source of foreign exchange and as an engine for overall socio-economic development, through forward and backward linkages with the manufacturing sector, also remains unchallenged in many SSA countries. On average, 60 percent of the total population in SSA lives in rural areas, with people depending mainly on agriculture, fishing and forestry for their livelihood (IAASTAD, 2009).

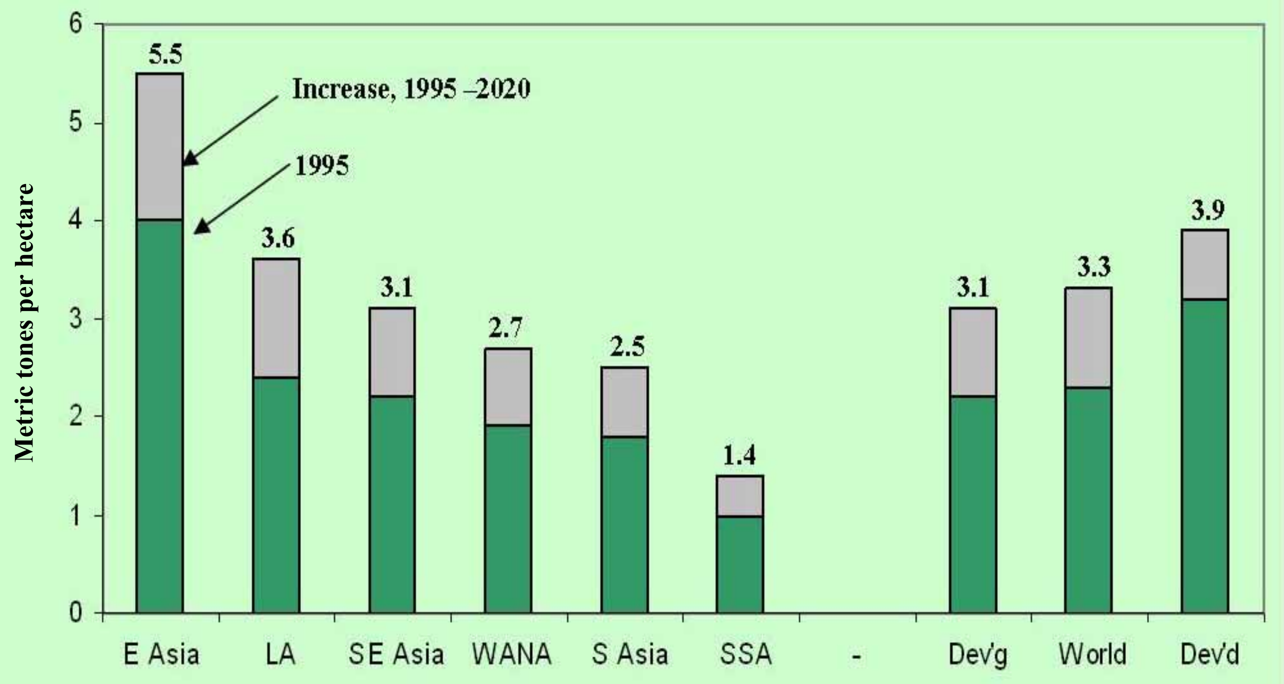
Yet despite the importance of agriculture on the continent, 16 of the 18 most undernourished countries in the world are in SSA, and it remains the only region where per-capita food production continues to deteriorate year on year.

While the gap between average cereal yields in the developed and developing countries is slowly beginning to narrow, SSA continues to lag behind (Pinstrup-Anderson *et al.*,1999), (Figure 1).

The Food and Agriculture Organization (FAO, 2009) quoted by a report on the State of Food Insecurity in the World (SOFI), predicts that the number of people living in hunger will reach an all time high of 1.2 billion, aggravated by persistently high prices of staple foods following the food crisis of 2006–2008. At the 16th session of the United Nations Commission on Sustainable Development (UNCSD-16) in 2008, the Organization for Economic Co-operation and Development (OECD) stated that about 265 million people, translating to one out of every three persons in Africa, are undernourished, as compared to about 17 percent for the developing world as a whole. Currently there are 25 countries in Africa out of the 38 countries globally experiencing perpetual food emergencies.

Picture 1. Bt Maize in a confined field trial, Kenya

Figure 1. Global cereal yields trends, 1995-2020



Source: P. Pinstrup-Anderson et. al. 1999

Yet Africa has the potential not only to meet its own food security needs, but also to catalyze broader economic growth. Indeed, the continent is well-endowed with a wealth of physical and biological natural resources. Africa's lagging agricultural performance is commonly attributed to many interrelated factors, including a rapid decline in food production caused by flawed agricultural policies, political and institutional instability, chronic droughts, disease epidemics such as malaria and HIV/AIDS, increased environmental degradation, deterioration of infrastructure and declining investments in agricultural research. However, as Paarlberg (2008) argues, some of these factors are not unique to Africa. Furthermore, even countries like Ghana, Kenya and Tanzania, classified as relatively peaceful and politically stable, are yet to experience substantial agricultural growth and reduced poverty.

Paarlberg attributes poverty and hunger in Africa to low land and labour productivity; "For farmers in Africa today, productivity is low and poverty high because far too little science has been brought to farming. Currently, only 4 percent of Africa's farmland is irrigated, less than 30 percent is planted to improved seeds, and average fertilizer in use is only 9 kg per hectare, compared to 117 kg per hectare in the industrial world" (Paarlberg, 2008:187). To enhance land and labour productivity, he posits that African farmers must utilize improved technologies such as improved draft animals, fertilizers and insect and disease resistant crop varieties. This brings into sharp focus the role that advanced agricultural technologies including modern biotechnology could play in advancing agriculture for socio-economic development in Africa.

Biotechnology is defined as "any technique that uses living organisms or substances from these organisms to make or modify a product for a practical purpose" (FAO, 2004). The tools of biotechnology are based on several scientific techniques, the major ones being tissue culture, genetic modification (genetic engineering) and molecular breeding (marker-assisted selection). Biotechnology has diverse applications in agriculture, health, industry and the environment. Therefore, it should not be confined or equated to genetic modification (GM), which is one of the component within a broader field.

Why biotechnology?

A growing body of evidence and experiences from 13 years of commercial cultivation reveals that modern biotechnology has the potential to significantly increase productivity per unit area of land, reduce the use of pesticides and offer safer and more nutritious food, and consequently contribute to environmental sustainability (FAO, 2004; Juma and Serageldin, 2007; James, 2008; Brookes and Barfoot, 2008).

The global area under modern biotech crops (or GM crops) has increased from 1.7 million hectares in 1996 to 125 million hectares in 2008-a 74-fold increase. According to the *2008 Global Status of Commercialised Biotech/GM Crops* report authored by Clive James, the number of farmers growing biotech crops reached 13.3 million in 25 countries, up from 22 countries in 2007. The most recent survey of the global impact of biotech crops for the period 1996 to 2007 (Brookes and Barfoot, 2009) estimates that the global net economic benefit to biotech crop farmers in 2007 alone was US$ 10 billion (US$6 billion for developing countries and US$4 billion for industrial countries). The accumulated benefit during the period 1996 to 2007 was US$44 billion, with US$22 billion each for developing and industrial countries. Therefore, biotech crops have improved the income and quality of life of farmers and consumers, and contributed to the alleviation of poverty.

India's experience is particularly dramatic. A record five million smallholder farmers planted Bt cotton on 7.6 million hectares in 2008, realizing a 39 percent reduction in insecticide usage, 31 percent increase in yields, and 88 percent ($250/ha) increase in profitability (James, 2008).

Biotechnology contributes towards arresting the effects of climate change, mainly through savings in carbon dioxide (CO_2) emissions associated with fewer insecticide and herbicide sprays, and from conservation tillage (herbicide-tolerant biotech crops facilitate conservation tillage). In 2007, for example, reduced spraying resulted in an estimated savings of 1.1 billion kg of carbon dioxide (CO_2), equivalent to reducing the number of cars on roads by half a million. A further 13.1 billion kg of CO_2 were saved by conservation tillage, due to increased soil carbon sequestration, equivalent to removing 5.8 million cars off the road.

Picture 2. Bt cotton farmers in the field sharing experiences, India

While acknowledging that biotechnology will not be a panacea for the plethora of problems facing sub-Saharan Africa's agricultural sector, the efforts being directed towards addressing production constraints cannot be addressed by conventional breeding alone. And as UN Secretary General Ban Ki-moon declared at the annual meeting of the Commission for Sustainable Development in May 2008, "to mitigate these threats, there is need for a fresh generation of agricultural technologies to usher in a second green revolution in Africa-one that permits sustainable yield improvements with minimal environmental damage and contributes to sustainable development goals."

In this context, drought-tolerant traits would ensure that food security is realized in drought-prone areas where one third of Africa's population lives.

Further, rising food prices and the threat posed by competition for food crops by the biofuel industry imply that there is need to invest in technologies that will contribute towards the production of abundant and cheaper food.

The comparative advantage of currently available biotech crops is that they confer inbuilt defense against insect-pests and tolerance to weed killers, making them suitable for the African farmer. Biotechnology is scale-neutral and with proper stewardship, even the very small and marginal farmers stand to benefit.

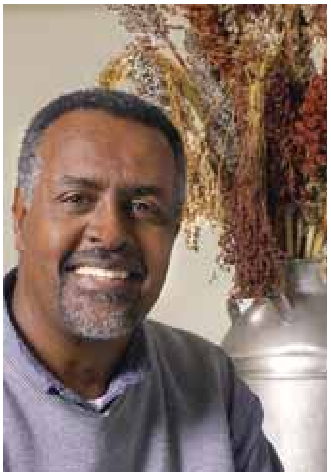
Integrating the best of conventional breeding with the best of modern biotechnology would constitute the most realistic approach for SSA. Further, to reap maximum benefits, African farmers require high quality seed, good agronomic practices, appropriate inputs and support services. Several initiatives including the Alliance for a Green Revolution in Africa (AGRA) are closing this gap by developing and distributing appropriate seeds for various African local environments. The establishment of responsible and efficient regulatory systems that are appropriate for African countries will also assure public confidence, encourage local biotech innovation based on local priority needs, and help mitigate against any possible adverse effects on human health and the environment. Ultimately improved communication with society about the attributes and potential of biotech crops will also play a major role in enhancing adoption and acceptance.

Recent developments on the African agricultural scene

History abounds with examples of how availability and access to science-improved farming technologies by farmers in Europe and Asia raised productivity and led to what is now commonly referred to as "a science-based escape from widespread rural poverty". Asia's Green Revolution in the 1960s through the 1980s was based on agricultural technological breakthroughs that developed high-yielding varieties of rice and wheat, saving nearly one billion people from hunger.

While Africa has not experienced significant quantum leaps in food production, recent developments in agriculture have demonstrated the continent's ability to apply cutting-edge agricultural science with significant results.

The 2009 World Food Prize, for example, was awarded to Professor Gebisa Ejeta, an Ethiopian national based at Purdue University, for his work on sorghum, a staple diet for more than 500 million people in sub-Saharan Africa. Professor Ejeta's scientific breakthroughs in breeding for drought-tolerant and striga-weed-resistant sorghum enhanced the food supply of hundreds of millions of people in SSA. Combined with his persistent efforts to foster economic development and the empowerment of subsistence farmers, Prof. Ejeta has helped create several agricultural enterprises in rural Africa.



Picture 3. Professor Gebisa Ejeta-Winner of World Food Prize, 2009

Another African scientist, Dr. Monty Jones from Sierra Leone, received the 2004 World Food Prize for his work on rice. Jones, named by Time Magazine in 2008 as one of "the world's most influential people," led a team of plant breeders and molecular biologists at the West Africa Rice Development Association (WARDA, now the Africa Rice Center) in developing the widely adopted New Rice for Africa (Nerica). The upland rice variety Nerica is not restricted to growing in paddies, thus enabling African farmers to grow rice in environments not previously thought possible.

Several African countries have since adopted the technology including: Nigeria with over 30 percent expansion in upland rice cultivation; Guinea, where the Nerica area has quickly superseded the modern varieties introduced by the national research system; and Uganda, which launched the Upland Rice Project in 2004, with Nerica as a major component. The Uganda National Agricultural Research Organization (NARO) reported an almost nine-fold increase in the number of rice farmers, from 4,000 to over 35,000 between 2005 and 2007. Over the same period, the country almost halved its rice imports, from 60,000 to 35,000 tonnes, saving roughly US$ 30 million.

Picture 4. Dr. Monty Jones (left) with farmers in a NERICA field

When Dr. Jones set up the biotechnology research programme in 1991, some 240 million people in West Africa were dependent on rice as their primary staple food, but the majority of the rice was imported, at an annual cost of US$ 1 billion.

Nearly a decade ago the improvement of banana (*Musa* spp.) through tissue culture techniques won the First Place Research Medal in the Global Development Network Awards for Science and Technology for Development in the year 2000. The project was a collaborative initiative among several local and regional partners led by the Kenya Agricultural Research Institute (KARI) and facilitated by the International Service for the Acquisition of Agri-biotech Applications (ISAAA) *Afri*Center. The project demonstrated the potential of conventional biotechnology to alleviate hunger by increasing food production and reducing poverty among nearly 1 million small-scale farmers in eastern Africa and raising household incomes by about 38 percent. Smallholder farmers, the majority of them women, have been able to contribute to family welfare by paying school fees for their children, expanding their farm enterprises with high-value ventures like dairy farming and goat-keeping, thereby acquiring cell phones and bicycles, which have further improved their access to other development services. The story of the tissue-cultured banana farming has continued to dominate international circles with more players for example, Africa Harvest led by Dr. Florence Wambugu a prominent biotech voice in Africa, replicating the model with great success.

The above three projects and several others represent a unique learning experience for all involved in the dissemination of new technologies to small-scale farmers. For example, resource-poor farmers adopting first-generation technologies being transferred through current projects represent motivated clients who could benefit from a further enhancement of technology such as genetic engineering, of the same or other crops. This then becomes a vehicle and platform for scaling up and incorporating more enhanced technologies to an improved crop which already has the confidence of farmers using a distribution system that is already in place.

With these remarkable achievements through conventional biotechnology, Africa is now poised to take advantage of modern biotechnology. By tapping into the abundant knowledge on the technology that has been developed elsewhere, the continent could move faster than her counterparts in other developing countries without needing to re-invent the wheel. There are also positive indications that the significant barriers that hinder biotech applications on the continent are starting to decline as elaborated further in this publication.

Picture 5. TC Banana farmers admiring their healthy crop

Signs of change: The advent of agricultural biotechnology in Africa

From Cape Town to Cairo to the Gold Coast, there is a wave of change in Africa in literally all spheres of life politics, sports, religion, business, education, and most significantly in agricultural sciences, technology and innovation. The majority of countries have developed their manifestos for success (e.g. Kenya's Vision 2030; Malawi's Vision 2020 and Nigeria's Vision 2020) all rooted in science and technology as a key driving force.

In her vision 2020, Nigeria envisions becoming one of the 20 largest economies in the world by consolidating its leadership role in Africa and establishing herself as a significant player in the global economic and political arena by 2020. One of the key pillars for achieving this vision will be "a modern technologically enabled agricultural sector that fully exploits the vast agricultural resources of the country, ensures national food security and contributes significantly to foreign exchange earnings." Nigeria aims to raise productivity through the application of modern scientific agricultural methods including biotechnology (Nigeria Vision 2020; www.nv2020.org)

Political support for biotechnology in Africa

There is increased political will and support for biotech crops in realization of their potential to contribute to more affordable food production and food security (James, 2008). Indeed, various African leaders have come out candidly in support of biotechnology. While chairing the cabinet meeting in July 2008 that approved Malawi's National Biotechnology Policy, President Bingu wa Mutharika who is also the country's Minister for Education, Science and Technology said, "My government recognizes the pivotal role biotechnology can play towards economic growth and poverty reduction."

"My government recognizes the pivotal role biotechnology can play towards economic growth and poverty reduction."

(Malawi's President Bingu wa Mutharika)

The new policy provides a framework for effective implementation of biotechnology programmes and activities in Malawi. The Malawi President said that he believes biotechnology would facilitate the country's speedy attainment of its capacity to be food-secure, create wealth and achieve socio-economic development as stipulated in the Growth and Development Strategy and the country's Vision 2020.

In April 2008, State Minister of Finance in Uganda, Honourable Fred Jachan Omach approved the national biotechnology and biosafety policy. The policy states "Biotechnology is one of the frontiers of agricultural and industrial research in the world today and Uganda should not be left behind in these new technological advancements."

The policy's goal towards the safe application of biotechnology will be one of the instruments in poverty eradication, improvement of health care, food security, industrialization and the protection of the environment. The Minister further stated the approval of the policy was imperative, given that the country had already established an ultra-modern national agricultural biotechnology center, where genetic modification of cotton, bananas and other crops is being conducted.

During the opening of a Level-II biosafety greenhouse complex at the Kenya Agricultural Research Institute (KARI) in 2004, President Mwai Kibaki affirmed that the government strongly supported the use of genetically modified (GM) crops and other modern scientific technologies to boost agriculture. He said, "we must embrace and apply modern science and technology in farming. Indeed, there is evidence that countries which have embraced modern agricultural technologies have improved economic performance, reduced poverty, and ensured greater food security for their people." Such political statements are being translated into policy as evidenced by the numerous policy initiatives and administrative processes being undertaken on the African continent to address modern biotechnology.

Picture 6. Kenya's President opening a biosafety Greenhouse

Biotechnology policy initiatives in Africa

A comprehensive policy to guide research, development and commercialisation of modern biotechnology products is an important first step in defining a country's biotechnology agenda. A national biosafety law or strategy is also essential as it provides a set of principles to guide subsequent development and implementation of a legal biosafety framework and associated regulation that both responds to national needs and conforms with global obligations and trends.

An examination of Africa's biotechnology arena identifies a cross-section of diverse policy initiatives at the regional, sub-regional and national levels, an indication that biotechnology considerations are at the core of the development agenda. Table 1 captures some of these policy initiatives.

Bt maize in a field trial site

A field of biotech /GM soybeans

Table 1. Some biotechnology policy initiatives in Africa

Initiative	Institution	Objectives /Role	Achievements
High Level Africa Panel on Biotechnology (APB)	African Union (AU)	Advise the AU on current and emerging issues in the development and application of modern	The APB has produced a report, "Freedom to Innovate" (www.africa-union.org www.nepadst.org), with key policy recommendations on the way forward for biotechnology development.
African Biosciences Initiative (ABI)	The New Partnership for Africa's Development (NEPAD)	Establish centers of excellence for Science and Technology to generate a critical mass of technological expertise for improving agricultural productivity through biotechnology applications.	Four regional biosciences networks established: SANBio for South Africa, BecANet for eastern and central Africa, WABNet, for West Africa, & NABNet for North Africa. Flagship programme: the Comprehensive Africa Agricultural Development Programme (CAADP), focusing on biotechnology, biodiversity, and indigenous knowledge systems.
Southern Africa Development Community (SADC) Advisory Committee on Biotechnology and Biosafety (SACBB).	15 SADC countries	Advise SADC policy makers on handling of GM food aid; policy and regulations; capacity building; and public awareness and participation.	Developed policies and guidelines on handling GM food aid; harmonized policies and regulations; capacity building and public awareness in SADC member states.
Common Market for Eastern and Southern Africa (COMESA) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)	19 COMESA countries	Establish regional policies and guidelines for centralized risk assessment on the commercial planting of and trade in GM crops; and food aid with GM content.	The Regional Approach to Biotechnology and Biosafety in Eastern and Southern Africa (RABESA) programme initiated in 2003; Status of biotechnology and biosafety frameworks assessed (2008); Draft guidelines on commercial planting of GMOs, trade and access to GM food aid developed; Roadmap for implementation established
Economic Community of West African States (ECOWAS)	14 ECOWAS countries (*Guinea suspended in 2008 after a coup d'état)	Adopt a regional approach to biotechnology and biosafety	Recommendations on the use of biotechnology; development of regional biosafety regulations and communication strategy.

Source: ISAAA, AfriCenter, 2009

Picture 7. A scientist working in a biotechnology laboratory

Progress in biotechnology research and development in Africa

Much of the biotechnology debate in Africa presupposes that African countries are being pushed to accept products developed elsewhere. To the contrary, substantial research and development programmes on biotechnology are taking place in many parts of the continent. While investments have been low particularly in public-sector R&D, different innovative public–private partnerships (PPP) have been adopted to improve the pace of research on and delivery of modern agricultural techniques in Africa, with significant outputs. Through these partnerships, research is being undertaken on various crops such as cotton, maize, cassava, sweet potato, banana, soybean, groundnut and cowpeas, among others.

In Kenya confined field trials of Bt cotton that have been going on for the last 5 years have yielded promising results (Waturu *et al.,* 2009; Miriti *et al.,* 2008). The trials have indicated that Bt cotton yielded 25 percent more and gives higher positive net benefits than the conventional cotton varieties, even though the experimental Bt cotton was not from locally adapted varieties.

These results also confirmed a 20 percent reduction in costs when untreated Bt cotton (06Z604D) was grown, as compared to a conventional variety (HART 89M) treated for all insect pests. This indicates that Bt cotton not only increases yields manifold but also substantially reduces pesticide applications. The latter would reduce pesticide poisoning, thus benefiting people, wildlife and the environment. These results are consistent with widely published data on the benefits of Bt cotton from countries such as India and South Africa (Biotech Crops in India, 2009; Brookes and Barfoot, 2009; James, 2008; Morse *et .al.,* 2005). A summary of some on-going crop biotech research activities in Africa is presented in Table 2.

Picture 8. Dr. Charles Waturu, Principal Investigator, Bt cotton project, Kenya

Table 2. Some on-going biotech/GM crops research activities in Africa

Country	Crop	Trait	Event	Institutions involved	Stage
Kenya	Maize, *Zea mays l.*	Insect resistance	Mon 810	KARI, CIMMYT, Monsanto, University of Ottawa, Syngenta and Rockefeller Foundations	Confined field trials (CFT)
		Insect resistance	Cry1Ab 216		
		Insect resistance	Cry 1Ba		
	Cotton, *Gossypium hirsutum L.*	Insect resistance	Bollgard II	KARI/Monsanto	CFT
	Cassava, *Manihot esculenta*	Cassava mosaic disease	AC1-B	KARI, Danforth Plant Science Center	CFT
	Sweet potato, *Ipomoea batatas*	Viral disease	CPT 560	KARI/Monsanto	CFT
Uganda	Cotton, *Gossypium barbadense*	Insect resistance / herbicide tolerance	Bollgard IR/HT	NARO/Monsanto, ABSPII, USAID & Cornell University	CFT approved
	Banana, *Musa sp.*	Black sigatoka	Chitinase gene	NARO-Ug, University of Leuven	CFT
				IITA,USAID	
	Cassava, *Manihot esculenta*	CMD and cassava brown streak disease (CBSD)		NaCRRI, CIP, Danforth Plant Science Center	Application for CFT approved by the NBC.
Nigeria, Burkina Faso, Ghana	Cowpea, *Vigna unguiculata*	Insect resistance	*Cry1Ab and nptII genes*	AATF, NGICA IITA, Purdue University, Monsanto, Rockefeller Foundation USAID, DFID, CSIRO Australia. INERA, IAR, The Kirkhouse Trust	CFT approved in Nigeria
Kenya, Tanzania, Uganda, S.Africa & Mozambique	Maize, *Zea mays L.*	Drought tolerance	CspB-Zm event 1	AATF, NARIs in the 5 countries, CIMMYT, Monsanto, Bill & Melinda Gates Foundation, Howard G. Buffett Foundation	CFTs pending regulatory approval in Kenya CFT in South Africa on-going
South Africa Burkina Faso Kenya	Sorghum, *Sorghum bicolor*	Nutrition enhancement		A consortium of 9 institutions led by AHBFI funded by Bill & Melind Gates Foundation	Contained Greenhouse Trials (CGH) - Kenya and South Africa
South Africa	Maize, *Zea mays L.*	Drought tolerance	MON 89034, MON 87460	Monsanto	CFT
		Herbicide tolerant	Syngenta GA21	Syngenta	Field trial release
		Insect resistant	Syngenta MIR162		Field Trial release
		Insect/herbicide tolerance	Syngenta BT11xGA21		
			BT11xMIR162		
			Pioneer 98140	Pioneer	CFT
			Pioneer 98140 x Mon810		
	Cassava, *Manihot esculenta*	Starch enhanced	TMS60444	ARC-IIC	Contained trial
	Cotton, *Gossypium hirsutum L.*	Insect/herbicide tolerance	Bayer BG11xRR FLEX;	Bayer	Trial release
			GHB119		
			BG11xLLCotton25		
			Cotton T304-40		
		Herbicide tolerance	Cotton GHB614		
			CottonGHB614xLLCotton25		
	Potato, *Solanum tuberosum L.*	Insect resistance	G2 Spunta	ARC-OVI	Field trials
	Sugarcane, *Saccharum officinarum*	Alternative sugar	NCo310	SASRI	Field trials
Egypt	Maize, *Zea mays*	Insect resistance	MON810	Monsanto	Approved for commercialisation
		Insect resistance	Not available	Pioneer	Field trails
	Cotton, *Gossypium barbadense*	Salt tolerant	MTLd	AGERI,	CGH
	Wheat, *Triticum durum L.*	Drought tolerant	HVA1	AGERI	Field trials
		Fungal resistance	Chitinase	AGERI	CGH
		Salt tolerant	MTLd	AGERI	Contained trial
	Potato, *Solanum tuberosum L.*	Viral resistance	Cry V	AGERI	Filed trials
			CP -PVY	AGERI	Field trials
	Banana, *Musa sp.*	Viral resistance	CP-Banana CMV	AGERI	Contained trial
	Cucumber, *Cucumis sativus*	Viral resistance	Cp-ZYMV	AGERI	Field trial
	Melon, *Cucumis melo*	Viral resistance	Cp-ZYMV	AGERI	Field trial
	Squash, *Cucurbita pepo*	Viral resistance	Cp-ZYMV	AGERI	Contained trial
	Tomato, *Lycopersicon esculentum*	Viral resistance	CP- REP- TYLCV	AGERI	Contained trials

Source: ISAAA AfriCenter, 2009

Commercialisation of biotech crops in Africa

As a result of consistent and substantial economic, environmental and welfare benefits, a record 13.3 million large, small and resource-poor farmers planted biotech crops in 2008. It is noteworthy that two of the three countries that planted biotech crops for the first time in 2008 globally were African, and, for the first time, there was a lead country commercializing biotech crops in each of the three principal regions of the continent: South Africa in southern Africa; Burkina Faso in West Africa; and Egypt in North Africa. This broad geographical coverage is of strategic importance in that it allows the three countries to become role models in their respective regions. It also allows more African farmers to become practitioners of biotech and to benefit directly from "learning by doing," which has proven to be an important feature in the success of Bt cotton in China and India. This section captures the experiences of the three African countries growing biotech crops commercially.

South Africa

Biotechnology development in South Africa

South Africa boasts a highly advanced agricultural industry based on first-generation biotechnologies and internationally competitive animal and plant breeding capabilities. The country has been involved with biotechnology research and development for over 20 years and has developed a globally competitive biotechnology industry. In 2003, a survey of biotechnology activities conducted in the country identified a total of 622 research groups involved in biotechnology-related activities, with at least 154 biotechnology products and services (www.africabio.com).

To date, South Africa has commercialised Bt maize (both yellow and white), soybean and Bt cotton, (Table 3) and continues to maintain its number eight position in the world ranking of biotech crop area.

The progressive and steady increase in adoption of biotech crops in South Africa is highlighted in Figure 3. The total hectarage of biotech crops increased consistently from 197,000 hectares in 2001 to 573,000 hectares in 2004, reaching 1.8 million hectares in 2008. Of the three biotech crops grown, Bt maize has always occupied the largest area, with 166,000 hectares in 2001 (84 percent of the total biotech crop area) and 1.6 million hectares in 2007 (89 percent of all biotech crops). A record US$383 million in the form of benefits from these crops for the period 1998 to 2007 was realized, with benefits for 2007 alone estimated at US$227 million (Brookes and Barfoot, 2009).

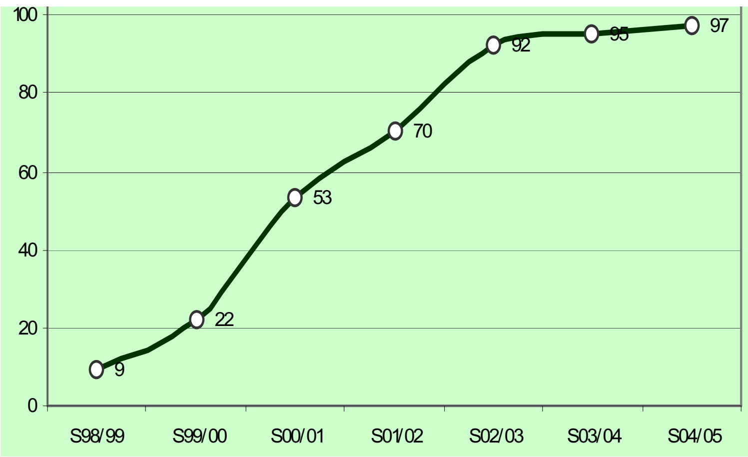
Status of biotech/GM cotton in South Africa

Bt cotton was the first GM crop variety to be grown commercially in sub-Saharan Africa. Early adopters were small-scale farmers in Makhatini Flats in KwaZulu-Natal who have been growing the crop since 1998 (Figure 2). Total cotton plantings in 2008 were estimated at 13,000 hectares, up from 10,000 hectares in 2007, of which 12,000 hectares or 92 percent were of biotech cotton. This constituted 83 percent (or 10,000 hectares) of Bt/herbicide-tolerant stacked traits, 9 percent (1,000 hectares) of

Picture 9. A Kenyan parliamentarian with farmers in a Bt cotton field, South Africa

herbicide-tolerant and 8 percent of Bt trait. A new variety with hairy leaves has been introduced along with the Bt trait to protect against non-target sucking insect pests that are not controlled by the Bt toxin alone.

Figure 2. Adoption of biotech/GM cotton in South Africa, 1998-2005



Source: Makinde, 2006

Benefits from biotech/GM cotton

The Agricultural Research Council conducted field trials of Bt cotton on the Makhathini Flats over a 5-year period. Results indicated an average yield gain of 349 kg per hectare with Bt cotton. At Rand (R) 3 per kg (US$0.45), this meant an extra profit of R1,047 (US$156) per hectare planted (Sunday Independent Business Report, 2005). More extensive studies have reported substantial benefits for small-scale farmers. A study conducted by the University of Reading and the University of Pretoria found that Bt cotton yielded about 40 percent higher than conventional cotton (Ismael et al 2002). Additionally, farmers paid 42 percent less in spraying costs (Morse *et al.,* 2005). Additional literature (AfricaBio, 2007) has documented increased adoption rates with the following milestones:

- Over 90 percent of cotton seed planted by farmers is genetically modified,
- The number of pesticide sprayings has reduced from 10 to 4 per season,
- Women and children now have more time for family welfare and education respectively,
- Lower production costs provide farmers with higher gross margins estimated at US$ 70–130 /2 ha of cotton.

It is noteworthy that while farmers continue to increasingly adopt Bt cotton, recent climatic changes manifested through erratic rainfall patterns, prolonged drought spells, and fluctuating international prices continue to pose production challenges.

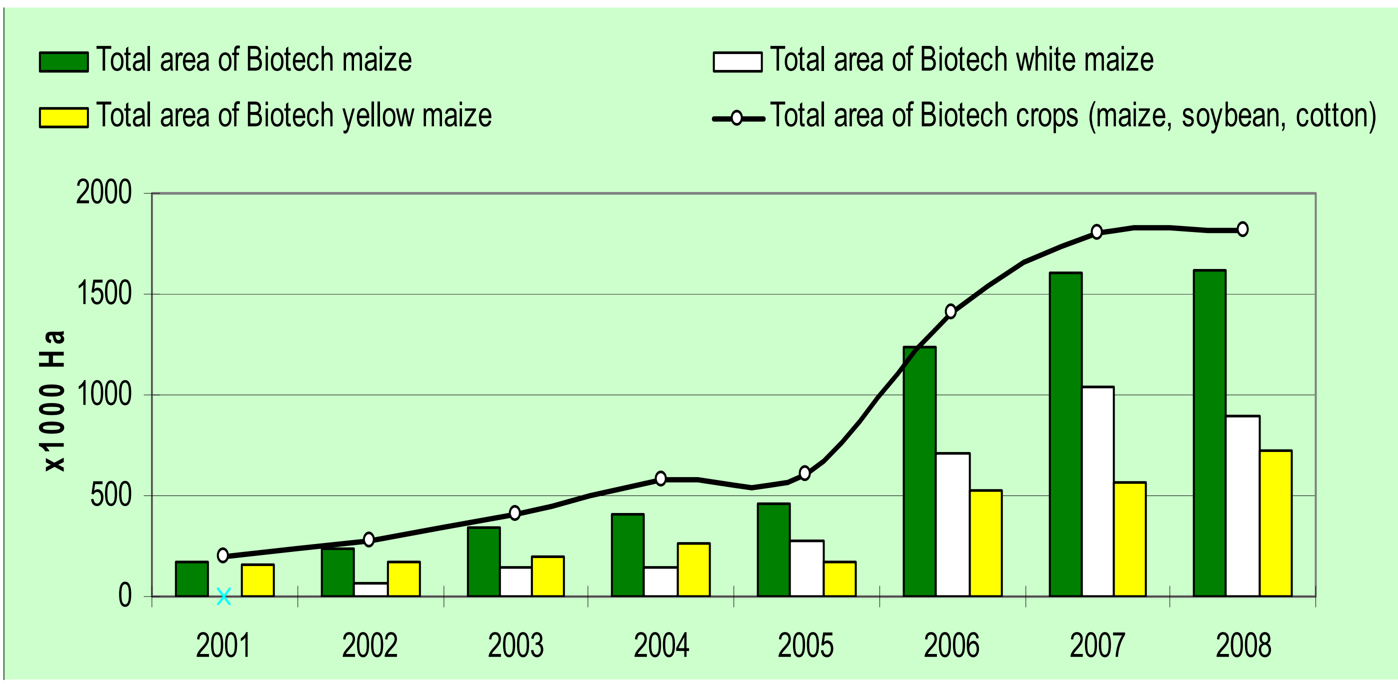
This is even more serious in many parts of Africa since agriculture is predominantly rainfed. Complementing the technology with farmer support services and fortifying current products with additional traits including drought tolerance, will help address these multiple challenges, thus ensuring Africa continues to reap socio-economic benefits and environmental gains from biotechnological applications in the agricultural sector.

Status of biotech/GM maize in South Africa

Maize occupies the largest acreage out of the three commercial biotech crops grown in South Africa since 2001. Out of the estimated 2.6 million hectares of white and yellow maize grown in 2008, 1.6 million hectares were of biotech maize, equivalent to 62 percent of the total maize area, up from 57 percent in 2007. Of the total area under biotech maize, 64 percent, (equivalent to about 1 million hectares) was Bt. 17 percent (280,000 hectares) was herbicide-tolerant and 19 percent (302,000 hectares) had stacked traits for Bt and herbicide tolerance. This represented a four-fold increase in stacked-trait maize for the year, reflecting farmer priorities for addressing the multiple constraints to increased maize production.

It is noteworthy that white biotech maize used for food is well accepted in South Africa. White biotech maize occupied 6,000 hectares in 2001 (<1 percent of the white maize area) and increased to 1.040 million hectares by 2007 (equivalent to 62 percent of the total white maize area of 1.61 million hectares). With the doubling of herbicide costs, herbicide-tolerant maize is expected to continue to lose market share to stacked-trait maize, as seed becomes more available. The hectarage of white biotech maize decreased from 1,040,000 hectares in 2007 to 891,000 hectares in 2008, in line with a 7 percent reduction in total white maize plantings in 2008 (Figure 3).

Figure 3. Adoption of biotech/GM maize in South Africa



Source: James, 2008

In 2005, Gouse et al. conducted a study to assess the benefits of Bt maize, involving 368 small-scale and resource-poor farmers and 33 commercial farmers, the latter divided into irrigated and dryland maize production systems. Under irrigated conditions, Bt maize resulted in an 11 percent yield increase (from 10.9 to 12.1 MT /ha). This resulted in costs saving of insecticides by US$18/ha equivalent to a 60 percent reduction and an increased income of US$117/ha. Under rainfed conditions Bt maize resulted in an 11 percent yield gain (from 3.1 to 3.4 MT/ ha) a cost saving on insecticides of US$7/ha (equivalent to a 60 percent reduction) and an income increase of US$35/ha.

For the smallholder farmers, the benefits were measured using only yield-per-hectare data. Bt maize yielded 31 percent more than the corresponding conventional hybrids and 134 percent more than conventional open-pollinated varieties planted by some smallholder farmers.

A longitudinal study over 9 years from 2000 to 2008 shows that small-scale farmers planting Bt maize in South Africa gained an additional US$ 267 million. This figure was based on an average yield increase benefit of 10.6 percent and annual grain prices over the period (Goose and Van der Walt, 2008, quoted by James, 2008).

Picture 10. Bt Maize farmers share experiences in the field, South Africa

Status of biotech/GM soybean in South Africa

Genetically modified soybean was first approved for commercialisation in South Africa in 2000; by 2006, 75 percent of the crop grown there was GM. In 2008, farmers planted 230,000 hectares of soybean, of which about 184,000 hectares was herbicide tolerant, equivalent to 80 percent adoption.

Although there is paucity of socio-economic data on GM soybean in the country, the high rate of adoption is evidence of the satisfaction of farmers as a result of decreased expenditure on chemical insecticides and more facile crop management.

Sharing of experiences from South Africa

South Africa plays a pivotal role in sharing its rich experience with other countries in Africa interested in exploring the potential that biotech crops offer. It is encouraging to note that the country already participates in technology transfer programmes with other countries and is engaged in training and human resource development programmes within the continent. One practical example is the collaboration with Egypt that adopted Bt Maize hybrid developed in South Africa which is the first commercialised GM crop in Egypt. Given it's rich experience with biotech crops, it can also play an important role as the key partner country on the continent in collaborating and cooperating with China and India in Asia, and, Argentina and Brazil in Latin America.

Already, the governments of India, Brazil and South Africa have established a platform for cooperation that includes research collaboration on crop biotechnology. Indeed South Africa has the necessary resource base and experience in biotech crops that allows it to exert leadership in international networking with both public and private sector institutions in industrialized countries, to develop innovative and creative new modes of cooperation and technology transfer that can be shared with other countries aspiring to adopt biotech crops in Africa.

Farmer experiences with biotech crops in South Africa

Smallholder farmers who have been assisted to enter mainstream agricultural production, known as emergent farmers, as well as large-scale farmers, continue to share their successes with biotech crops.

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

Velapi Mlambo, *small-scale cotton farmer on the Makhathini Flats, S. Africa has been planting Bt cotton for 3 years on his 5-ha farm. His yield during one of the worst droughts in many years was 800 kg/ha compared to 600 kg with conventional cotton – an increase of 25 percent. He sprayed three times for insects compared to 15 times with conventional cotton (Mlambo, 2007).*

Picture 11. A farmer-to- farmer seeing-is-believing study tour, South Africa

Table 3. A 10-year chronology of biotech/GM crops approvals for cultivation in South Africa

Event	Crop	Trait	Company	Year Approved
Yieldgard RR	Maize	Insect resistance/ Herbicide tolerance	Monsanto	2007
Bollgard RR	Cotton	Insect resistance /Herbicide tolerance	Monsanto	2005
Bollgard II, line 15985	Cotton	Insect resistance	Monsanto	2003
B*t*11	Maize	Insect resistance	Syngenta Seeds	2003
NK603	Maize	Herbicide tolerance	Monsanto	2002
GTS40-3-2	Soybean	Herbicide tolerance	Monsanto	2001
RR lines 1445 & 1698	Cotton	Herbicide tolerance	Monsanto	2000
Line 531/ Bollgard	Cotton	Insect resistance	Monsanto	1997
MON810/ Yieldgard	Maize	Insect resistance	Monsanto	1997

Source: AfricaBio, 2008

Burkina Faso

Biotechnology development in Burkina Faso

In 2008, Burkina Faso for the first time planted approximately 8,500 hectares of Bt cotton for seed production and initial commercialization, becoming the 10th country globally to grow commercial Bt cotton. The other nine countries that have collectively and successfully commercialised over 81 million hectares of biotech cotton (Bt, HT and Bt/HT) in the 12-year period 1996 to 2008 are listed in decreasing order of cumulative biotech cotton hectares; USA (44 million hectares), China (22 million hectares), India (12 million hectares) and Australia (1–2 million hectares), with the balance of five countries Argentina, Brazil, Mexico, South Africa and Colombia each growing less than 1 million hectares.

Located in the Sahel, Burkina Faso is rated as one of the poorest countries in the world. Annual average rainfall is 100 centimeters in the South to 25 centimeters in the North. Almost 40 percent of the country's GDP of US$ 7 billion is derived from agriculture, which provides employment for up to 80 percent of the Burkina Faso's 15 million inhabitants. However, drought, poor soil, insect pests and lack of infrastructure and finances pose significant challenges to the agriculture sector and economic development.

Cotton is the principal cash crop in Burkina Faso. The crop generates over US$ 300 million in annual revenues, and represents over 60 percent of the country's export earnings (ICAC, 2006). Some 2.2 million people depend directly or indirectly on cotton, often referred to locally as "white gold" (Vognan *et al.,* 2002) "the king" (CARITAS, 2004; Elbehri and MacDonald, 2004) and "the foundation" of rural economies. Burkina Faso planted approximately 475,000 hectares of cotton in 2008. However, yields are low, at approximately 367 kg per hectare compared with 985 kg per hectare in USA (Korves, 2008). Crop losses of 30 percent or more are attributed to insect-pests of cotton (Goze *et al.,* 2003; Vaissayre and Cauquil, 2000).

At the national level, the annual cost for insecticides for the control of cotton bollworms and related insect-pests is around US$ 60 million per year (Toe, 2003). However, insecticides are proving ineffective, with losses due to bollworm as high as 40 percent even with full application of insecticides (Traoré et al., 2006). As a result of these challenges, Burkina Faso's cotton production decreased to 0.68 million bales in 2007/08 from 1.3 million bales in 2006/07.

In an effort to address the insect pests challenge, the national research institute, Institut de l'Environnement et de Recherches Agricoles (INERA), has been field-testing

A field of Bt cotton ready for harvest

Bt cotton since 2003 with excellent results. INERA scientists in collaboration with Monsanto incorporated the Bt gene (Bollgard II(R)) into selected popular cotton varieties that are well adapted to the local environment. After rigorous risk assessment and stakeholder consultations, the National Bio-Security Agency approved two varieties of Bt cotton for seed production and commercialisation. The Bt cotton varieties offer several advantages including reduced number of insecticide applications to two, compared with 6 to 8 for conventional cotton, and yields approximately 30 percent higher than conventional cotton. This translates into a more competitive product for the international cotton market and higher profits for resource-poor subsistence farmers, thus making a contribution to the alleviation of poverty.

Royalties from the sale of Bt cotton seed have already been negotiated among Burkina Faso farmers, ginners and the technology provider. It is projected that in 2009 approximately 120,000 hectares of Bt cotton will be planted, which is equivalent to 25 percent of the total cotton area in Burkina Faso. This is a significant launch by any standards, and compares favorably with the earlier Bt cotton launches in the USA, Australia, China, and India.

The Bt cotton programme initiated and expedited by the Government of Burkina Faso can serve as a model for many other developing countries growing cotton. It is also consistent with the recommendation of the 2008 G8 Hokkaido meeting which recommended the utilization of biotech crops, acknowledging the significant and multiple benefits they offer. Burkina Faso, as one of the four cotton-growing countries in West Africa with Benin, Chad and Mali) and the second-largest cotton seed producer in Africa, is now in a position to share its valuable knowledge and experience with Bt cotton with its neighbours.

This would ultimately expedite the commercialisation process in those countries for the benefit of their cotton farmers. It is noteworthy that these countries are beginning to put regulatory mechanisms in place as a first step towards preparing themselves for the safe and responsible uptake of the technology. The National Assemblies of Mali and Togo for example, passed national biosafety laws in 2008 (James, 2008).

In an effort to generate evidence on the real and potential benefits of Bt cotton in Burkina Faso and indeed the western African region, several socio-economic studies have been initiated. Vitale *et al.,* (2008) estimated that Bt cotton would generate US$ 106 million per year for Burkina Faso based on yield increases of 20 percent and a decreased need for insecticides. Falck-Zepeda *et al.,* (2008) studied potential payoffs and economic risks of adopting biotech cotton in 5 countries in West Africa namely; Benin, Burkina Faso, Mali, Senegal and Togo. The study concluded that Bt technology needs to be adopted, in order to 'catch up' with major cotton-producing countries in the rest of the world. Under the assumptions of the model, all of the study countries would be worse off economically by not adopting Bt cotton.

Referencing the cotton initiative in the WTO's Doha Round of discussions, a paper from the World Bank (WPS3197-Anderson *et al.,* 2006) concluded that cotton-growing developing countries in Africa and elsewhere do not have to wait until the Doha Round is completed before benefiting from increased income from cotton.

Developing countries that have elected to growing conventional cotton instead of Bt cotton have the option and authority to approve and adopt Bt cotton and enjoy the significant benefits it offers. These benefits, the paper concludes, would be greater than the potential benefits from the removal of all subsidies and tariffs negotiated under the Doha Round. Furthermore, the study contends that the gains from the Doha Round would be greater if cotton-growing developing countries adopted Bt cotton.

Thus, the onus is on governments of cotton-growing developing countries to exercise their authority and responsibility to appraise, approve and adopt Bt cotton at the earliest opportunity. Fortunately, this can be greatly facilitated and accelerated today by learning from the wealth of knowledge and experience of the 9 countries, 6 of them developing that have adopted, commercialised and benefited significantly from this proven technology over the last decade. Bt cotton is no longer the "new" technology with a potential risk as it was perceived to be 11 years ago. To the contrary, the risk is to consciously elect not to use the technology especially for countries that depend on cotton as their major source of livelihood and economic development.

Farmer experiences with Bt cotton in Burkina Faso

El-hadji Karim Ouédraogo is the President of the Provincial Union of Cotton Producers, which has a countrywide membership of 325,000 farmers, most of them smallholders with less than 10 hectares of land. The size of Karim's farm (approx. 20 ha) is exceptional. Cotton occupies 34 percent or 7 ha of his land, in which 4.5 ha is planted to conventional cotton. In July 2008 he planted his first 2.5 ha to Bt cotton with seed supplied by INERA thereby becoming a pioneer Bt cotton farmer in Burkina Faso. Karim says he sprayed the Bt cotton only twice (compared to the eight or more times on the conventional cotton), harvested a better grade crop and recorded a higher yield of 1,600kg/ha compared to 900kg/ha from the conventional field. He has decided he will plant only Bt cotton in his farm come next season. He has also used his position as president of the Cotton Union in his province to influence many more farmers to grow Bt cotton. "My farm now serves as a 'classroom' for the many 'doubting Thomases' in the country and the region," he says with pride and confidence (source: ISAAA Brief 40)

Picture 12. Journalists on a travelling workshop in Bt cotton fields, Burkina Faso

Egypt

Biotechnology development in Egypt

In 2008, Egypt became the first country in the Arab world to commercialize biotech crops, by planting 700 hectares of hybrid Bt yellow maize.

Egypt with a population of 80 million, lies in the northeastern corner of Africa and has a total land area of approximately 100 million hectares. It is bounded by the Mediterranean Sea to the North, the Red Sea to the East, and Sudan to the South. The topography of Egypt is dominated by River Nile, the longest river in the world, which provides the critical water supply to this arid country.

Only 3 percent of the land area, approximately 2.5 million hectares, is devoted to agriculture. However, agriculture is considered to be a principal sector of the economy, contributing about 20 percent to GDP and providing close to 50 percent of employment. About 90 percent of Egypt's agricultural land is in the Nile Delta and the remainder is within a narrow strip along the Nile between Aswan and Cairo. The rich cultivated land, irrigated by the Nile, is very fertile and allows double cropping. Nevertheless, Egypt is dependent on imports for about half of its food supply due to the meager area of cultivable land, as well as problems related to salinity and low soil fertility.

The principal crops grown in Egypt are rice, wheat, sugarcane and maize. The major challenges for agricultural development are the limited arable land base, erosion of land resources, loss of soil fertility, salinity and the high rate of population growth. Government policy is to enhance agriculture as a major contributor to the national economy, by promoting privatization and decreasing government controls and subsidies. The President of Egypt his Excellency Hosni Mubarak has indicated that education, science and technology are top priorities for the development of an indigenous capacity. According to the president, numerous policy impact assessment studies have proven that reforms of the past two decades and the Egyptians farmer's responsiveness to new technology packages and price incentives account for the agricultural development and food security realised by Egypt. New crops and animal breeds have also been introduced alongside research dedicated to problem-solving in basic and advanced sciences under the Agricultural Research Center (ARC).

"Whoever does not command the means to feed himself, can neither feel freedom nor dignity …
Egyptian Agriculture is the major foundation of the country 's social economic development"
(Egypt's President , Hosni Mubarak)

Egypt has been undertaking research in genetic engineering since the early nineties. One of the most elaborate initiatives was a cooperative research agreement between the Agricultural Genetic Engineering Research Institute (AGERI) of the ARC and Agricultural Biotechnology Support Project (ABSP) of USAID. One of the aims of the cooperation was to develop the country's agricultural biotechnology system by addressing specific commodity constraints and policy issues including biosafety and intellectual property rights. Over the years, AGERI, a lead crop biotech institute in the Arab world has grown to become a centre of excellence in biotechnology, molecular biology, and genetic engineering research, focusing on the production of biotech crops and biotechnology-based products.

The institute has a broad range of biotech crop activities including development of crops resistant to biotic stresses caused by viruses, insects, fungal pests and nematodes, and tolerance to the prevalent abiotic stresses of drought and salinity.

Some basic research is also conducted on genome mapping, and, protein and bio-molecular engineering. There are several biotech crops under research in Egypt. Wheat, barley, maize and cotton are key biotech crops that are being developed to confer tolerance to drought and salinity. In addition, there is a set of projects incorporating resistance to different viruses of potato, squash and melons (zucchini yellow mosaic), tomato yellow leaf curl, and banana (bunchy top and cucumber mosaic). Similarly, there is a suite of projects incorporating resistance to insect pests, mainly featuring Bt genes, including projects on the *Gossypium barbadense* species of cotton (bollworm and other lepidopteran pests), potato (tuber moth), and maize (sesamia stem borer).

"Biotechnology is the hope for producing safe food"

(Prof. Magdy Madkour, former President. of ARC, Egypt)

Awarded for scientific excellence by the Arab Organization for Agricultural Development. and Egyptian National Academy of Science.

Maize is an important crop in Egypt, planted on approximately 728,000 hectares. Egypt produces about 6.1 million tons of maize domestically and imports 4.5 million tons of yellow maize annually valued at US$1.3 billion. Of the 728,000 hectares of maize grown, approximately 75,000 hectares are planted to yellow, and the rest to white maize.

Status of biotech/GM maize in Egypt

In 2008, the Bt yellow maize hybrid (*Ajeeb-YG*) became the first biotech commercial crop approved in the Arab world. It was developed by crossing Bt maize (MON 810) with the local maize variety Ajeeb and was planted on 700 hectares for initial commercialisation. Rigorous field trials conducted from 2002 to 2007 prior to release indicated that Ajeeb-YG was resistant to three maize borers (Massoud, 2005) and yielded up to 30 percent more than conventional yellow hybrid maize. The increased productivity is estimated to contribute to import substitution of the 4.5 million tons imported annually.

Farmer experiences with Bt maize in Egypt

Mohamed Alsayed, a maize farmer, planted one acre of Bt maize to compare with the conventional maize that he normally grew. "I found a 25 percent increase in yield and high maize quality in the Bt maize variety compared to the conventional variety, and although I planted it late, the Bt maize was able to resist borer infestation," says Alsayed.

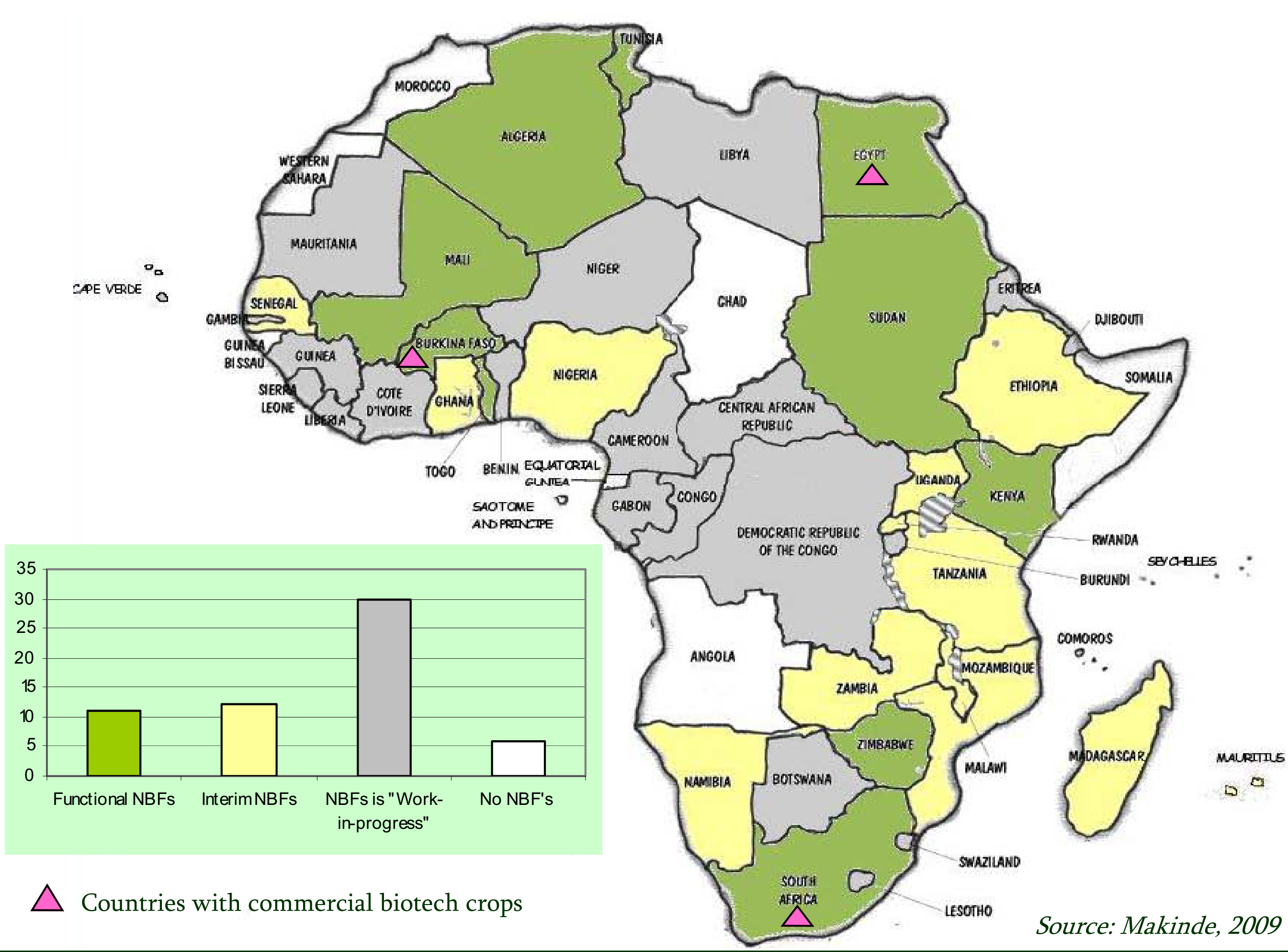
Morsy, another maize farmer, said that he sprayed the conventional maize variety thrice with pesticides, which cost him about US$ 90, while he used no pesticides for the Bt maize variety."

Picture 13. An Egyptian farmer displays Bt Maize cobs

Progress in the development of regulatory and biosafety regimes in Africa

In order to position themselves to fully exploit the benefits arising from modern biotechnology applications while safeguarding against potential risks, most African countries have signed and ratified important legally binding international instruments like the Convention on Biological Diversity (CBD) as well as the Cartagena Protocol on Biosafety CPB). This means that such countries have agreed to take the necessary legal, administrative and other measures to implement certain obligations to ensure that the development, handling, transportation, use, transfer and release of living modified organisms are undertaken in a manner that prevents or reduces the risks to biological diversity or human health. Complying with the provisions of Cartagena Protocol, African countries are developing functional National Biosafety Frameworks (NBFs) to oversee the development and utilization of GM products. Although components of NBFs vary from country to country, these typically comprise existence of (1) a policy on biotechnology, (2) laws and regulations on biosafety, constituting a regulatory regime for biotechnology, (3) an administrative system for handling applications and issuance of permits and (4) a mechanism for public participation in biosafety decision making process (SCBD, 2000). African countries are at different stages of enacting biosafety legislation, ranging from functional, interim and 'work-in-progress' NBFs, as illustrated in the continent's map in Figure 4. Countries that have enacted biosafety laws include; Burkina Faso, Cameroon, Kenya, Malawi, Mali, Mauritius, Namibia, South Africa, Tanzania, Togo and Zimbabwe while Madagascar, Rwanda, Sudan, Uganda and Zambia have elaborate national biotechnology and biosafety policies.

Figure 4. Status of national biosafety framework in Africa



Source: Makinde, 2009

Table 4. Status of biotechnology policies & biosafety legislation in the COMESA region, 2008

Member country & population	Biotechnology/biosafety policy	Biosafety regulatory regime
Burundi	Draft biotechnology policy	Sectoral legislation with ref. to biotech draft Biosafety Bill, 2006.
Comoros	Draft policy on biotechnology issues	No specific biosafety policy.
DR Congo	Draft national biosafety law	Draft Biosafety Bill.
Djibouti	No stand alone biotech policy. References to biotech issues implicit in policy on Environment.	No specific biosafety policy.
Egypt	No stand alone biotech policy. Various government policies on biotech and biosafety issues.	Regulations governing GMOs through Ministerial Decree. No specific biosafety policy.
Eritrea	Draft national biosafety law.	Sectoral legislation with ref. to biotech. Draft biosafety policy and guidelines.
Ethiopia	No stand alone biotech policy. References to biotech issues made in other sectoral policies e.g. policy on Environment.	Draft biosafety proclamation and six ministerial directives.
Kenya	Has stand-alone national biotechnology development policy.	Biosafety Act 2009
Libya	Draft national biosafety law.	No specific biosafety policy.
Madagascar	National biosafety law.	Draft Biosafety Bill.
Malawi	Has stand-alone national biotechnology policy.	Biosafety Act 2002. Biosafety regulations approved in 2007.
Mauritius	No stand alone biotech policy.	GMO Act 2003.
Rwanda	National biosafety law developed during NBF project.	Draft Biosafety Bill, draft biosafety guidelines.
Seychelles	No stand alone biotech policy. References to biotech issues made in other sectoral policies.	No specific biosafety policy, sectoral legislation with references to biotech.
Sudan	National biosafety law included in NBF.	Draft Biological Safety Bill.
Swaziland	Draft national biotech policy.	Sectoral legislation with ref. to biotech; draft biosafety policy.
Uganda	National biotechnology and biosafety policy 2008.	Sectoral legislation with ref. to biotech draft Biosafety Bill.
Zambia	Biotechnology & biosafety policy 2003.	Draft Biosafety Bill.
Zimbabwe	Has stand-alone national policy on biotechnology.	National Biotechnology Authority Act; Research (Biosafety) Regulations of 2000 to be replaced.

Source: Karembu et. al., 2008

Regional biosafety initiatives in Africa

The importance of regional cooperation in addressing biotechnology and biosafety issues has been recognized by various regional and sub-regional economic blocs. The main message from the African Union (AU)'s Africa Panel on Biotechnology (APB), for instance is to foster regional economic integration in Africa through building and accumulating capacities to harness and govern modern biotechnology (Juma and Serageldin, 2008). Regional economic integration can be an institutional vehicle for mobilizing, sharing and using existing scientific and technology capacities, including human, financial resources as well as physical infrastructure, for biotechnology R&D and innovation.

Furthermore, the 5th meeting of the COMESA Ministers of Agriculture held in Seychelles in 2008 endorsed the drafting of regional biosafety guidelines and policies for handling the commercial planting of GMOs, trade in GM products and to facilitate access to emergency food aid with GM content.

The West African Economic and Monetary Union (WAEMU) also launched a regional biosafety programme based on demand from WAEMU member countries (Burkina Faso, Togo, Ivory Coast, Senegal, Benin and Mali) to have a centralized system of regulation for the development and rapid expansion of modern biotechnology activities in the West African sub-region. The programme envisages the institution and implementation of a common institutional and legal framework for the whole sub-region, and also facilitation of member countries to honour the Cartagena Protocol on Biosafety.

These developments clearly indicate that African countries are recognizing the need to pool resources to harness the potential of biotech in agriculture, build collaborative efforts and safeguard biosafety measures. Most of these initiatives emphasize the need for harmonized regulatory systems for approval and commercialization, transboundary handling and trade in biotech crops. Table 5 summarizes some of these initiatives.

Table 5. Some biosafety initiatives in Africa

Initiative	Key players	Activity/objective
ASARECA	Eastern and central Africa countries	Using biotechnology safely as a tool to enhance the utilisation of agro-biodiversity.
CORAF/WECARD, under ECOWAS & WAEMU/UEMOA	14 ECOWAS countries (*Guinea suspended in 2008 after a coup d'état)	Promoting biotechnology-product-specific agribusiness, strengthening seed systems and national phytosanitary legislations to facilitate dissemination of products, reinforce intellectual property systems and harmonise biosafety legislation in the sub-region.
COMESA & RABESA	19 COMESA countries	Developing centralized risk assessment procedures for commercial planting of GM crops, handling of emergency food aid & trade in GM products. Develop harmonized regional policies on GMO governance in the sub-region; roadmap for implementation.
FARA - ABBPP	All African countries	Facilitating biotechnology and biosafety policy dialogue and stakeholder consensus building among the different actors in regulatory and biosafety efforts on biotechnology at the continental, sub-regional and national levels.
UNEP/GEF	All African countries	Building capacities of countries in biosafety, in conformity with the Cartagena Protocol on Biosafety.
ICGEB	Sub-Saharan countries	Strengthening and expanding biosafety systems in sub-Saharan Africa.
PBS ABSP II and	East Africa, South Africa, Malawi, Mozambique, Nigeria, Mali, Ghana	Capacity building and providing regulatory technical support for handling and managing confined field trials.
ABNE - an initiative of NEPAD	African countries	Consolidating the work of various biosafety initiatives in the continent to ensure utilization of the existing capacity effectively and adequately.

Source: ISAAA AfriCenter, 2009

Investments in human and infrastructural capacity in Africa

Over the years, African countries have made great strides in the development of human and scientific infrastructure. Universities have increased in number, and student enrollment has risen especially in the physical and biological sciences. Contrary to a previous survey by Alhassan (2003) which indicated constraints, the situation is changing as evidenced by the increasing number of scientists trained to graduate, post graduate and PhD level in biotechnology. In addition, a number of research institutions are now fairly well equipped to handle research in advanced areas of biotechnology. There also exists a large number of African scientific in the Diaspora, many of whom contribute to the research environment in their countries of origin, by organizing international collaborative projects involving researchers from Africa and abroad. Several initiatives are engaged in human and infrastructure capacity building activities.

In addition to the elaborate infrastructure in several South African research and private institutions, other African countries are beginning to invest in infrastructural capacity for biotechnology. The Kenya Agricultural Research Institute (KARI), NARO, Uganda and AGERI, Egypt for instance, have invested in various modern biotechnology facilities, including level II biosafety green houses and laboratories. Some of the key capacity building initiatives are the BIO-EARN programme, BecA, United Nations Industrial Development Organization (UNIDO), several Consultative Group of International Agricultural Research (CGIAR)

Picture14. Researchers working in a striga-resistant sorghum field trial (Left), and a scientist explaining a point to parliamentarians

ICRISAT scientists have developed striga resistant sorghum varieties using marker assisted backcrossing and farmer participatory selection , currently under trials in four African countries - Eritrea, Kenya, Mali and Sudan.

centers and collaborative programmes with universities such as Michigan State, Cornell and other emerging biotech countries such as Brazil, China and India.

Additionally, the recent call to African governments during the 2009 AU summit to "invest in modern agricultural technologies for economic growth and food security" is a sign of political will to modernize Africa's agricultural sector.

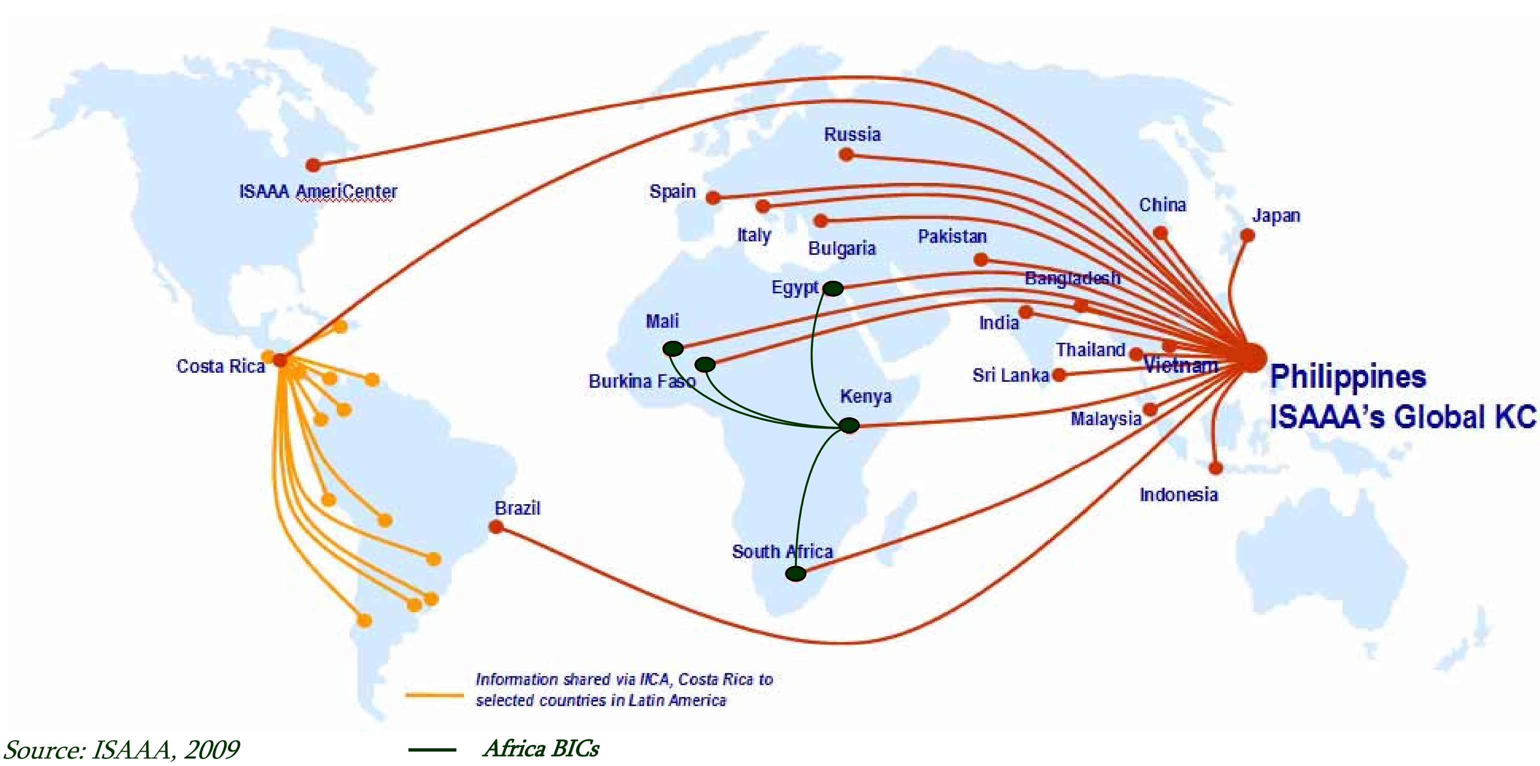
Public awareness and participation in biotech

It is now widely acknowledged that the adoption of modern biotechnology can be hampered by inaccurate, unreliable information, lack of knowledge and awareness at all levels of society. This is especially true in Africa, a situation that has brought about fear, concerns and myths about the technology. Recommendations from stakeholder workshops, seminars and other deliberations continue to identify the need for mechanisms and processes for information-sharing and education on biotechnology, biosafety and intellectual property rights.

Indeed, one of the key recommendations of the AU High Level Panel on Biotechnology (APB) was that "Public awareness of, and public engagement in biotechnology is needed at all levels in Africa. A lack of either will make it difficult for AU member states to individually and collectively discuss, set priorities and exploit economic and other opportunities offered by biotechnology" (Juma and Serageldin, 2007: 59).

ISAAA is ideally placed to assist Africa in this endevour given that its principal mission is to freely share authoritative knowledge on biotech crops, whilst respecting the rights of stakeholders to make decisions based on that knowledge. Through its Global Knowledge Center (KC) on Crop Biotechnology based in Manila Philippines, ISAAA facilitates and supports the sharing of information and experiences among different stakeholders. It does this through its network of 23 Biotechnology Information Centers (BICs) and country nodes in Africa, Asia, Europe, and Latin America (Figure 5)

Figure 5. ISAAA knowledge sharing network of Biotechnology Information Centers (BICs)

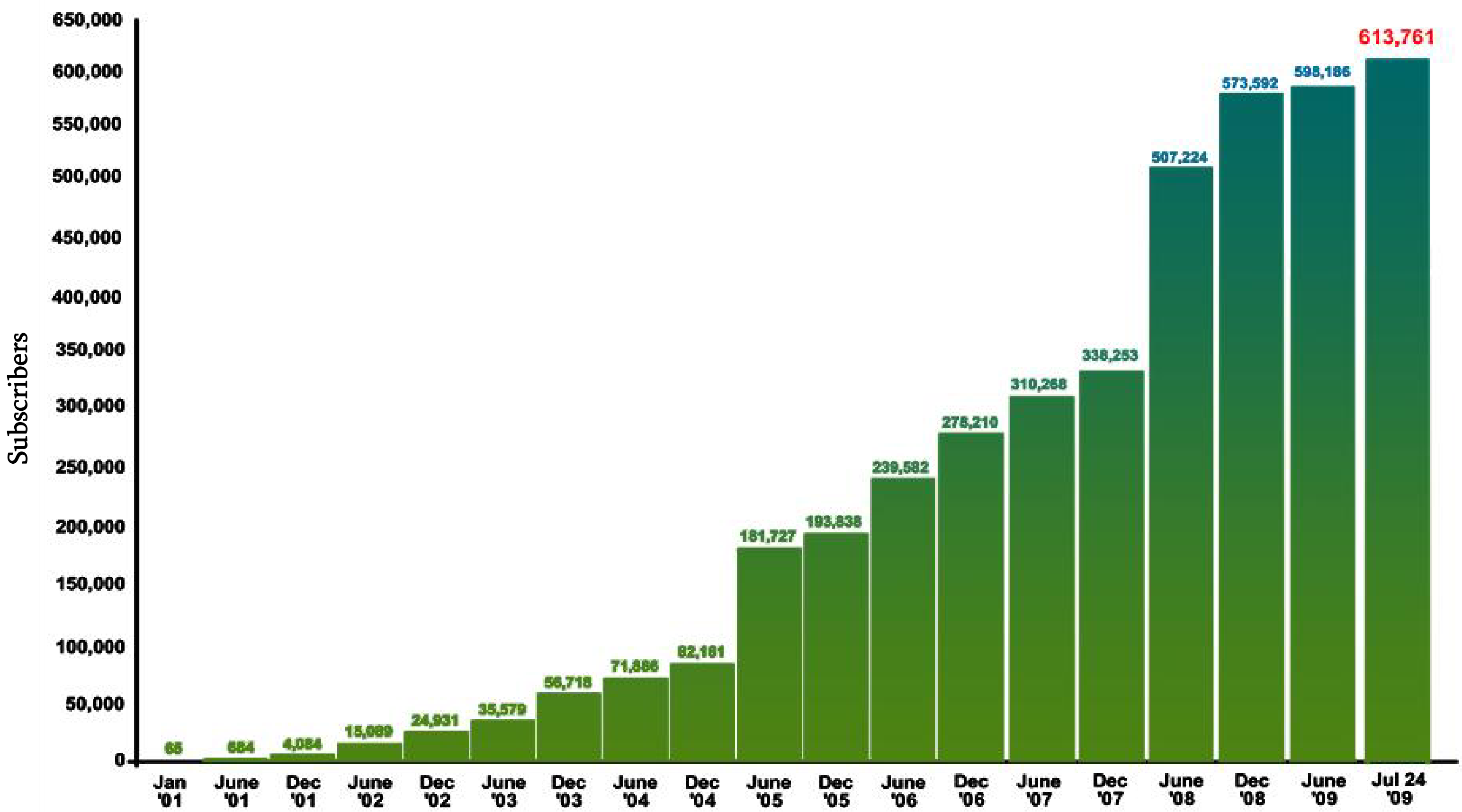


Source: ISAAA, 2009

In addition, ISAAA provides weekly updates on global developments in crop biotechnology through an electronic newsletter the *Crop Biotech Update* (CBU) which has a

This made Kenya the second country in Africa (after South Africa) to put in place a national biotechnology awareness strategy.

Figure 6. Periodic increase in number of *Crop Biotech Update* subscribers



Source: ISAAA, 2009

subscription of over half a million readers. Figure 6 show the progressive increase in the number of subscribers to the CBU over the years.

ISAAA *Afri*Center efforts in this direction along with other stakeholders, have played a significant role in sharing knowledge on crop biotechnology across the African continent. In Kenya, for example, ISAAA *Afri*Center played a key role in coordinating activities that saw the development and the launching of the National Biotechnology Awareness Strategy (Bio*AWARE*-Kenya) in 2008.

Along with this, ISAAA *Afri*Center in collaboration with the African Agricultural Technology Foundation (AATF) coordinates an outreach initiative dubbed the "Open Forum on Agricultural Biotechnology in Africa" (OFAB) with chapters in Egypt, Kenya, Nigeria, Tanzania and Uganda. OFAB provides a regular platform for networking and sharing information and experiences on biotechnology among various stakeholders. In addition, various African governments, civil society organizations and public–private partnerships have been engaged in creating public awareness on biotechnology. A summary of some of the initiatives is presented in Table 6.

Table 6. Some initiatives aimed at creating public awareness on biotechnology in Africa

Programme/initiative	Area of focus
International Service for the Acquisition of Agri-biotech Applications (ISAAA) AfriCenter	Communication and knowledge sharing, through collection, packaging, dissemination, networking, building partnerships and fostering joint initiatives to share resources, experiences and expertise on crop biotechnology. *Afri*Center coordinates a network of Biotechnology Information Centers (BICs) located in Egypt (EBIC for Arab-speaking), Mali /Burkina Faso (Mali BIC for French-speaking) and East and Central Africa (ECABIC for English and Swahili-speaking) www.isaaa.org/kc
Public Understanding of Biotechnology (PUB)	Operated by the South African Agency of Science and Technology Advancement (SAASTA). Aimed at promoting clear understanding of biotechnology's potential and ensuring broad public awareness, to stimulate dialogue and debate on biotechnology. www.pub.ac.za
AfricaBio	A biotechnology stakeholders association whose key role is to provide accurate information and create awareness, understanding as well as knowledge on biotechnology and biosafety in South Africa and the African region. www.africabio.com
African Biotechnology Stakeholders Forum (ABSF)	Creating an innovative and enabling biotechnology environment in Africa through education, enhanced understanding and awareness creation. www.absfafrica.org
Africa Harvest Biotech Foundation International (Africa Harvest)	Aims at building capacity of scientists, science and agricultural organizations in integrating communication strategies into their research activities. Also helping the news media improve their coverage of science and agricultural issues. www.ahbfi.org
National Biotechnology Awareness Creation Strategy (Bio*AWARE*-Kenya)	Spearheaded by Agricultural Sector Coordinating Unit (ASCU) under the Ministry of Agriculture, Aimed at providing a knowledge-base for informed decision-making to hasten deployment of biotechnology through a participatory awareness creation process.
Open Forum on Agricultural Biotechnology (OFAB) in Africa	Strengthening inter-institutional networking and sharing of credible, sound and factual biotechnology information through a platform that brings together stakeholders in biotechnology and enables interactions between scientists, journalists, the civil society, industrialists and policy makers. www.ofabafrica.org
Réseau des Communicateurs ouest-Africains sur la Biotechnologie (RECOAB)	Network of both Francophone and Anglophone West African journalists that builds capacity and provides factual and balanced information on biotechnology to enable informed participation in debates on biotechnology. cyrpayim@hotmail.com
Biotechnology-Ecology Research and Outreach Consortium (BioEROC)	Aims at delivering relevant research, training, management and outreach services in natural resources and to promote responsible and relevant application of biotechnology and its products. bioeroc@sdnp.org.mw
Burkina Biotech Association (BBA)	Created by Burkina Faso scientists, with the objective to provide a forum for stakeholders in the field of biotechnology to dialogue, voice their opinions and concerns . bba@fasonet.bf

Source: ISAAA AfriCenter, 2009

"The Government is committed to ensuring that information on biotechnology is accurately and efficiently disseminated to the public for informed decision-making regarding adoption and safe application".

Honourable William Ruto, Minister for Agriculture, Kenya

Picture 15. Kenyan Minister for Agriculture, Honourable William Ruto launching the Bio*AWARE*- Kenya, 2008

Conclusion

Agricultural biotechnology holds great promise towards raising farm productivity and developing environmentally sustainable agriculture in Africa. African leaders are realising the importance of investing in new agricultural methods and have made considerable progress in setting up special governance and capacity building mechanisms to advance the application of biotechnology in agriculture. African Union leaders took another important step in acknowledging the potential of biotechnology to help agricultural development, by endorsing the "Freedom to Innovate" plan in 2008. About 40 out of the 54 African states have developed draft national biosafety frameworks, signaling their willingness to responsibly exploit and utilize biotechnology applications on the continent.

This document presents the progress on agricultural biotechnology in Africa, which demonstrates that biotech crops have already started to make a significant impact on African farms by increasing crop productivity and alleviating poverty.

Developing and deploying key biotech crops to confer resistance to insect-pests and viruses have led to a decreased use of insecticides, increased yields and higher income for commercial and smallholder farmers in Africa. Biotech crops are beginning to usher in the much awaited Green Revolution for Africa against the widely held perception that such a revolution for Africa is an impossible dream. By far the highest priority for Africa is to put in place appropriate biosafety laws and corresponding regulations that are efficient and cost-effective for implementation. Field trials and commercialisation of biotech crops can then be expedited and benefits delivered to the African people at the earliest opportunity. The cost for Africa of not doing so is enormous.

Combined with enabling policies, strategic partnerships, efficient regulatory systems and effective communication, biotechnology applications in Africa will surely make a significant contribution towards improving the continent's crop productivity, positively impact on farmers' livelihood and ensure environmental sustainability.

Picture 16. Parliamentarians with other stakeholders on a study tour to biotech crops fields, South Africa

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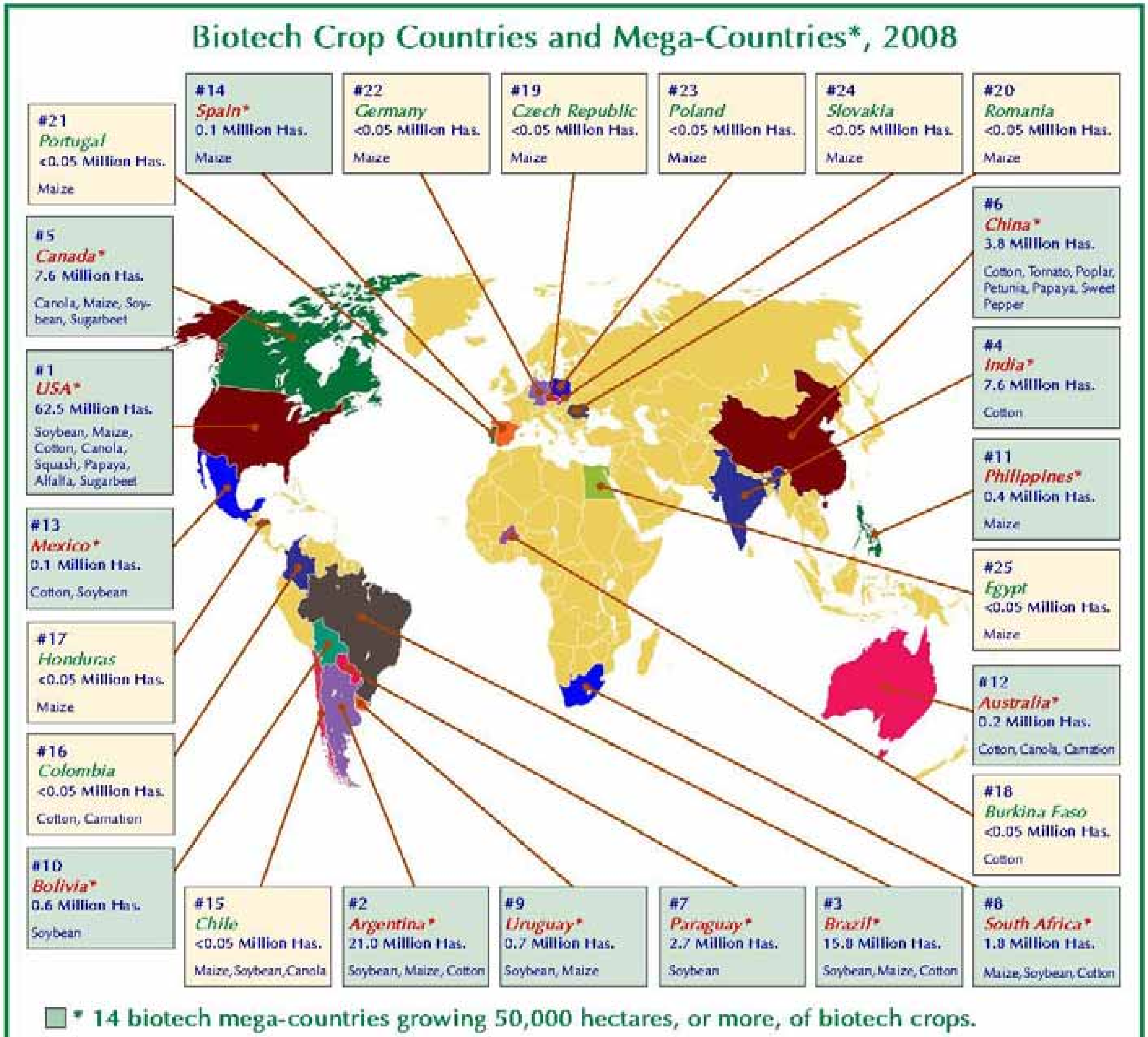
List of acronyms

AATF:	African Agricultural Technology Foundation
ABBPP:	African Biotechnology and Biosafety Policy Platform
ABI:	African Biosciences Initiative
ABNE:	African Biosafety Network of Expertise
ABSF:	African Biotechnology Stakeholders Forum
ABSP:	Agricultural Biotechnology Support Project
AHBFI:	Africa Harvest Biotech Foundation International
AGERI:	Agricultural Genetic Engineering Research Institute
AGRA:	Alliance for a Green Revolution in Africa
AIRF:	Agricultural Innovation Research Fund
APB:	High-level African Panel on Biotechnology
ARC-IIC/OVI:	Agricultural Research Council for Industrial Crops/Onderstepoort Veterinary Institute
ASARECA:	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATPS:	African Technology Policy Studies Network
AU:	African Union
BBA:	Burkina Biotech Association
BecA:	Biosciences eastern and central Africa
BecANet:	Biosciences eastern and central Africa Network
Bio*AWARE*:	National Biotechnology Awareness Creation Strategy - Kenya
BIC:	Biotechnology Information Center
BioEROC:	Biotechnology-Ecology Research and Outreach Consortium
Bt :	*Bacillus Thuringiensis*
CAADP:	Comprehensive Africa Agriculture Development Programme
CBD:	Convention on Biological Diversity
CPB:	Cartagena Protocol on Biosafety

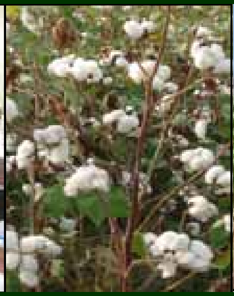
CFT:	Confined Field Trials
CGIAR:	Consultative Group on International Agricultural Research
CIMMYT:	International Maize and Wheat Improvement Center
CIP:	International Potato Center
CIRAD:	Centre de cooperation internationale en recherche agronomique pour le Dévelopment
COMESA:	Common Market for Eastern and South Africa
CORAF:	Conseil Ouest et centre Africain pour la Recherche et le Dévelopment Agricoles
CSIRO:	Australia's Commonwealth Scientific and Industrial Research Organisation
DFID:	Department for International Development
EARI:	Ethiopia Agricultural Research Institute
ECOWAS:	Economic Community of West African States
FAO:	Food and Agriculture Organization
FARA:	Forum for Agricultural Research in Africa
GDP:	Gross Domestic Product
GEF:	Global Environment Facility
GM:	Genetic modification/ Genetically modified
GMO:	Genetically Modified Organism
HIV/AIDS:	Human Immuno-Deficiency Virus/Acquired Immuno Deficiency Syndrome
IAASTAD:	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAR:	Institute of Agricultural Research
ICGEB:	International Centre for Genetic Engineering and Biotechnology
ICTSD:	International Centre for Trade and Sustainable Development
IFPRI:	International Food Policy Research Institute
IICA:	Instituto Interamericano de Cooperación para la Agricultura (Costa Rica)
IITA:	International Institute of Tropical Agriculture
INERA:	Institut de l'Environement et de Re cherches Agricoles
IRMA:	Insect Resistant Maize for Africa
ISAAA:	International Service for the Acquisition of Agri-biotech Applications
ISNAR:	International Service for National Agricultural Research
KARI:	Kenya Agricultural Research Institute
MDGs:	Millennium Development Goals
NABNet:	North Africa Biosciences Network
NaCCRI:	National Crops Resources Research Institute
NARI:	National Agricultural Research Institute
NARO:	National Agricultural Research Organization
NBF:	National Biosafety Framework
NEPAD:	New Partnership for Africa's Development
NERICA:	New Rice for Africa
NGICA:	Network for the Genetic Improvement of Cowpea for Africa
OECD:	Organization for Economic Cooperation and Development
OFAB:	Open Forum on Agricultural Biotechnology
PBS:	Programme for Biosafety Systems
PUB:	Public Understanding of Biotechnology
RABESA:	Regional Approach to Biotechnology and Biosafety in Eastern and South Africa
RECOAB :	Réseau des Communicateurs ouest-Africains sur la Biotechnologie
SAASTA:	South African Agency for Science and Technology
SACBB:	Southern Africa Advisory Committee on Biotechnology and Biosafety
SADC:	Southern Africa Development Community
SANBio:	South Africa Network for Biosciences
SCBD:	Secretariat of the Convention on Biological Diversity
SASRI:	South African Sugarcane Research Institute
SOFI:	State of Food Insecurity in the World
SSA:	sub-Saharan Africa
UEMOA:	Union Economique et Monétaire Ouest Africaine
UNCSD:	United Nations Commission on Sustainable Development
UNEP:	United Nations Environment Programme
UNIDO:	United Nation Industrial Development Organization
USAID:	United States Agency for International Development
TC:	Tissue Culture
WABNet:	West Africa Biosciences Network
WAEMU:	The West African Economic and Monetary Union
WARDA:	West African Rice Development Association
WECARD:	West and Central African Council for Agricultural Research and Development
WEMA:	Water Efficient Maize for Africa
WPS:	World Bank Policy Research Working Paper
WTO:	World Trade Organization



Source: James, 2008

In 2008, the global market value of biotech crops, estimated by Cropnosis, was US$7.5 billion, (up from US$6.9 billion in 2007) representing 14% of the US$52.72 billion global crop protection market in 2008, and 22% of the approximately US$34 billion 2008 global commercial seed market. The value of the global biotech crop market is based on the sale price of biotech seed plus any technology fees that apply. The accumulated global value for the twelve-year period, since biotech crops were first commercialised in 1996, is estimated at US$49.8 billion, which when rounded off to US$50 billion is a historical landmark for the global biotech crop market.

Source : James, 2008



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