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AFRICA AGRI-BIOTECH UPDATES

PROGRESS WITH BIOTECH CROPS IN AFRICA 2013

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Introduction

Africa is the second largest continent in both size and population with an estimated one billion people as of 2013. The continent largely depends on agriculture for socio-economic development. The sector is crucial for food security, income generation and employs an estimated 65 % of Africa's labour force which contributes about 32 % of the continent's gross domestic product. Agricultural production in Africa is however below the world average levels and is attributed partly to constraints such as:

- Pests and diseases;
- Decreasing soil fertility;
- Climate change related weather vagaries like droughts and floods;
- Low investment in agricultural research and development;
- Unfavorable and/or ineffective policies
- Low use of improved seed, fertilizer and irrigation,
- Agro-ecological complexity and heterogeneity
- Poor infrastructure and access to competitive markets.

A range of measures including technological, innovations, management, infrastructural and institutional interventions are required to address each of the constraints mentioned above. Some of the interventions have been addressed in the Comprehensive African Agriculture Development Program (CAADP) and its accompanying Framework for African Agricultural Productivity (FAAP) which provides a vision for improving agricultural productivity in Africa through enabling and acceleration of innovation. Through the CAADP programme, the African Union is encouraging member countries to allocate at least 10 % of their annual national budgets to agriculture to achieve about a 6 % growth in the sector. However, only a handful of countries have surpassed the anticipated 6 % agricultural growth in recent years.

Modern biotechnological tools especially genetic modification (GM) technology, offer promise and potential for resolving some of the major agricultural constraints in African small farms. Biotechnology is defined as a set of tools that uses living organisms (or parts of organisms) to make or modify a product, improve plants, trees or animals, or develop microorganisms for specific uses. Agricultural biotechnology is the term used in crop and livestock improvement through biotechnological tools. It contributes to food security, sustainability and the environment/climate change by: Increasing crop production; providing a better environment by reducing use of pesticides; conserving biodiversity by not expanding land for new production and helps alleviate poverty. Biotech applications that have so far been deployed in African countries like South Africa, Burkina Faso and Sudan have shown great results by raising farm yields, reducing excessive use of pesticides and the associated labour costs. This publication therefore highlights the status of biotechnology application in Africa in 2013. It shows progress made in Africa in development and commercialization of biotech crops from the commercialization in Burkina Faso, South Africa and Sudan to the on-going trials in Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria and Uganda.

Status of Crop Biotechnology in Africa

The revolutionary rise in the potential of crop biotechnology in agriculture is illustrated by the global adoption trends from 1.7 million ha in 1996 to 175.2 million ha in 2013. According to James (2013), Africa has made significant progress with biotech crops adoption. Burkina Faso and Sudan increased their Bt cotton hectarage substantially, while South Africa's biotech hectarage was marginally less but practically the same level as 2012 (~2.9 million ha). Burkina Faso increased its Bt cotton ha by over 50 % from 313,781 ha to 474,229. Sudan, in its second year of commercialization tripled its Bt cotton from 20,000 ha in 2012 to 62,000 in 2013. Encouragingly, an additional seven African countries namely Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria and Uganda have conducted field trials on a broad range of "new" biotech crops (cotton, maize, bananas and cowpeas), including several orphan crops such as sweet potato. The WEMA project is expected to deliver its first biotech drought tolerant maize in Africa by 2017. Other advancements include the continued development of Genetically Engineered Maize for Drought Tolerance (GEMADOT) and sorghum for tolerance to drought by the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA).

Despite these progressive efforts, there has been a slow pace of adoption of biotech/GM crops in the continent. This can be attributed to an array of factors including anti-biotech activism, limited political goodwill, protracted development of regulatory structures and trade-related issues among others. Propaganda and misinformation spread by opponents has denied farmers access to the technology by creating fear and generating negative perceptions. There is a persistent debate on whether or not to adopt biotechnology in Africa. This has led to a cautious approach in decision-making by policy makers thus delaying the development of biosafety frameworks.

Image source: http://www.infiniteunknown.net/tag/soybeans

GM Crops Commercialization

Notwithstanding the aforementioned challenges, GM crops were grown in three African countries. South Africa grew biotech maize, soybean and cotton while Burkina Faso and Sudan grew biotech cotton.

a) South Africa

South Africa is the pioneer nation in terms of GM crops adoption in Africa. GM cotton was the first crop to be commercially cultivated in the country in 1997. Commercial cultivation of GM maize and soybean soon followed (Table 1) with 2013 marking the 18th consecutive year of cultivation of biotech/GM crops in the country on an accumulated area of 2.8 million ha. The area planted with maize reduced marginally due to limited rainfall and financing for farmers. Both conventional and biotech maize were grown on approximately 2.7 ha compared to 2.83 million ha in 2012. Biotech maize alone covered 2.3 million ha compared to 2.4 million ha in 2012. The adoption rate for herbicide-tolerant biotech soybean was 92 % which is equivalent to 478, 000 ha. In 2012, biotech soybean covered 450, 000 ha. Adoption of biotech cotton remained at 100 %. However, the total area under the crop reduced from 11,000 ha to 8, 000 ha due to competition from maize and soybean. The accumulated net economic gain from biotech/GM crops between 1996 and 2012 is estimated to be $1.15 billion. The economic benefits for 2012 alone are approximately $218 million.

Table 1: Commercialized crops and traits in South Africa since 1998

Crop	Trait	Year of Commercialization
Cotton	Ht/Bt – Herbicide tolerant/insect resistance (Bolgard RR)	2005
	Bt – Insect resistant (Bolgard II, line 15985)	2003
	Ht - herbicide tolerance (RR lines 1445 & 1698)	2000
	Bt – insect resistance (Line 531/ Bollgard)	1997
Maize	Ht/Bt – Herbicide tolerant/insect resistance (Yieldgard RR)	2007
	Bt – insect resistance (Bt11)	2003
	Ht – herbicide tolerance (NK603)	2002
	Bt – insect resistance (MON810/ Yieldgard)	1997
Soybean	Ht – herbicide tolerance (GTS40-3-2)	2001

Source: ISAAA AfriCenter 2013

In addition a number of traits in maize and soybean have been approved for field-testing as indicated in Table 2.

Table 2: Trial Release Approvals for GM crop Testing 2013 (confined Field Trials)

Crop	Trait	Event Name
Maize	Drought tolerance	MON87460
	Insect resistance, including IR/IR	59122
	Insect Resistance/Herbicide tolerance	TC1507 x 59122 MON89034 x TC1507 X NK603 TC1507 x NK603 TC1507 x MON810 TC1507 x MON810 x NK603 PHB37046 PHB37050
	Male sterility, Fertility Restoration, Visual Marker	DP32138-1
Soybeans	Modified oils/HT	305423-40-3-2 305423

Source: Clive James, 2013

b) Burkina Faso

Burkina Faso became the second country in Africa to adopt insect-resistant Bt cotton in 2008 with an initial planting of 8,500 ha. According to the country's Minister for Science, Technology and Innovations, Prof. Gnissalsaie Konate, Burkina Faso made a strategic choice in 2008 to apply biotechnology in order to solve severe production constraints facing the country's cotton sector. In 2013, adoption of Bt cotton increased by a record 51 % from 313,781 ha in 2012 to 474,000 ha in 2013. This was equivalent to 68 % of the total cotton hectarage. The number of farmers growing Bt cotton was approximately 150,000, majority of who were smallholders.

Since the adoption of Bt cotton, Burkinabe cotton farmers have experienced numerous benefits. The farmers report cutting chemical use by two-thirds hence reducing the cost of production.

> *"I have been growing Bt cotton for the last four years and will continue since it is less strenuous to manage, given the reduction of pesticide sprays from six to only two per season. Spraying less saves me on production costs and I am no longer in danger of getting poisoned by the pesticides."* ***Mr. Sanou Sibiri, small scale farmer***

There has been a 20 % increase in yields in farmers' fields and 30-40 % in the research station. Less pesticide use has led to reduced environmental pollution. The net economic gains from Bt cotton is estimated at $187 million for the period 2008 to 2012 and $90 million for 2012 alone. Additionally, Burkina Faso is conducting confined field trials for Bt cowpea (insect resistance) that was in the fourth season as of November 2013.

Goodwill from the country's political leadership has played a major role in the rapid adoption of Bt cotton. This is in addition to having a functional Biosafety Framework, which is implemented through the revised Biosafety Act of 2006 /2012.

c) Sudan

Sudan commercially planted Bt cotton for the second time in 2013 with a three-fold increase in hectarage. The insect-resistant cotton covered a total of 61, 530 ha compared to 20,000 ha in 2012. This was equivalent to 89 % of the total cotton grown in the country. Biotech cotton was planted by approximately 27,000 farmers on both rain-fed and irrigated areas including: Gezira, Rahad, New Halfa, Suki, Sennar, White Nile, Blue Nile State, North Kordufan, Arab Company Sudan and Egyptian Company.

In the first year of commercialization, 2012, Bt cotton saved 37 % of the direct cost of production. The cost of producing conventional cotton was much higher at $886 for one hectare compared to $586 per hectare for Bt cotton. The economic benefits gained by farmers planting Bt cotton were $405 per hectare.

Cotton is a major cash crop in Sudan but production declined over the past five years due to bollworms. The introduction of Bt cotton was therefore a welcome change expected to boost productivity. The three-fold increase in Bt cotton hectarage between 2012 and 2013 is clear evidence that farmers have had a positive experience with the technology.

Progress in other Countries

A number of African countries are making positive strides towards GM crops research and development with nine countries conducting confined field trials as indicated on Table 3. The trials are focusing on improving important food staples including banana, cassava, cowpea, maize, rice, sorghum, wheat and sweet potato. The traits of interest are relevant to the continent and will be of benefit to both the consumers and the farmers. These include drought-tolerance, nutrient use efficiency, nutritional enhancement, salt tolerance and resistance to tropical pests and diseases. Successful completion of these trials will see commercialization of superior crop varieties that can withstand various biotic and abiotic constraints.

Table 3: Status of Crop Biotechnology R & D in Africa 2013

Country	Crop	Trait	Stage as in November 2013
Burkina Faso	Cowpea, *Vignaunguiculata*	Insect resistance	CFT – 4th season
Ghana	Bt. Cotton (Bollard II)	Insect resistance	Multi-locational trials in 6 sites
	NUWEST rice	Nitrogen Use Efficiency/Water Use Efficiency and Salt Tolerance	1st CFT
	Bt. Cowpea	Insect resistance	1st CFT
Egypt	Wheat Triticum durum L.	Drought tolerant/salt tolerant	CFT approved by NBC in 2010 and updated in November 2013
		Fungal resistance	3rd season approved by NBC in 2010 and updated in November 2013
Nigeria	Cassava	Biofortified with increased level of beta-carotene, provitamin A	CFT 2end season completed
	Cowpea	Insect Resistant against Maruca pest	Multi-locational trials in 3 sites
	Sorghum *Sorghum bicolor*Moench(ABS)	Biofortification	3rd CFT and back crossing with preferred Nigerian varieties
Cameroon	Cotton	Insect resistance & Herbicide tolerant	2nd season CFT in 3 sites
Kenya	Maize *Zea mays l.*	Drought Tolerance (WEMA)	CFT – 4th season completed. 5th season about to be planted.
		Insect resistance	Approved by NBA. 1st season completed. 2nd season planted and about to be harvested.
	Cotton, *Gossypiumhirsutum L.*	Insect resistance	CFTs completed; Awaiting submission of application for commercial release.
	Cassava *ManihotesculentaCrantz*	Cassava mosaic disease	CFT–1st season completed.
	Cassava *ManihotesculentaCrantz*	Cassava Brown Streak Disease	1st season CFT about to be harvested and second season plants being

			acclimatized in greenhouse about to be planted in CFT.
		Vitamin A enriched	CFT – 1st season completed
	Sweet potato *Ipomoea batatas*	Sweetpotato virus disease	CFT – Mock trial completed. Application for CFT approved by IBC.
	Sorghum (ABS) *Sorghum bicolor* Moench	Enhanced Vit A levels, Bioavailable Zinc and Iron	Greenhouse trial completed CFT- 1st, 2nd and second season completed.
	Pigeon pea*Cajanuscajan*	Insect resistance	Lab and Greenhouse transformation approved by NBA in March 2011.
	Sweet potato *Ipomoea batatas*	Insect resistance	Lab and Greenhouse transformation approved by NBA in April 2011.
	Gypsophila flowers	Flower colour	Application for CFT approved by IBC and submitted to NBA.
Uganda	Maize, *Zea mays l.*	Drought tolerance	CFT - 5th season planted
	Maize, *Zea mays l.*	Insect resistance	CFT- 1st season planted
	Banana, *Musa spp.*	Bacterial wilt resistance	CFT – 1st trial of 60 lines harvested, repeat trial planted on 14th Sept with 10 selected lines
		Nutrition enhancement (Fe and Pro-vitamin A)	Harvested (one ratoon), conducting 3rd season
		Banana parasitic nematode resistance	CFT – Planted in August
	Cassava *ManihotesculentaCrantz*	Virus resistance	CFT – 3rd season
		Cassava brown streak virus (CBSV) resistance	Multi location CFT application submitted to IBC/NBC
	NEWEST Rice	Nitrogen Use Efficiency/Water Use Efficiency and Salt Tolerance	1st CFT harvested in September, application for second planting submitted to NBC, planting expected in October
Malawi	Cotton *Gossypiumhirsutum L.*	Insect resistance (Bt) and Herbicide tolerance (Ht)	1st season CFT harvested
South Africa 1st Commercialized 1998	Maize Zea mays L.	Drought tolerance	CFT 5th season
		Sterility/Fertility	CFT 2nd season
		Stack Insect resistance	CFT 4th season

		Stack Insect resistance/Herbicide tolerance	CFT multiple repeats (2nd and 4th seasons)
	Cotton Gossypiumhirsutum L.	Stack Insect resistance/ Herbicide tolerance	CFT multiple repeats (2nd and 4th seasons)
	Soya Beans *Glycine max*	Modified oils/HT	CFT approved

Source: Clive James, 2013

Biotech/GM Crops Globally

Despite the continuing debate on biotech crops, millions of large and small-scale farmers in both developing and industrial countries have continued to benefit from planting them. Below is a summary of economic benefits of GM crops from 1996 - 2012:

- In 2012, the direct global farm income benefit from GM crops was nearly $19 billion. This is equivalent to having added 6 % to the value of global production of the four main crops of soybeans, maize, canola and cotton. Since 1996, farm incomes have increased by $117.1 billion. Over the 17 years, 1996–2012, the cumulative farm income gain derived by developing country farmers was $58 billion, equal to 49.7 % of the total farm income during this period (Brookes and Barfoot, 2014).

- GM crops have added 122 million tons and 230 million tons respectively, to the global production of soybeans and maize since the introduction of the technology in the mid-1990s.

- Overall, in 2012, GM herbicide-tolerance (HT) technology in soybeans boosted farm incomes by $4.8 billion, and since 1996 it delivered $37 billion of extra farm income. Of the total cumulative farm income gains from using GM HT soybeans, $13.9 billion (38 %) has been due to yield gains and the balance, 62 %, has been due to cost savings.

- The use of herbicide-tolerant cotton delivered a net farm income gain of about $147 million in 2012. In the 1996–2012 period, the total farm income benefit was $1.37 billion.

- In 2012, the total global income gain from the adoption of GM herbicide-tolerance technology was $481 million and cumulatively since 1996, it was $3.66 billion.

- The global farm income gains from using genetically modified insect-resistant (IR) maize and cotton in 2012 was $6.71 billion and $5.3 billion respectively. Cumulatively since 1996, the gains have been $32.9 billion for GM IR maize and $36.3 billion for GM IR cotton.

In Africa, farmers in South Arica, Burkina Faso and Sudan are now sharing in these economic and social benefits attested to by the farmers as quoted below.

"Adoption of Bt cotton has led to a reduction of chemical sprays hence saving farmers the agony of having to walk long distances when spraying their farms. There is also low exposure to chemicals which is good for one's health. Yields from GM cotton are also high and the quality of the lint is good. Consequently, farmers are able to get more incomes from their produce. There has been some opposition from anti-GM groups but we are not deterred since we know the benefits."- ***Mr. Karim Traore, President, Burkina Faso Cotton Farmers Association***

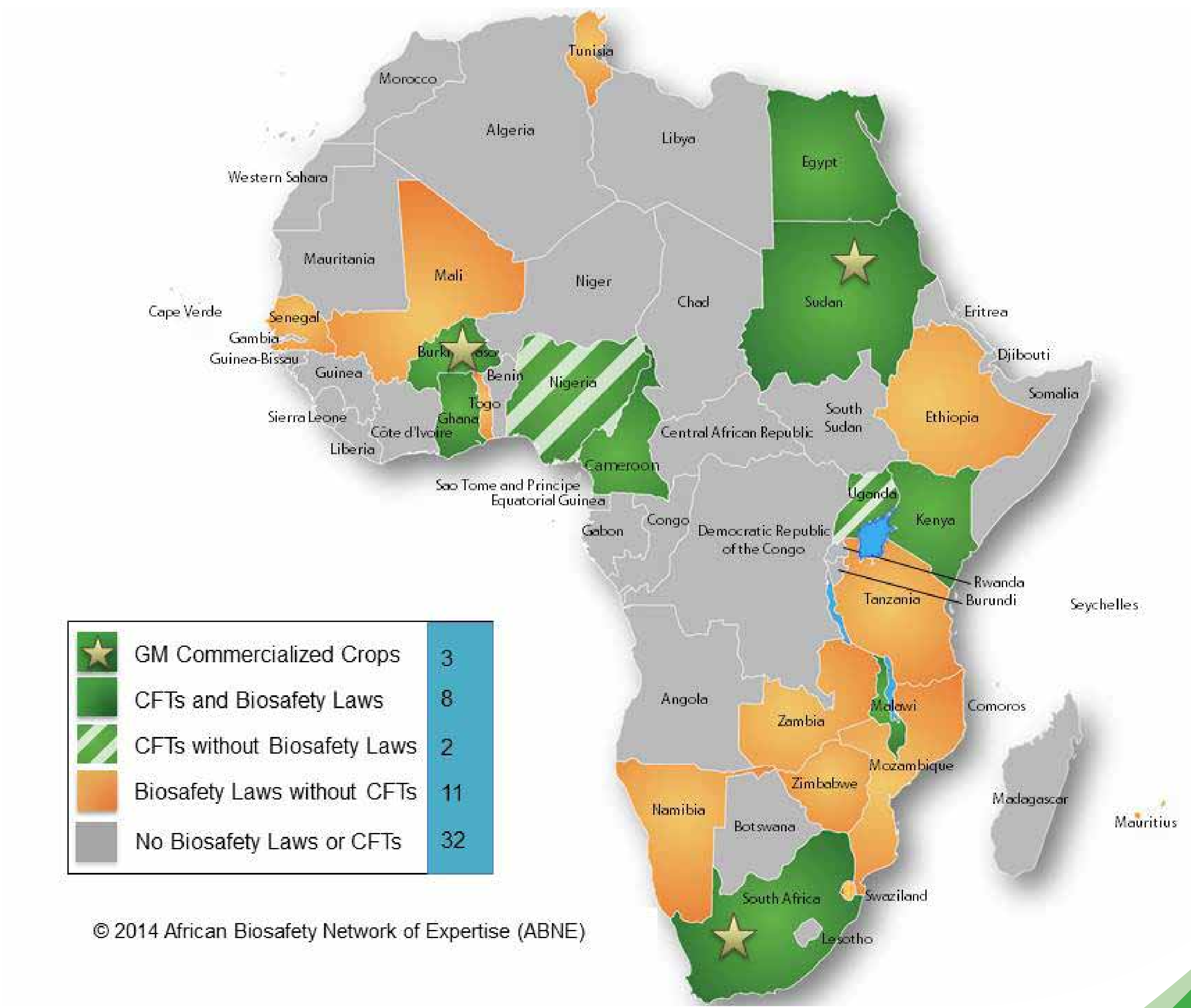
"I have been growing Bt cotton for the last four years and will continue since it is less strenuous to manage, given the reduction of pesticide sprays from six to only two per season. Spraying less saves me on production costs and I am no longer in danger of getting poisoned by the pesticides. Additionally, I get more yields hence more income from Bt cotton. I am now harvesting approximately three tons per hectare compared to the two I was getting from conventional cotton. As a result, I have acquired an additional pair of oxen for my field and I am comfortably paying school fees for my three children, two of them are in high school now. I also plan to expand hectarage on Bt cotton."- ***Mr. SanouSibiri, small scale farmer, Burkina Faso***

Biosafety Frameworks

Safe and responsible use of biotech/GM crops depends on the presence of an enabling regulatory framework. Most African countries have signed and ratified the Convention on Biological Diversity as well as the Cartagena Protocol on Biosafety. Nineteen countries have also enacted biosafety laws (Figure 1). However, the road to establishing functional biosafety frameworks has been protracted. The process has been derailed by lack of political goodwill and anti-GM activism in some countries. Other countries have also adopted highly restrictive biosafety laws—which discourage research and investment in the technology.

Lack of appropriate, science-based and cost/time-effective regulatory systems continues to be the major constraint to adoption. Responsible, rigorous but not onerous regulation is needed, particularly for small and poor developing countries.

Figure 1: Status of Biosafety Regulation in Africa



Challenges to GM Adoption

In spite of the progress reported in 2013, a number of challenges derailed advancement in some countries. Egypt did not grow biotech corn for the first time in five years following a temporary ban and political instability. Preparation for commercialization of Bt cotton in Kenya—expected in 2014—was also derailed by a cabinet ban imposed on the importation of GM foods. This has led to a "wait-and-see" attitude as the technology developers want to be certain of the governments' commitment to biotechnology before submitting an application for environmental release. In Uganda, biotech cotton trials were put on hold as the partners set out to review varietal choices and devise new technology transfer modalities, slowing down commercialization as well. Another challenge in the country is the upsurge of anti-biotech activism, which has delayed tabling of the National Biotechnology and Biosafety Bill (2012) in the parliament for debate, the penultimate stage before it is enacted.

Future Prospects

There is cautious optimism as regards to the next batch of biotech/GM crops expected to be commercialized in the continent. There are indications that some of the products to be commercialized in the next five years include: The drought-tolerant maize and insect-resistant cowpea expected in 2017, insect-resistant cotton in countries like Kenya and virus-resistant cassava among others. The biotech crops and traits in field trials in Africa can significantly expand their quantity of adoption and commercialization globally. There are currently nine biotech crops adopted and commercialized globally, listed in Table 4, in descending order of hectarage. Also listed in the table are other 10 "new" biotech crops in field trials in Africa, half of them "food security" crops. These are banana, cassava, cowpea, potato, rice, sorghum, sugarcane, sweet potato, tomato and wheat: Thus, Africa has the potential to contribute up to 10 "new" biotech crops.

Table 4: Biotech Crops Commercialized and in Field Trials in Africa, 2013

	Current Biotech Crops	Biotech Crops in Field Trials in Africa
1.	Soybean	Banana
2.	Maize	Cassava
3.	Cotton	Cowpea
4.	Canola	Potato
5.	Sugar beet	Rice
6.	Alfalfa	Sorghum
7.	Papaya	Sugarcane
8.	Squash	Sweet potato
9.	Poplar	Tomato
10.		Wheat

It is also anticipated that more countries will proceed to inaugurate science-based biosafety frameworks. There is need for immense political will from the leaders to ensure the commercialization of biotech crops. Burkina Faso provides the best example of how deliberate political goodwill can ensure positive progress with agricultural biotechnology in a country. Finally, there needs to be a sustained and appropriate communication regarding the impacts and benefits of biotech crops.

ABOUT OFAB

The Open Forum on Agricultural Biotechnology in Africa (OFAB) is a platform that brings together stakeholders in agricultural biotechnology to share knowledge and experiences on all aspects of the technology. It is currently operational in eight countries- Burkina Faso, Egypt, Ghana, Kenya, Nigeria, Tanzania, Uganda and Zimbabwe. The Kenya Chapter is hosted by the International Service for the Acquisition of Agri-biotech Applications (ISAAA) *Afri*Center under a collaborative agreement with the African Agricultural Technology Foundation (AATF).

ISAAA INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

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FONDATION AFRICAINE POUR LES TECHNOLOGIES AGRICOLES

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