syngenta foundation for sustainable agriculture

FARA

Status of Biotechnology and Biosafety in sub-Saharan Africa

A FARA 2009 Study Report

Forum for Agricultural Research in Africa (FARA)

Syngenta Foundation for Sustainable Agriculture (SFSA)

Contents

Tables

Figures

Status of Biotechnology and Biosafety in sub-Saharan Africa

A FARA 2009 Study Report

Forum for Agricultural Research in Africa (FARA)

Syngenta Foundation for Sustainable Agriculture (SFSA)

Forum for Agricultural Research in Africa

12 Anmeda Street, Roman Ridge

PMB CT 173, Accra, Ghana

2011

Citation: FARA (Forum for Agricultural Research in Africa). 2011. *Status of Biotechnology and Biosafety in sub-Saharan Africa: A FARA 2009 Study Report.* FARA Secretariat, Accra, Ghana.

Forum for Agricultural Research in Africa (FARA)
12 Anmeda Street, Roman Ridge
PMB CT 173, Accra, Ghana
Tel: +233 302 772823 / 302 779421
Fax: +233 302 773676
Email: info@fara-africa.org
Website: www.fara-africa.org

ISBN 978-9988-1-3722-x (print)

ISBN 978-9988-1-3731-0 (pdf)

Editing: Sue Hainsworth, SDH Publishing

Design: www.bluepencil.in

Print: www.pragati.com

Executive summary

ACMV-protected GM cassava (left of picture) growing next to African Cassava Mosaic Virus (ACMV)-diseased (inoculums) plant. Confined field trial at NaCRRI, Namulonge, Uganda.

1. The status of agricultural biotechnology at the end of 2009 was studied in six African countries (Burkina Faso, Ghana, Kenya, Malawi, Nigeria and Uganda) participating in the regional project Strengthening Capacity for Safe Biotechnology Management in sub-Saharan Africa. (SABIMA). In addition to the six countries in which the FARA-led SABIMA project is being implemented, this study was extended to include: Cameroon, Côte d'Ivoire, Egypt, Madagascar, Mali, Mozambique, Namibia, Senegal, the Republic of South Africa, Togo, Tanzania and Tunisia. The study also included Consultative Group on International Agricultural Research (CGIAR) centres and several regional institutions. Increasing the study scope beyond the six SABIMA-implementing countries was expected to provide greater insight into the prospects of genetic engineering (GE) technology adoption and commercialisation in African countries. Lessons from countries such as South Africa, the first African country to introduce and commercialise GE products, were expected to motivate the adoption of GE technology.

2. The study consisted of a desk review during which some secondary information was examined, and field studies channeled toward collection of new primary data from the participating countries.

The field studies used structured, semi-closed questionnaires and telephone interviews to collect qualitative and quantitative data.

3. The desk review of earlier studies in the West and Central Africa (WCA) sub-region indicated that although several national research centres had the potential to study tissue culture, levels of scientific expertise were generally low and there were insufficient infrastructural facilities for GE research. Strengthening research capacity, molecular biology, biochemistry, genomics, plant breeding, bioinformatics, and policymaking were identified as priorities for the effective application of home-grown GE to African agriculture. Burkina Faso enacted its biosafety law in 2003 and by 2006 had adopted GE technology (Bt cotton) in its agriculture. This seems to have galvanised Cameroon (in 2004), Mali (in 2007) and Togo (in 2008) to enact their own biosafety laws. Cameroon, Mali and Togo were still to develop their biosafety regulatory procedures at the time of this review in September/October 2009. At that time Côte d'Ivoire, Equatorial Guinea, Guinea-Bissau, and Sierra Leone were the only countries, among the 24 in WCA, not to have ratified the Convention on Biological Diversity (CBD).

4. Most of the countries of the Eastern and Southern Africa (ESA) sub-region belong to the Common Market for Eastern and Southern Africa (COMESA). They developed their biosafety frameworks under the United Nations Environment Programme–Global Environment Facility (UNEP-GEF) project during 2001–2004. However the levels of implementation of these biosafety frameworks varied widely among countries. The following ESA countries had enacted their biosafety laws: South Africa (1997), Zimbabwe (2000), Mauritius (2003), Tanzania (2005), Namibia (2006) and Kenya and Malawi (2007). Although Uganda did not have a biosafety law, it had been conducting confined field trials (CFTs) on banana (*Musa* spp.) and cotton (*Gossypium hirsutum*) since 2007. Tanzania had been conducting CFTs on Bt cotton and drought-resistant maize (*Zea mays*) since 2006 as had Kenya since 2008. South Africa was the first African country to adopt GE technology after launching Bt cotton trials in 1990; and authorising the first home grown commercial release of a GE product (Bt cotton) in Africa in 1997. By 2006 over 90% of the country's cotton crop was GE. Similarly, GE maize was commercialised in 1998, followed by soybean (*Glycine max*) in 2000. In 2006 about 75% of the South African soybean crop was covered by GE soybean while 50% of the yellow maize and 44% of white maize crops were GE maize. This puts South Africa ahead of several countries in the acceptance of GE technology and products. Angola was the only ESA country not to have ratified the CBD at the time of this report.

5. Egypt and Tunisia were the only Northern African countries conducting GE crop studies in 2009 when the current study was undertaken. The review found that most of the commercial GE products such as maize, soybeans, soy meal and vegetable oils marketed in Egypt were imported from Argentina and the United States. Egypt released Bt maize, its first home grown commercial GE crop, in 2008. In contrast, at the time of the current studies, Tunisia was still conducting GE crop research in bio-contained facilities. The absence of enabling government policies and a biosafety law were restraining Tunisia from proceeding to commercialisation of GE products. At the time of the study, Morocco was the only Northern African country that had not deposited an instrument of ratification or accession to the CBD.

6. There were only 12 countries: Algeria, Burkina Faso, Egypt, Ethiopia, Kenya, Mali, Mauritius, South Africa, Sudan, Togo, Tunisia and Zimbabwe with functional National Biosafety Frameworks (NBFs). Eleven countries: Ghana, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Tanzania, Uganda and Zambia were operating on interim NBFs. Encouraging policy support from the governments of these countries enabled their research institutions to apply for and obtain permission from national biosafety regulatory authorities for GE research and commercialisation. Proponents of the technology have roundly cheered the most recent approval for commercialisation Bt cotton in Burkina Faso in October 2008. Burkina Faso has thus become the third African country to commercialise a 'home-grown' GE crop after South Africa in 1997, and Egypt in early 2008.

7. The literature review indicated inadequate diffusion of science-based information on GE crops at both grassroots and policymaker levels. It was reasoned that such lags were being exploited by anti-GMO non-governmental organisations (NGOs) such as Greenpeace, Friends of the Earth, etc. to spread negative information on GE, which in turn formed the basis of the cautious approach to GE technology adoption in several African countries. The cautious approach to GE crops in Europe, Africa's major trading partner, also appeared to be affecting the adoption of GE technology in several African countries.

8. Information obtained directly from surveyed countries during the current studies indicated that: 17 Burkinabe research institutions; 18 Ghanaian institutions; 14 Kenyan; 6 Malawian; 12 Nigerian; 16 Ugandan and 9 Africa-based CGIAR centres were introducing biotechnology tools into their research programmes. These institutions included national research centres, universities and government ministries. Among the biotechnology research activities on-going at the time of the study there were: 30 in Ghana; 27 in Kenya; 21 in Burkina Faso; 10 in each of Nigeria and Uganda; and 13 across all Africa-based CGIAR centres. All the other countries had a few ongoing biotechnology research activities. Although most of the biotechnology activities were on molecular marking and tissue culture, a good number involved transgenic crops. Most of the research on transgenic crops was being conducted in Kenya, Burkina Faso, Uganda and Nigeria in that order. It was therefore not surprising that 42% of the biotechnology laboratories in the surveyed countries were working on molecular marker assisted plant breeding; 32% on tissue culture; 13% on GE and 13% on fermentation research activities. Interestingly, most of the GE research projects were concentrated on crops of importance to food security (cassava, cowpea maize and sorghum) and on livestock vaccine production. During the initial arrival of GE technology to Africa the listed crops had attracted little attention. This new trend of conducting more GE research on staple crops needs to be continuously emphasised to ensure the realisation of the 6% annual growth of the joint African Union/ New Partnerships for Africa's Development Comprehensive Africa Agricultural Development Program (AU/NEPAD CAADP) programme goal. It was also observed that most of the agricultural productivity challenges on which the biotechnology laboratories were working involved the control of insect pests and fungal and bacteria pathogens. There were a few studies on such abiotic stresses as drought, salinity, heat, etc.

9. Investments in human resources for biotechnology research appeared to be on the upward trend, especially in Ghana that had 38 experts and Burkina Faso that had 22. However, human capital development appeared to be a critical constraint in most of places surveyed

where there were fewer than 15 biotechnology experts in the entire country. Many of the countries were dependent on experts from ancillary disciplines to complement the human resources needed for biotechnology research. A big gap in the requisite expertise in GE still needs to be filled. The development and maintenance of the expensive infrastructure needed for GE remained a challenge for most of the countries. All who participated in the studies agreed that GE technology debates should go beyond the confines of research laboratories and scientific conferences to the common users of technology and to policymakers. They emphasised the need for communication to be channeled through specialised media. About 60% of respondents agreed that there was a need to increase the level of public awareness on the science and usefulness of GE technology in African agriculture. This should encourage a wider acceptance of the technology by policymakers, farmers and even skeptical NGOs.

10. The nonavailability of biosafety legislation, lack of biotechnology policies and absence of biosafety procedures in several countries constituted significant impediments to about 50% of research institutions that wished to undertake GE research. Such institutions could not successfully apply for, or obtain permission for, GE research from regulatory authorities. The absence of enabling GE laws mainly resulted from the lack of capacity for GE policymaking. The lack of strong policy support, political commitment and acceptance of GE technology could continue to retard the adoption of this technology for agricultural development. FARA and its constituent sub-regional organisations (SROs) need to invest more in strengthening capacity for GE policy-making. Although the lack of this capacity was an issue in several countries, it was also found that some countries appeared to be adopting a 'wait-and-see' attitude towards agricultural biotechnology. A strategy for marketing the acceptance of GE technology to such countries would be helpful. Such a strategy should be built around science-based information systems.

11. The respondents to this study wanted FARA and its constituent SROs to continue providing leadership in catalysing and coordinating regional approaches to: agricultural biotechnology, training support and mobilisation of research investments. The Regional Economic Communities (RECs), on the other hand, should provide more institutional support to FARA and its SRO's regional approach to biotechnology. The RECs could do this by mobilising their constituent countries to provide enabling policy environments together with the requisite investments in financial, material and human resources needed to ensure GE technology can thrive in Africa.

12. In conclusion, it was generally found that many African national agricultural systems (NARS) had fragile crop or livestock research programmes that were often dependent on a handful of individuals. Faced with human, financial and infrastructural constraints many of such programmes often had limited capacity to implement promising initiatives beyond the pilot scale. The challenge is therefore for FARA and its SROs to examine the means by which, through sustained networking, African institutions conducting research on GE could optimise their research capabilities and outputs. FARA and its constituent SROs would also need to establish a biotechnology cooperation service to be charged with linking Africa to GE research facilities around the world. Such a service could help to maximise international training opportunities and encourage the rapid development of GE technology in Africa. Most of the research staff in service did not have the necessary scientific background to

use GE technologies. Hence, in-service staff training would be required to enable its use in most of the surveyed countries. FARA and its partners could invest in the creation of professorial chairs in reputable African universities and research centres working on GE. Such positions, which should be held by world-renowned professors, should facilitate the local strengthening of GE research capacity in the identified institutions. The challenge to manpower resource management would be to avoid losses of the trained, skilled African researchers through brain drains. It was observed that the priority that many developing countries place on building capacity in policy and regulatory issues such as agricultural biosafety is increasing. It was also noted that many African countries still face particular challenges in the implementation of the Cartagena Protocol on Biosafety (CPB), since their capacities to enact, implement, monitor and enforce national biosafety laws remain weak. FARA and its constituent SROs need to organise special regional training for policymakers to facilitate their tasks in GE law-making.

13. Several national laboratories could not function properly because of inadequate power supplies and frequent breakdowns in their research equipment. The present lack of engineers trained to service the sophisticated equipment required in GE research compels frequent recourse to manufacturing firms abroad for essential repairs. It is therefore recommended that in parallel with the development of GE research infrastructure, African countries should also build an infrastructure of support services for equipment repair and maintenance.

14. For effective collaborative GE research in African countries to become a reality, repositories of biotechnology resources such as microbial type-culture collections, DNA clone libraries and germplasm and stock centres need to be developed. Such repositories should maintain the collections and supply authentic materials and cultures to research institutions. Selected African centres could be designated by RECs to perform these roles. Similarly, an African biotechnology information service is required to promote the exchange of information by all available means. This service should be responsible for the acquisition and management of all databases, information resources and reference standards relevant to advanced biotechnology. It should also be mandated to link African research institutions to global biotechnology information services and on-line databases, and to establish easy, systematised access to data banks.

Preface and acknowledgements

The potential of modern biotechnology to enhance agricultural productivity has been recognised. It augments traditional technologies in their effort to address the challenges of agriculture. FARA promotes capacity strengthening in the use of all biotechnology tools both genetic modification (GM) and non-GM based on the need to promote agricultural productivity in Africa to address food-security problems and alleviate rural poverty. For an objective assessment of the gaps in various African countries capacity-building capabilities in the research, development and deployment of modern biotechnology products, FARA identified the need for continuous assessment of the status of knowledge in the area. They therefore commissioned a survey on the status of biotechnology and biosafety in sub-Saharan Africa that would enable FARA and its development partners to target resources to the areas in need of such capacity strengthening.

The Syngenta Foundation for Sustainable Agriculture (SFSA) funded the study through the FARA Executive Secretariat. FARA is most grateful to SFSA for funding *Strengthening the Capacity for Safe Biotechnology Management in sub-Sahara Africa* (SABIMA), the project under which the survey study was conducted.

This report is based on a consultancy awarded to Dr Marcel Nwalozie formerly of le Conseil ouest et centre Africain pour la recherche et le développement agricole (CORAF)/West African Council for Agricultural Research and Development (WECARD).

The input of key people who administered questionnaires in the six project countries that supplied the necessary country data is highly appreciated. These persons, or their representatives, who submitted completed questionnaires included: Dr Clémentine Dabire (Burkina Faso), Dr Marian D Quain (Ghana), Dr Bosibori Bett (Kenya), Professor Moses Bauleni (Malawi), Dr Mohammad F Ishiyaku (Nigeria) and Dr Andrew Kiggundu (Uganda). Subsequently Dr Oumar Traoré took over as representative for Burkina Faso and provided supplementary data. Dr B Bett made submissions for Kenya on behalf of Dr Simon Gichuki and Professor Moses Bauleni represented Malawi for Dr Weston Mwase.

The SABIMA project coordinator, Professor Walter S Alhassan and the SFSA consultant, Dr Vivienne Anthony not only had input to the review of the report but also made sure the report was completed and published. They acknowledge the joint input by communication experts from FARA (Eric McGaw) and SFSA (Paul Castle) in reviewing the document to make it user-friendly for a wide audience.

The extensive database gathered in support of the written report will be formatted and published as a companion document to this report.

Prof Monty Jones
Executive Director
Forum for Agricultural Research in Africa

Introduction

Tissue culture plantlets in tubes, National Agriculture Research Laboratories, Kawanda, Uganda.

The need for technological innovations in Africa's agriculture

In sub-Saharan African (SSA) agriculture has not benefitted significantly from technological innovations of the last half-century. In other regions of the world per hectare crop yields are doubling or even quintupling, but yields have not increased in Africa. Even the high food prices of 2007/8 brought no economic advantage to poor farmers in Africa. The high-yielding varieties of Asia's Green Revolution of the 1960s and 1970s increased yields, ensured food security and improved farm incomes. Over and over again we are told that the Green Revolution by-passed Africa. Surely, scientific and technological advances could be used to mitigate the factors that have continued to keep African agricultural productivity at very low levels. Prospects do exist for significant productivity improvement through a combination of technological and policy measures. The African Union (AU)'s comprehensive approach that envisions a 6% annual growth in agricultural productivity through 2015 requires the deployment of advanced technologies coupled to strong policy support. This vision seeks to directly address low agricultural productivity and food and income insecurity. The Forum for Agricultural Research in Africa (FARA) is leading the implementation of the vision for agricultural research and development in Africa, derived from the AU/New Partnerships for Africa's Development (NEPAD) Comprehensive African Agriculture Development Program (CAADP) pillar 4. The compelling vision of pillar 4 urges a diametrical change in direction and approach in preparing for a new tomorrow for Africa's agricultural research for development. It projects strategic directions that should propel Africa's agriculture along a thriving path.

Achieving the ultimate goal entails a substantial productivity revolution in smallholder farming – a revolution that must be led by robust producer and consumer-centric research approaches. Understanding the technical and cultural underpinnings of the entire value chain in smallholder production and marketing should be key to influencing the direction of this revolution, and would form the bedrock for positioning African farmers to benefit from market opportunities. Realising a 6% agricultural productivity growth rate will need unprecedented policy support from African governments and international development partners. Such policy shifts should aim for sustained investment in the generation of agricultural technologies and most particularly for the deployment of advanced biotechnologies including genetically engineered crops and livestock.

The need to deploy such new technological innovations to improve productivity in African agriculture should focus on Africa's objectives for poverty reduction, and on the drive to ensure that both African agriculture and its economic growth are sustainable.

The other CAADP objectives include African countries' efforts to increase aggregate production and thus growth of gross domestic product (GDP) with associated improvement in:

- Employment opportunities
- Farm household incomes leading to poverty reduction
- Food production
- Assured food security and less hunger
- Reduced use of agro-chemicals (most of which have negative implications for human and environmental health).

African countries will therefore need to be proactive in the acceptance of genetic engineering's role in agriculture.

Genetic engineering (GE) and value addition

Following the discovery of the totipotency of individual cells, tissue culture technologies have been developed. Soon after scientists discovered the possibility of using deoxyribonucleic acid (DNA) segments to mark the presence of useful genes that could be transferred to future generations through traditional plant breeding, molecular marker technologies were developed to track the inheritance of such genes. Transgenic crops or animals, often referred to as GE crops or animals or simply genetically modified organisms (GMOs), are derived from the artificial insertion of genes from one organism to another to enhance the expression of desirable traits or to suppress undesirable ones. The deployment of tissue culture and molecular marker technologies in agriculture has been less controversial than GE. However, proponents of biotechnology have continued to argue that it has been around ever since humans started to collect landraces of crops and make efforts to improve them. This process evolved further after Mendel invented the science of genetics, and his Mendelian principles were applied to conventional plant breeding.

The controversy surrounding GE centres on the fact that in transgenic crops the well-characterised genes from one organism are transferred in a targeted manner to another organism without sexual crossing. The controversy, therefore, is whether such GE crops are substantially different from conventional varieties, and as such, whether such varieties pose a threat to human and environmental health. Advocates emphasise the technology's potential to boost productivity, while its opponents stress the possible threats to: human and environmental health; corporate control of seed supply systems and industrial agriculture. GE has been controversial ever since the technology was launched. However, its advocates, and even those who lobby against it, all agree on the need for safe biotechnologies. Hence countries are legislating to regulate research and commercialisation of GE crops based on their impact on humans, animals and the environment. The first genetically modified food – the anti-squash FlavrSavrT tomato engineered by Calgene – was approved for marketing by the American Food and Drug Administration in 1994. By 2001, more than 50 modifications involving 13 crops had been approved and produced on more than 52 million hectares in at least 14 countries (Philips, 2003). By 2003, Argentina, Brazil, Canada, China and the United States, accounted for 99% of the 67.7 million hectares under GE crop cultivation worldwide. Of this production, 99% concentrated on just four crops (canola (*Brassica napus*), cotton (*Gossypium hirsutum*), maize (*Zea mays*) and soybean (*Glycine max)*, that were developed to tolerate herbicides and/or resist insects (Clive, 2003; 2008). South Africa was the first African country to commercialise GE cotton in 1997. By 2008, two African countries, Burkina Faso and Egypt had joined South Africa in the commercialisation of GE crops.

The key value addition of the GE technology is that it enhances the efficiency of crop improvement; the process of generating an improved variety is less time-consuming; and the process for gene transfer to desired crops is more precise. However, generations of cross breeding are still required to identify desirable traits. GE significantly reduces the time needed for development

Research technician in a plant transformation laboratory at the National Agricultural Research Laboratories, Kawanda, Uganda.

work, and it improves of the products. GE expands the scope of what is possible in agricultural productivity providing a window of opportunities for African agriculture to rapidly fill the gaps in food production, availability and affordability. However, the adoption of this technology needs strong governmental policy support.

Role of institutions in adopting biotechnology in African agriculture

Safe biotechnology has the potential to address an array of constraints facing resource-poor farmers in Africa. However, a favourable policy environment remains a prerequisite for its adequate deployment. The advent of GE has been a unique experience in agricultural science. This is because the techniques were first developed by large, profit-making, private corporations operating in Organization for Economic Co-operation and Development (OECD) countries. Because GE technology originated from the private sector rather than the usual public sector led research and development, African public institutions must develop their ability to use a technology hitherto driven by powerful profit-taking corporations. African countries need to do this to enhance their nutritional and economic security. Interesting public–private partnerships have been forged in Africa in efforts to deploy GE technology in its agriculture. Cohen (2005) was therefore correct in pointing out that: "….genetically modified crops are often framed as the products of multinational corporations, but in poorer nations it is public research that is vibrant and attempting their development." This is particularly so because the concern of poor countries, especially those in SSA, is food security, and these countries see this technology as a vital tool and a direct response to their food productivity needs.

The origin of GE technology and its association with multinationals could prompt the following sombre reflections:

1. How might SSA countries, by-passed by the Green Revolution of the 1960s, manage the use of advanced biotechnology that is largely driven by profit-making companies for their own priorities in food security and poverty alleviation?
2. Would internal and external decision-takers and those investing in food security and poverty alleviation in Africa let the corporate world's model (driven by shareholders' interests and profit-taking) be the ideal choice for the application of advanced biotechnology in Africa?
3. How might enabling environments for the introduction and deployment of safe biotechnology to agriculture be created to achieve the goal of AU/NEPAD's CAADP?

Bearing these questions in mind it becomes necessary to understand; not only the role of African national, regional and international public institutions involved in deploying GE technology in agriculture, but also their associated capacity needs. The process of technological innovations depends as much on institutions as on the science itself (Hayami and Ruttan, 1985; Mokyr, 2002), since institutions with weak research and technology deployment capacities might not benefit from advances in the technology. Africa therefore needs to focus on creating the favourable environments needed for this technology to thrive, since an appropriate environment provides incentives for investment in the priority commodities and traits needed to increase agricultural productivity. Such favourable environments include: enacting the relevant biosafety laws; developing biosafety procedures and bio-containment facilities and food safety assessment protocols. The requisite resources for effective GE research and development should also be available.

FARA therefore commissioned a study on the status of biotechnology and biosafety in Africa focusing on the countries collaborating in its project: *Strengthening Capacity for Safe Biotechnology Management in sub-Saharan Africa* (SABIMA).

Content

This report contains information on the general capacity of some selected African institutions to develop and apply GE technology to agriculture. Specifically, the study reviewed the status of agricultural biotechnology and biosafety in African countries that were either commercialising or field-testing GMOs. It focused on the following FARA-led, SABIMA-project implementing countries: Burkina Faso, Ghana, Kenya, Malawi, Nigeria and Uganda. The study also reviewed the gaps in capacity-building capabilities in these countries and the modalities for FARA and its partners' intervention in strengthening capacity for the effective application of GE technology to agriculture in Africa. The present report also contains information on GE research and commercialisation from non-SABIMA project countries including: Cameroon, Côte d'Ivoire, Madagascar, Senegal, South Africa, Togo, regional centres and Consultative Group on International Agricultural Research (CGIAR) centres working in Africa. The study also briefly reviewed GE crop research and product commercialisation in Egypt, South Africa and Tunisia. Increasing the study's scope and coverage beyond the six SABIMA-project implementing countries was expected to provide greater insight into the prospect of GE technology's improving African agricultural productivity.

The study methodology comprised a review of secondary data from the literature and the collation of data from a comprehensive questionnaire administered in SABIMA project countries and other countries with biotechnology potential from representative regions of Africa. This report reflects the situation in November 2009 when the study was conducted.

Genetically modified banana plants in a greenhouse. National Agricultural Research Laboratories, Kawanda, Uganda.

Study findings

Prof Walter S. Alhassan (left), Coordinator of the SABIMA Project and Dr Vivienne Anthony (right), SFSA Consultant in a discussion at a Stewardship Meeting

Earlier studies on agricultural biotechnology in Africa

The strengths, weaknesses and opportunities of some African institutions in applying gene technology to agriculture have been studied and reported (Alhassan, 2003; Clark *et al*. 2007; Nwalozie *et al*. 2007; Karembu *et al*. 2008; Karembu *et al*. 2009). The findings for each sub-region are summarised.

West and Central Africa (WCA) sub-region

Alhassan (2003) surveyed agro-biotechnology capacities in the following seven WCA countries: Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria and Senegal and found they generally had low capacities for GE research. This was attributed to their low capacities in scientific expertise and infrastructure. However, the study indicated:

- Strength in tissue culture and increasing potential in molecular marker technology in Cameroon
- The existence of state-of-the-art infrastructures in Côte d'Ivoire and Nigeria
- Relatively good laboratory infrastructure and biotechnology expertise in Senegal
- The relatively strong personnel base in Ghana.

Alhassan (2003) also reported varying degrees of action with respect to biosafety, ranging from some countries: "taking steps to constitute biosafety drafting committees," to "bringing their biosafety framework documents to the point of legislation".

Alhassan's study revealed that by 2003, Cameroon was the only country from this sub-region that had signed and ratified the Cartagena Proctocol on Biosafety (CPB), whereas others had signed, but were still in the process of ratifying the Protocol. However, by the time of the current study in September/October 2009 most African countries, including those from WCA had signed and ratified the legally binding Convention on Biological Diversity (CBD) and the CPB.

Alhassan (2003) recommended the prioritisation and management of sub-regional biotechnology activities in WCA within the framework of le Conseil ouest et centre africain pour la recherche et le développement/West and Central Africa Council for Agricultural Research and Development (CORAF/WECARD). He further recommended that some identified centres with standard laboratory infrastructure be designated as centres for capacity strengthening in agro-biotechnology.

Subsequent studies (Nwalozie *et al*. 2007) confirmed the earlier findings by Alhassan (2003) and affirmed that the majority of biotechnology research conducted in WCA was on tissue culture for mass propagation of clean plantlets. Nwalozie *et al*. (2007) observed that few laboratories in the sub-region characterised germplasm and fewer still had the capacity to conduct molecular marker-assisted breeding. Generally, the lack of strong policy support, low political commitment and resistance to the technology continued to clog the wheels of GM research. This was further compounded by the actions of a small but vocal opposition to introducing GM technology (Nwalozie *et al*. 2007).

Insect pests constitute a major yield challenge for cotton and maize production in WCA. About 23% of cotton produced in the region is lost to insects, with the cotton bollworm (Helicoverpa spp) complex being the most damaging (Oerke, 2002). This problem is further complicated by the bollworms developing resistance to chemical pesticides (Martin *et al*. 2002; Goldberger *et al*. 2005).

Bt technology provides a very valuable solution to this problem. Vitale *et al*. (2007) cite several studies that concluded: "While Bt cotton only partially controls some of the bollworm species, Bt cotton provides superior performance to conventional insecticide approaches and has been found to either eliminate or significantly reduce the number of chemical sprays used on conventional cotton in various parts of the world." Based on these concepts an economic impact study on the introduction of Bt technology in smallholder cotton production systems in West Africa (Vitale *et al*. 2007) was conducted. The study indicated that the potential economic impacts to West African consumers and producers of cotton could potentially reach US$ 89 million in an average year for Mali alone. The economic model proposed by Vitale *et al*. (2007) propounded that the adoption of Bt maize could boost profitability for the producers and consumers, but that some specific reforms in maize markets and technology were needed. Table 1 provides information on on-going biotechnology/GM crop research in some Africa countries.

In 2008, Burkina Faso took a giant step toward the commercialisation of GM cotton. The country planted over 8,000 ha of land with Bt cotton for seed production and sale. Being the eighteenth country to introduce

Table 1. On-going biotechnology/GM crops research activities in Africa

Country	Crop	Trait	Event	Institutions involved	Stage
Kenya	Maize, *Zea mays*	Insect resistance	MON810	KARI[1], CIMMYT, Monsanto, University of Ottawa, Syngenta Foundation and Rockefeller Foundation	Confined field trials
		Insect resistance	Cry1Ab216		
		Insect resistance	Cry1Ba		
	Cotton, *Gossypium hirsutum*	Insect resistance	Bollgard II	KARI/Monsanto	Confined field trials
	Cassava, *Manihot esculenta*	Cassava mosaic disease (CMD)	AC1-B	KARI, Danforth Plant Science Center	Confined field trials
	Sweet potato, *Ipomoea batatas*	Viral diseases	CPT 560	KARI/Monsanto	Confined field trials
Uganda	Cotton, *Gossypium barbadense*	Insect resistance/ herbicide tolerance	Bollgard IR/HT	NARO/Monsanto, ABSPII, USAID and Cornell University	Confined field trials approved
	Banana, *Musa* spp.	Black sigatoka	Chitinase	NARO-Uganda, and University of Leuven	Confined field trials
	Cassava, *Manihot esculenta*	CMD and cassava brown streak disease (CBSD)		IITA and USAID	
Burkina Faso Ghana Nigeria	Cowpea, *Vigna unguiculata*	Insect resistance	Cry1Ab and nptII	AATF, NGICA, IITA, Purdue University, Monsanto, Rockefeller Foundation USAID, DFID, CSIRO Australia, INERA, IAR, The Kirkhouse Trust	Confined field trials approved in Nigeria
Kenya Mozambique South Africa Tanzania Uganda	Maize, *Zea mays*	Drought tolerance	CspB-Zm event 1	AATF, NARIs in the 5 countries, CIMMYT, Monsanto, Bill and Melinda Gates Foundation, Howard G Buffett Foundation	Confined field trials pending regulatory approval in Kenya Confined field trials on-going in South Africa

Country	Crop	Trait	Event	Institutions involved	Stage
Burkina Faso Kenya South Africa	Sorghum, *Sorghum bicolor*	Nutritional enhancement		A consortium of 9 institutions led by AHBFI funded by Bill and Melinda Gates Foundation	Contained greenhouse trials in Kenya and South Africa
South Africa	Maize, *Zea mays*	Drought tolerance	MON89034, MON87460	Monsanto	Confined field trials
		Herbicide tolerance	Syngenta GA21	Syngenta	Field trial release
		Insect resistance	Syngenta MIR162		
		Insect/herbicide resistance	Syngenta BT11xGA21		
			BT11xMIR162		
			Pioneer 98140	Pioneer	Confined field trials
			Pioneer 98140xMON810		
	Cassava, *Manihot esculenta*	Starch enhancement	TMS60444	ARC-IIC	Contained trials
	Cotton, *Gossypium hirsutum*	Insect/herbicide tolerance	Bayer BG11xRR FLEX	Bayer	Trial release
			GHB119		
			BG11xLLCotton25		
			Cotton T304-40		
		Herbicide tolerance	Cotton GHB614		
			Cotton GHB614 xLLCotton25		
	Potato, *Solanum tuberosum*	Insect resistance	G2 Spunta	ARC-OVI	Field trials
	Sugarcane, *Saccharum officinarum*	Alternative sugar	NCo310	SASRI	Field trials
	Wheat, *Triticum durum*	Drought tolerance	HVA1	AGERI,	Field trials

Country	Crop	Trait	Event	Institutions involved	Stage
Egypt	Maize, *Zea mays*	Insect resistance	MON810	Monsanto	Approved for commercialisation
		Insect resistance	Not available	Pioneer	Field trials
	Cotton, *Gossypium barbadense*	Salt tolerance	MTLd	AGERI	CGH
		Fungal resistance	Chitinase	AGERI	CGH
		Salt tolerance	MTLd	AGERI	CGH
	Potato, *Solanum tuberosum*	Viral resistance	Cry V	AGERI	Field trials
			CP-PVY	AGERI	Field trials
	Banana, *Musa* spp.	Viral resistance	CP-Banana CMV	AGERI	CGH
	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	CGH
	Tomato, *Lycopersicon esculentum*	Viral resistance	CP-REP-TYLCV	AGERI	CGH

Two stewards discussing maintenance of cultures in a tissue culture growth room, NARL, Kawanda, Uganda

GM technology in its territory, but after conducting confined field trials (CFTs) on Bt cotton (Bollgard II®, Monsanto Co., St Louis, USA) between 2003 and 2005, in 2008 Burkina Faso became the tenth country to grow Bt cotton commercially (Karembu *et al*. 2009). Burkina Faso's decision to embark on Bt cotton production is based on the country's conviction that this technology has great potential to become the backbone of its economy. It is important to mention that the 40% of Burkina Faso's GDP of approximately US$ 7billion is derived from agriculture (Karembu *et al*. 2009). Cotton contributes 5–8% of this GDP and generates over US$ 300million annual revenue, with more than 50–60% of its total exports (Yartey, 2008). The Burkinabe Government's strong policy and institutional support for the deployment of GM technology is transforming Burkina Faso into a focal centre for GM technology, and could hold the key to reversing poverty trends and putting the country on the path to sustainable prosperity.

Eastern and Southern Africa (ESA) sub-region

In a recent survey report Karembu *et al*. (2008) found that although most member countries of the Common Market for Eastern and Southern Africa (COMESA) had developed their biosafety frameworks between 2001 and 2004 under a United Nations Environment Programme–Global Environment Facility (UNEP-GEF) project, they are still at varying stages in the implementation of these frameworks. Among ESA countries: South Africa (in 1997); Zimbabwe (in 2000); Mauritius (in 2003); Tanzania (in 2005); Namibia (in 2006) and Kenya and Malawi (in 2007) had approved national biosafety policies and promulgated the relevant laws. All the other countries had: draft biosafety bills; sectoral legislation; policies with references to biotechnology or no specific biosafety laws. Although Uganda does not have a biosafety law, it has been conducting CFTs on banana (Musa spp.) and cotton since 2007. Tanzania has been conducting CFTs on Bt cotton since 2006, and Kenya CFTs on drought-resistant maize since 2008.

Similarly, Kenya, Madagascar, Malawi, Rwanda, Sudan, Uganda, Zambia and Zimbabwe had developed stand-alone national policies on biotechnology development, whereas other countries only had draft policy frameworks or references to biotechnology issues in such other sectoral policies as policy on the environment. Egyptian authorities approved the commercial planting of Bt maize in 2008; whereas in Kenya a number of CFTs have been in progress since 2008. Karembu *et al*. (2008) found that the other countries had precautionary approaches to the production, transit, importation, exportation and dissemination of GM products. Although the surveyed countries are at different stages in terms of biotechnology activities, their policies – whether approved or in draft form – emphasise different aspects of biotechnology. For example, Kenya and Uganda focus on facilitating biotechnology research through capacity building and infrastructure development; their policies anticipate commercialisation of GMOs and seek to regulate it. On the other hand, the policies of Malawi and Zambia seem to indicate a cautious approach to GMOs. "It is gratifying to note that by early 2009 89% of COMESA countries had developed national biosafety frameworks, and had acknowledged the need for regional collaboration in GM technology development and use" (Karembu *et al*. 2008).

African countries are among the developing countries that are commercialising GM crops. In 2008 Burkina Faso and Egypt joined South

Africa in commercialising GM products, thus becoming role models (Karembu *et al*. 2009) in leading in GM technology application and commercialisation in African agriculture. These three countries have also allowed farmers visiting from neighbouring countries to get a feel for real-life experience of GM crops. In more than 20 years' experience, South Africa has developed and integrated GM technology into the mainstream of its agriculture. Bosman (2008) stated that the total area sown to GM crops has continued to increase in South Africa. In 2007, the maize, soybean and cotton area increased by 30% to 1.8million ha from 1.4million ha in 2006. Maize topped the list with 1.6million ha (1.2million ha in 2006), up by 33%. Of the total maize crop 57% was GM. These crops have all been commercialised by South Africa.

The case of South Africa

South Africa boldly embraced GE technology in the early 1990s. It has signed and ratified the Cartagena Protocol on Biosafety (CPB); its national focal point is the Department of Environmental Affairs and Tourism (DEAT); its competent authority and government agency with responsibility for implementing the CPB is the Department of Agriculture (DoA). The South African Government ran an interim biosafety assessment and decision-making process from 1990 to 1999. This led to the establishment of the GMO Act number 15 of 1997. This GMO Act has since been amended to ensure compliance with the biosafety protocol. The National Biodiversity Act directly empowers DEAT on biosafety issues. There are two acts that directly border on GE crops: (http://www.africabio.com/status/south%20africa.pdf):
(1) The National Environmental Management Act, 1998 (Act No. 107 of 1998) which provides for: "cooperative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote cooperative governance and procedures for coordinating environmental functions exercised by organs of state; and to provide for matters connected therewith"; and (2) The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004). This Act provides for: "the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 1998; the protection of species and ecosystems that warrant national protection; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment and functions of a South African National Biodiversity Institute; and for matters connected therewith".

South Africa's CFTs with Bt cotton began in 1990 and resulted in the 1997 issuance of the first conditional commercial release permit by the DoA. After its full assessment Bt cotton was very rapidly adopted in the country. By 2006 the national cotton crop was over 90% GE, with small-scale farmers growing a larger proportion of GE cotton (http://www.africabio.com/status/south%20africa.pdf). Similarly, GE maize was approved for commercial use in South Africa in 1998, followed by GE soybean in 2000. By 2006 GE soybean constituted about 75% of the crop. In 2005 South Africa biotechnology research successfully launched their first double (stacked) trait GE crop, GE cotton (with bollworm resistance and herbicide tolerance) for commercial use. Their second stacked trait, GE maize with stem borer resistance and herbicide tolerance was approved in 2007, and in that year the country also initiated field trials on drought-tolerant maize. It is important to state that South Africa has made significant advances in research and commercialisation of GE crops. By 2006, for example, a total of 1,414,000 ha of the country's arable land (http://www.africabio.com/status/south%20africa.pdf) was sown to GE crops. This area comprised 22,000 ha of GE cotton (or 92% of the crop); 160,000 ha of GE soybean (75% of the crop); 528,000 of GE yellow maize (50% of the crop); and 704,000 of GE white maize (44% of the crop). South Africa's labeling legislation came into effect in January 2004. This legislation was aimed at guiding labeling of foodstuffs significantly different from their conventional non-GM counterparts in: composition, nutritional value, mode of storage, preparation or cooking, allergenicity, or that contained genes of human or animal origin.

South Africa's success story in GE technology and its acceptance could be attributed to its widely accepted national biotechnology strategy that was designed to stimulate innovative growth in biotechnology. The acceptance of this strategy and an enabling policy environment enhanced local and foreign investments in GE in the country.

Northern Africa sub-region

At the time of the current studies in September/October 2009 Egypt and Tunisia were the only Northern African countries conducting research on GE crops. Egypt leads the sub-region in the development and acceptance of agricultural biotechnology with strong support from its Ministry of Agriculture. Egypt is a large consumer of such agricultural products as maize, soybeans, soy meal and vegetable oils that are derived through modern biotechnology and imported from Argentina and the United States of America. The Government maintains a general import policy that allows imports so long as the imported product is also consumed in its country of origin (Mansour, 2009). The process for securing commercial release approval for crops genetically engineered outside of Egypt is as follows:

1. The applicant must obtain a permit for importing the initial seed material from the Supreme Committee for Food Safety (SCFS), Ministry of Health
2. The permit is presented to the National Biosafety Committee (NBC) and the Seed Registration Committee (SRC)
3. The seed is imported into the country
4. After the seed is imported, the approval procedure for GE crops produced in Egypt is strictly followed. This includes:

- Providing details of the genetic material
- Describing the insertion process used
- Providing information on food and feed safety
- Evidence of environmental safety
- Approvals of the application by NBC and SRC followed by multilocational trials for evaluation
- Confirmation of the application's information.

Formal release of the crop follows thereafter.

Egypt's GE research projects are led by the Agricultural Genetic Engineering Research Institute (AGERI) that was established in 1989 as the National Agricultural Genetic Engineering Laboratory (NAGEL). It started research into crop GE in the 1990s. The country planted about 700ha of hybrid Bt yellow maize for commercial release in 2008. Several other GE crops including: wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), maize and cotton are being developed for drought and salinity tolerance. Amongst other research activities (see Table 1), AGERI and its partners are also working on the following in Egypt:

- Production of transgenic local varieties of squash (*Cucurbita pepo*) and some varieties of melon (*Cucumis melo*) plants resistant to zucchini yellow mosaic potyvirus (ZYMV)
- Developing GE resistance to potato virus
- Engineering tomato (*Lycopersicon esculentum*) to induce resistance to tomato yellow leaf curl virus (TYLCV)
- Production of transgenic banana plants with resistance to banana bunchy top virus and or banana cucumber mosaic cucumovirus (Banana-CMV)
- Isolation and identification of Bt toxin gene from local isolates in Egypt
- Development of potato tuber moth resistance in potato (*Solanum tuberosum*)
- Development of stem borer resistance using Bt genes
- Production of transgenic Egyptian cotton plants expressing insecticidal toxin genes
- Development of transgenic insects using transposon elements for autocidal pest control
- Isolation and characterisation of chitinase gene as a plant defense gene against fungal infection
- Development of transgenic wheat with improved salt and drought tolerance
- Breeding *Triticum durum* in the Mediterranean region using intro and genetic transformation tools
- Genome mapping for development of improved rapeseed (*Brassica napus*) varieties using molecular markers
- Finger-printing of elite maize lines using molecular markers
- Molecular cloning and expression of hepatitis B surface antigens (HBsAG) in plants.

In Tunisia, microorganisms and plants are involved in GE technology in bio-contained facilities not in field cultures (Tebourski and Ammar-Elgaaied, 2004). GE research in Tunisia could move to the next level when enabling government policy and laws come into effect, but commercialisation of GE products in Tunisia is still some time away.

Adherence of African countries to the Cartagena Protocol on Biodiversity (CPB)

The Cartagena Protocol is a binding international agreement under the CBD. The CPB obligates countries to establish biosafety procedures for trans-boundary movement and handling of all living modified organisms that could have effects on the conservation and sustainable use of biological diversity, considering also effects on human health.

By the time of the current study in September/October 2009 forty-five (45) African instruments of ratification or accession had been deposited with the UN Secretary General from the following African Parties to the CBD. These were: Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Democratic Republic of the Congo, Djibouti, Egypt, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Sudan, Swaziland, Togo, Tunisia, Uganda, United Republic of Tanzania, Zambia and Zimbabwe.

The following six African countries are yet to ratify the Convention:

- West and Central Africa: Côte d'Ivoire, Equatorial Guinea, Guinea-Bissau, and Sierra Leone

- Eastern and Southern Africa: Angola
- Northern Africa: Morocco.

National Biosafety Frameworks (NBFs) vary from country to country, but they usually contain the following common components (Anonymous, 2003):

» A government policy on biosafety, which is usually part of a broader policy such as that on biotechnology in general, agricultural production, health care or environmental protection

» A regulatory regime for biosafety, which is often a combination of an act or decree, complemented by implementing technical regulations and guidelines

» A system to handle notifications or requests for authorisations for certain activities, such as releases of GMOs into the environment. Such systems typically include: administrative functions, risk assessment, decision-making and public participation

» Systems for 'follow up' such as enforcement and monitoring for environmental effects. Monitoring is a term used for evaluating actual impacts on the environment and human health, whereas enforcement typically focuses on compliance with the regulatory regime

» Approaches for public information and public participation, i.e., informing and involving stakeholders in the development and implementation of the NBF.

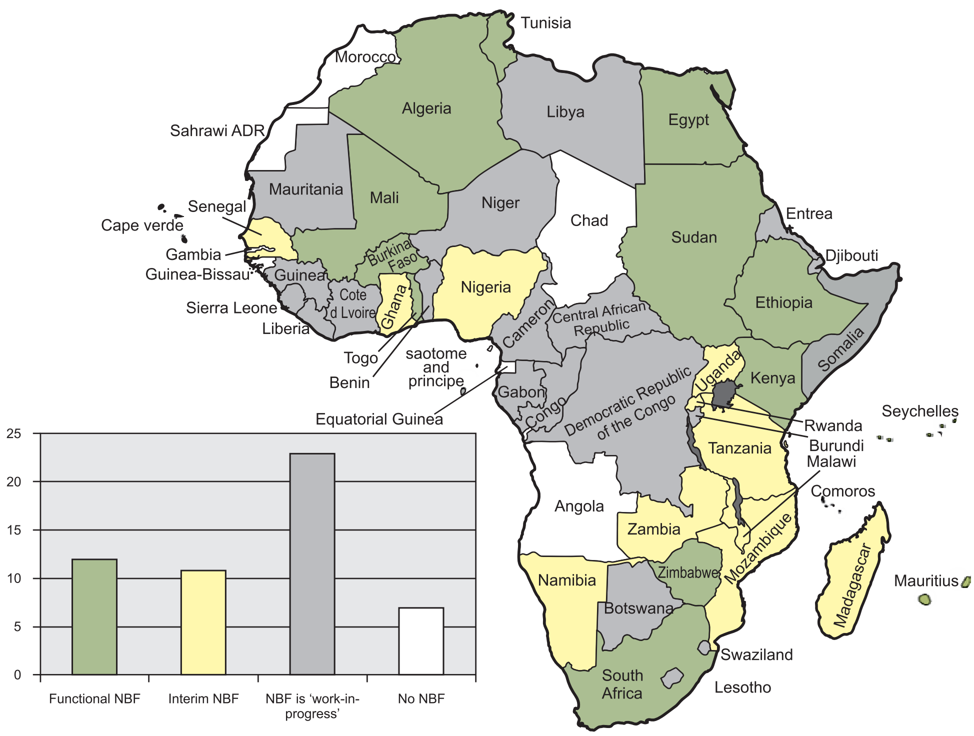

Figure 1. Status of National Biosafety Frameworks (NBFs) in Africa (Source: Diran Makinde cited by Karembu et al. 2008)

Resistance to GE technology in Africa

The anti-GMO campaigns of such European-based international NGOs as Greenpeace, Friends of the Earth and few others seem to have influenced several African political leaders who are reluctant to embrace GE technology. The negative positions of such NGOs seem to have crept into decision-making processes, thus retarding the acceptance of GE in Europe. Such a cautious approach to GE crops by Europe, Africa's major trading partner, constitutes a major reason why several African countries are reluctant to adopt GE crops. In a press interview the new Executive Director of the African Agricultural Technology Foundation (AATF) said that: "Public opinion in Africa has tended to be shaped by European public opinion partly because the NGOs, which are anti-GMO and operating in Europe, are for the most part exactly the same NGOs who come to Africa and spread exactly the same message" (http://www.theparliament.com/no_cache/latestnews/news-article/news-article/africa-resistant-to-gmos-because-of-relationship-with-eu/). This assertion is confirmed by the French Alliance of Liberals and Democrats for Europe (ALDE) representative at the European Parliament, Corinne Lepage, who said: "We must continue to make every effort to press for GMO-free agriculture" (http://www.theparliament.com/no_cache/latestnews/news-article/newsarticle/gmos-causing-genetic-pollution-parliament-conference-told/). A position such as this would appear to be founded more on politics than on science and the socio-economic benefits of GE. However, a parallel interview given by the Chief Executive of Syngenta, Mike Mack, (published in the same link as Lepage's interview) expressed worries that the European Union (EU) was; "…moving further and further away from the principles of science-based decision-making" especially as related to GE.

Role of accurate science-based information in the acceptance of GE

It is important to stress the importance and place of accurate information dissemination in GE. A review of the literature indicates that accurate information on GE is currently lacking at both the grassroots and policymaker levels. Public awareness on the processes and uses of GE technology is as important as the science itself in Africa. Clark *et al*. (2007: p.7) stated that: "…. The general public and farmers in particular are uninformed about the nature of the technology, its potential benefits and risks, and rarely do they participate in deciding on which crops or problems biotechnology research and development should focus on." Inaccurate information on GE could impede the advancement of the technology in Africa. "This is especially true in Africa, a situation that has brought about fear, concerns and myths about the technology" Karembu *et al*. (2008). 'Misinformation' by the anti-GMO group of NGOs makes newspaper headlines, and these constitute most of the public knowledge on GE technology.

Building public confidence in GE technology would greatly influence acceptance of GE crops in Africa. Such confidence building should focus both on the safety and reliability of the science and on the institutions that serve as pedestals for risk assessment and management of GE products. In these regards, a more prolific generation and dissemination of accurate, science-based information on the safety of GE products in Africa is required.

Regional biotechnology and biosafety programmes

In addition to the individual national programmes on the application of biotechnology to agriculture, regional organisations operating in Africa have established regional biotechnology programmes aimed at adding value to these national programmes. These include:

1. FARA African Biotechnology and Biosafety Policy Platform (ABBPP) – aimed at facilitating safe biotechnology policy dialogue and stakeholder consensus-seeking in Africa (http://www.fara-africa.org/networking-support-projects/abbpp/).

2. Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) Botechnology and Biosafety Program (BBP) – focused on the use of biotechnology to enhance utilisation of biodiversity (http://www.asareca.org/index.php?page=programmemesanda=27).

3. CORAF/WECARD BBP – centred on promoting product-driven capacity building activities in safe agricultural biotechnologies. It emphasises the development of a biosafety framework that builds commonalities in regulatory procedures across the countries of the sub-region (http://www.coraf.org/BB.html).

4. COMESA and the Regional Approach to Biotechnology and Biosafety Policy in Eastern and Southern Africa (RABESA) – developing a common risk-assessment procedure for commercialising GM products (http://www.africa-union.org/root/au/AUC/Departments/HRST/biosafety/DOC/level2/RegHarm_COMESA2006.pdf).

5. The AU/NEPAD Africa Biosafety Network of Expertise (ABNE) –consolidating capacity, network and information resources for regulators in order to build functional biosafety systems in Africa (http://www.nepadbiosafety.net/).

6. Program for Biosafety Systems (PBS)– Agricultural Biotechnology Support Project II (ABSP II) – strengthening the capacities of national systems in agricultural biotechnology, and providing regulatory technical support for handling and managing field trials (http://www.absp2.net/index.php).

7. International Centre for Genetic Engineering and Biotechnology (ICGEB) – strengthening and expanding biosafety systems in Africa (http://www.icgeb.org/biotechnology-transfer.html).

8. UNEP/GEF – capacity building in biosafety in compliance with the CPB (http://www.undp.org/gef/).

9. Biosciences eastern and central Africa (BecA) Hub – increasing access to affordable, world-class research facilities and strengthening human resources in biosciences and related disciplines in Africa (http://hub.africabiosciences.org).

Current status of safe biotechnology in studied countries

The SABIMA project countries were the focus of study, and those selected to complement these countries in stated regions of Africa.

Institutions undertaking biotechnology and regulatory activities

The findings of this study reveal that agricultural biotechnology is being increasingly adopted as a strategic tool for improving crops and livestock productivity in Africa. Several institutions were found to be introducing biotechnology tools into their agricultural research and training programmes. Burkina Faso, Ghana, Kenya, Nigeria and Uganda, have between them 12–18 research institutions that are successfully introducing biotechnology tools

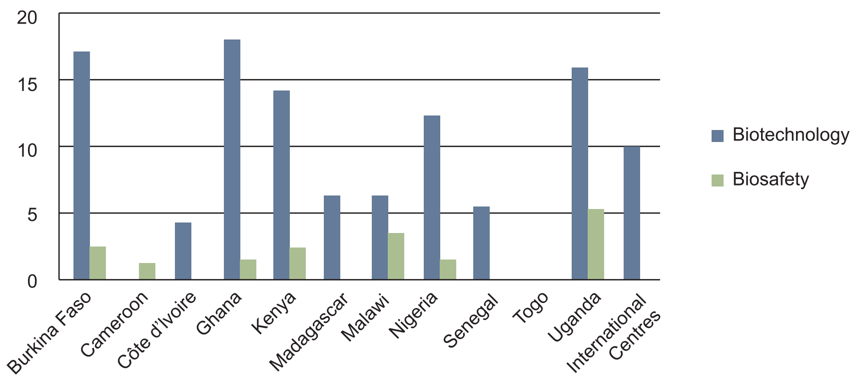

Figure 2. Number of institutions involved in biotechnology research, training and regulatory activities in each sampled country

into their research programmes (Figure 2) to complement their traditional research.

These research institutions include various national agriculture research institutes (NARIs), centres, universities and government ministries in charge of biosafety regulation (in most countries the Ministry of Environment is in charge, but in a few cases, e.g., Burkina Faso it is the Ministry of Science and Technology). The two CGIAR centres that participated in this study: the International Livestock Research Institute (ILRI) in Kenya and the Africa Rice Center (AfricaRice) in Benin, equally demonstrated their involvement with some nine other CGIAR centres working on agricultural biotechnology. These centres demonstrated their readiness to continue backstopping the NARS centres on biotechnology research for agricultural development in Africa.

Ongoing biotechnology activities

Research institutions in Burkina Faso, Ghana and Kenya, had between 20 and 30 biotechnology research activities that were on-going or being planned for implementation at the time of this study (Figure 3).

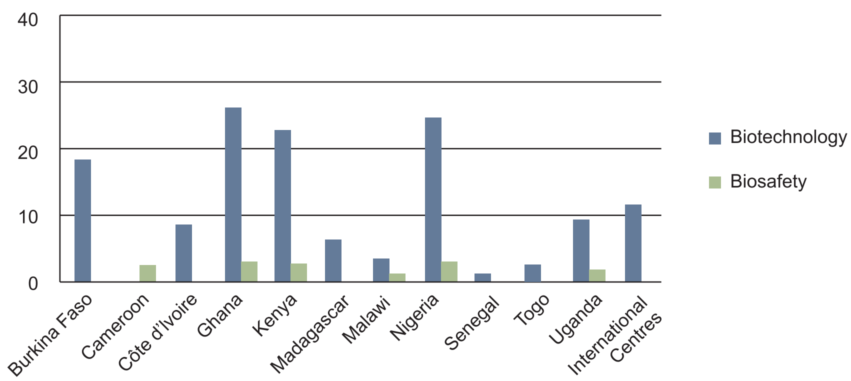

Figure 3. Number of on-going and planned biotechnology activities involving major institutions in each sampled country

Discussions with some of the participating research staff from various institutions revealed their enthusiasm in contributing to making a difference in the coming gene revolution in Africa.

Types of biotechnology laboratories

Of the laboratories studied 42% were using molecular biology tools to assist plant breeding (Figure 4) and in the production of diagnostic tools for livestock diseases as seen at le Centre international de recherche-développement sur l'élevage en zone subhumide (CIRDES) and the BecA Hub at ILRI.

The molecular marker work included:

- Molecular characterisation and diagnostics of plant viruses – being conducted by l'Institut de l'environnement et de recherches agricoles (INERA) in Burkina Faso in partnership with l'Institut de recherche pour le développement (IRD) in France
- Improving the molecular diagnostic tools for trypanosomes by PCR – by the regional centre CIRDES based in Burkina Faso in partnerships with le Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) and IRD in France.
- Molecular characterisation of root crops – by the Council for Scientific and Industrial Research–Crop Research Institute (CSIR–CRI) in Ghana
- Development of molecular assays for sexing guinea pigs – by Ghana's Atomic Energy Commission
- DNA marker-assisted breeding for resistance to Striga in cowpea (Vigna unguiculata) – by the Nigerian Institute for Agricultural Research (IAR) in partnerships with Kirkhouse Trust, UK and University of Virginia, Charlottesville, USA

Tissue culture research is another important tool being used by about 32% of biotechnology laboratories in the sampled countries. About 13% of the laboratories and support agencies participating in this study were involved in research on crop GE. These included: INERA in Burkina Faso; the Kenyan Agricultural Research Institute (KARI); Africa Agricultural Technology Foundation (AATF), African Biotechnology Stakeholders Forum (ABSF) and Africa Harvest Biotechnology Foundation International (AHBFI) all based in Nairobi; Kenya Plant Health Inspectorate Service; Kenyatta University; Bunda College of Agriculture in Malawi; Nigerian Institute for Agricultural Research (IAR); Nigeria Institute For Oil Palm Research (NIFOR);

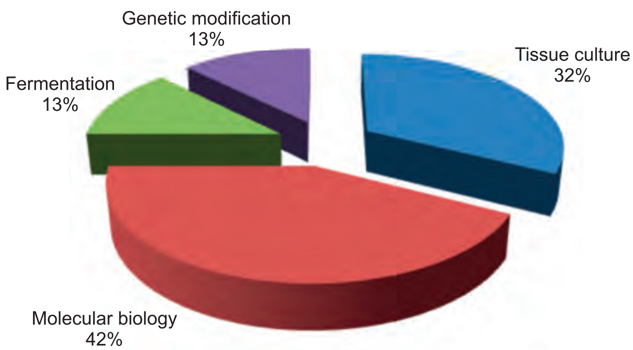

Figure 4. Most-commonly available biotechnology laboratories in sampled countries

Sheda Science and Technology Complex (SHESTCO) and National Root Crops Research Institute (NRCRI) in Nigeria and the National Agriculture Research Organisation (NARO) of Uganda. Networking among these laboratories (conducting studies on GE or supporting them) to exchange research information should encourage synergy and Africa–Africa collaboration on the biotechnology needed for food and income security.

The review revealed the following studies:

- Production and up-scaling of Bt cotton by INERA (Burkina Faso) in collaboration with the companies SOFITEX and Monsanto
- Improving productivity of cowpea via the adoption of Bt technology by INERA (Burkina Faso), IAR (Nigeria) and Council for Scientific and Industrial Research–Savanna Agriculture Research Institute (CSIR–SARI) (Ghana)
- Transgenic sorghum (*Sorghum bicolor*) biofortified with iron and zinc by KARI (Kenya)
- Production of transgenic sweet potato (*Ipomoea batatas*) resistant to viral attacks by KARI (Kenya) in partnership with Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
- Genetic transformation of local rice (*Oryza* sp.) cultivar for resistance to rice blast fungus (*Pyricularia oryzae*) by SHESTCO (Nigeria) in partnership with Ketudat-Cairns (Thailand) and the John Innes Centre, Norwich (UK)
- Genetic transformation of cassava (*Manihot esculenta*) with glutamine gene by SHESTCO (Nigeria)
- CFTs of banana resistant to black sigatoka disease caused by (*Mycosphaerella fijiensis*) by NARO (Uganda) in partnerships with the Katholic University of Leuven (Belgium), Agricultural Biotechnology Support Project II (ABSP-II), Cornell University (USA) and the University of Leeds (UK).

A trend observed during the study was that most of the laboratories were concentrating on GE studies on crops of importance to food security – a domain that had hitherto attracted little attention from large multinational companies. The multinationals previously concentrated on industrial crops that guaranteed higher economic dividends than food security crops. To ensure the achievement of the CAADP target of 6% annual growth in agriculture through 2015, these higher investments in agricultural biotechnology focusing on the food security of Africa countries need to be given more priority.

Currently, the most vibrant sub-regional centre of excellence in biotechnology is the BecA Hub at ILRI. It offers the following capacity-building and training services:

- Co-supervision of thesis-related research, in association with specific projects
- Short courses and workshops
- Seminar series, including traveling seminars in various countries in the ESA sub-region
- Group and individual practical and theoretical training.

In 2009, 52 African students (including 24 women) conducted their graduate research in Hub laboratories. While similar facilities in other sub-regions of Africa are advocated the BecA Hub facility should attract greater patronage from countries like Kenya and Uganda that are participating in the SABIMA Project.

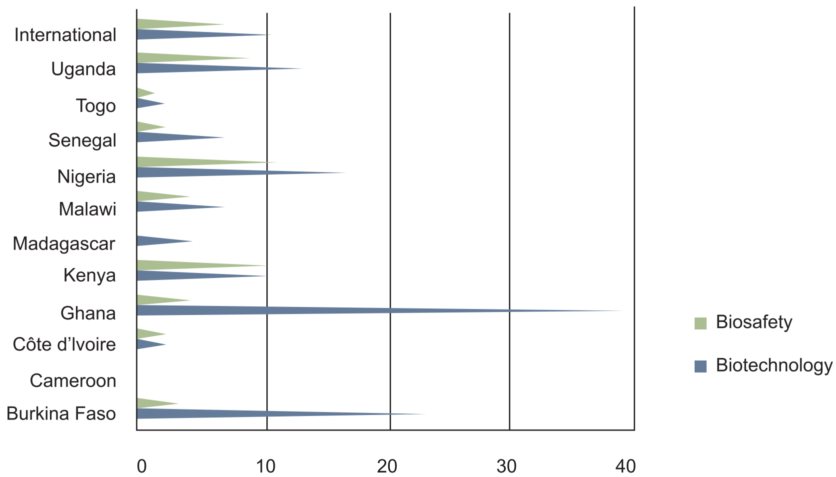

Figure 5. Number of biotechnology research staff in each sampled country

Human resources for biotechnology research

The current study observed that several countries were investing heavily in human capital for safe biotechnology research (see Figure 5). There were also increasing numbers of staff working in such ancillary or complementary fields as: phytopathology and mycology, plant breeding and genetics, plant physiology, entomology, biochemistry, food science, virology, microbiology, ruminant physiology, etc. (Figure 6), but Burkina Faso and Ghana had far more scientists working on biotechnology. Kenya, Nigeria and Uganda

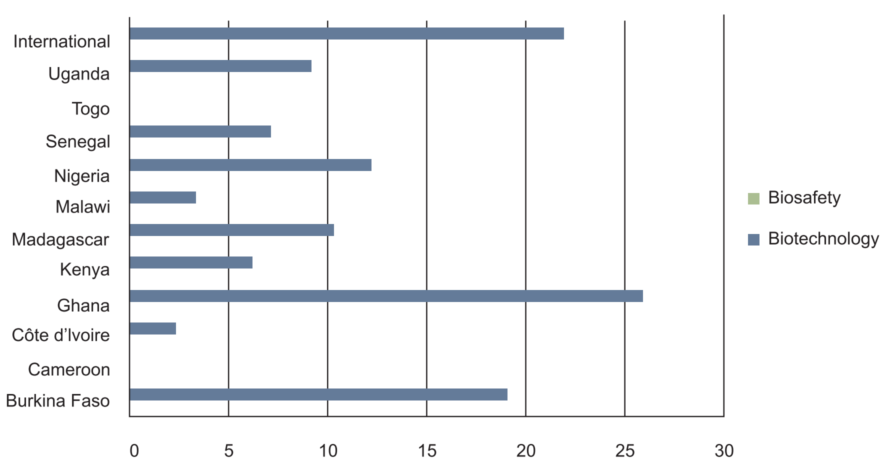

Figure 6. Number of research staff working in fields ancillary or complementary to biotechnology in each sampled country

were also investing significantly in biosafety and biotechnology regulatory processes and human resource development.

However, some of the respondents failed to provide information on the staffing of institutions in their countries, or on the type of research activities being conducted by such institutions.

Biosafety legislation, biotechnology policy and resources for research

Results obtained from the current field studies revealed that 50% of the respondent institutions had never applied for permission to conduct GE research from their national regulatory authorities (see Figure 7). The reason being that the countries in which such institutions were based had not adopted biosafety laws, or had no biosafety regulatory procedures in place to facilitate GE research. In most countries in which biosafety laws existed and the requisite regulatory procedures were in place, it took almost a year between the time of application for permission and the granting of approvals for laboratory and/or CFTs. In 14% of the countries the lag period between application for permission and approvals was more than one year. Delays in the granting of approvals mainly resulted from the complex or less-friendly regulatory procedures that exist in some countries.

The challenge therefore is to ensure not only the passage of biosafety laws, but also that a workable regulatory procedure exists – and is managed professionally by qualified experts.

This is a challenge currently being tackled by the AU/NEPAD initiative on biosafety, i.e., the African Biosafety Network of Expertise, based in Ouagadougou, Burkina Faso. The capacity of African institutions to draw up regulatory procedures for the application of safe biotechnology to agriculture needs to be significantly strengthened to facilitate the enactment of biosafety laws adopted in each country. About 36% of institutions studied (Figure 8) agreed the need to increase funding and make significant provision of both infrastructure (33% of respondent

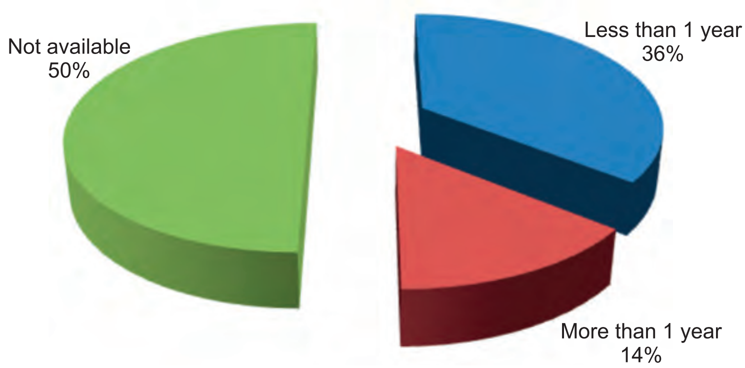

Figure 7. Average time taken by regulatory authorities in sampled countries to grant permission for laboratory/confined field trials

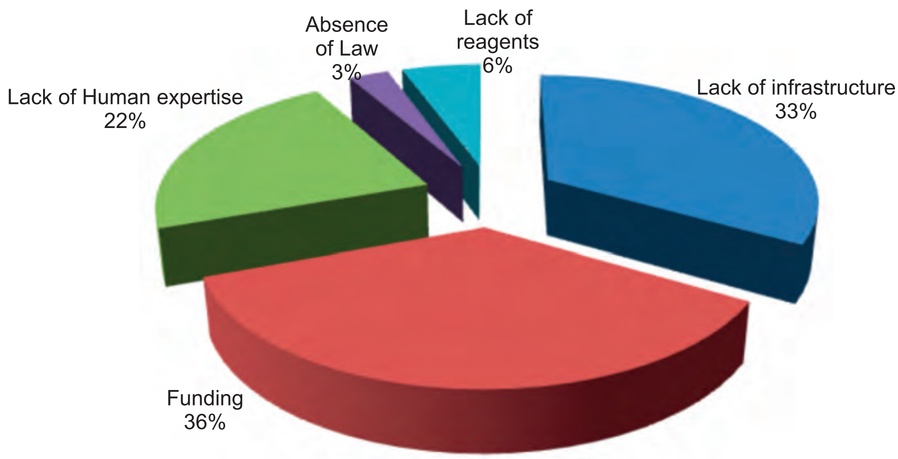

Figure 8. Constraints faced by institutions conducting biotechnology research in sampled countries

institutions) and human expertise (22%) The availability of biosafety laws is therefore only part of the prerequisite for GE research. Such other requirements as human and financial resources and available infrastructure are also needed before any meaningful GE studies can start.

Results obtained during this study indicated that 39% of the countries studied had legislated on the safe application of biotechnology to agriculture, and that 33% had policies on the conduct of advanced biotechnology (see Figure 9).

Insect pests (38%) and fungal and bacterial pathogens (32%) constitute the most imposing challenges to food security commodities – crops and livestock that scientists in the studied institutions are striving to tackle using such modern tools as biotechnology (Figure 10). Pests and diseases attack food crops at various stages of their life cycles causing: total crop loss where the crop fails to achieve maturity; drastic reduction in yields; reduction in produce quality and damage leading to post-harvest loses. It was observed, however, that most of the research institutions were not working in close partnerships with farmers and NGOs. In order to tackle these constraints effectively research institutions really need to work in close rapport with the various actors on the production–consumption continuum value chain.

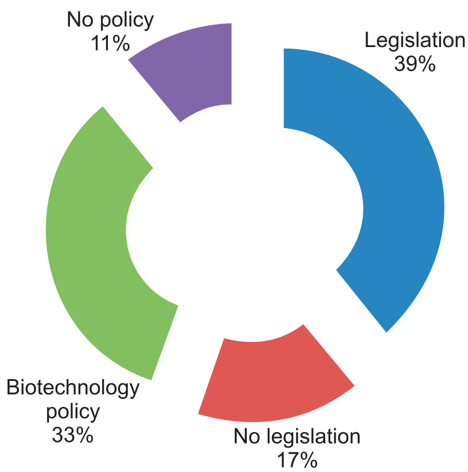

Figure 9. Status of biotechnology legislation in sampled countries

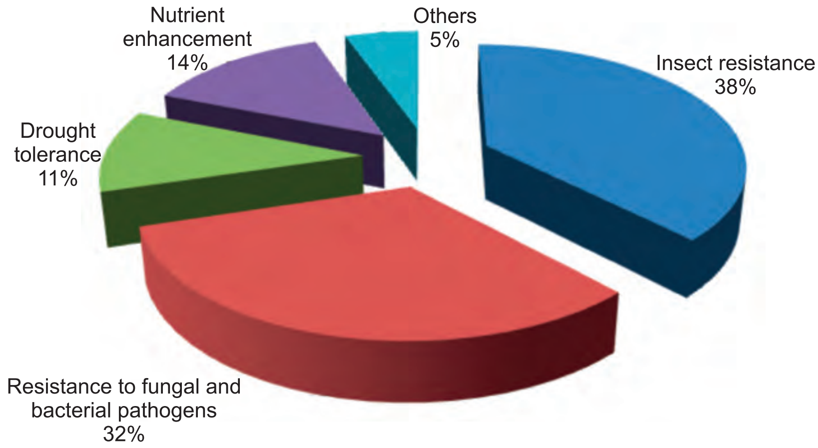

Figure 10. Traits researched by biotechnology laboratories in sampled countries

Biotechnology companies operating in surveyed countries

Monsanto, Syngenta and Pioneer were operating in most of the studied countries. Four biotechnology companies were operating in Kenya (Figure 11). Some of the companies working in surveyed countries were of local origin, for example, Sociéte de commercialisation de la banane in Côte d'Ivoire.

Creating awareness of safe biotechnology

The study revealed that much remains to be done to create awareness of the benefits of agricultural biotechnology. Even the

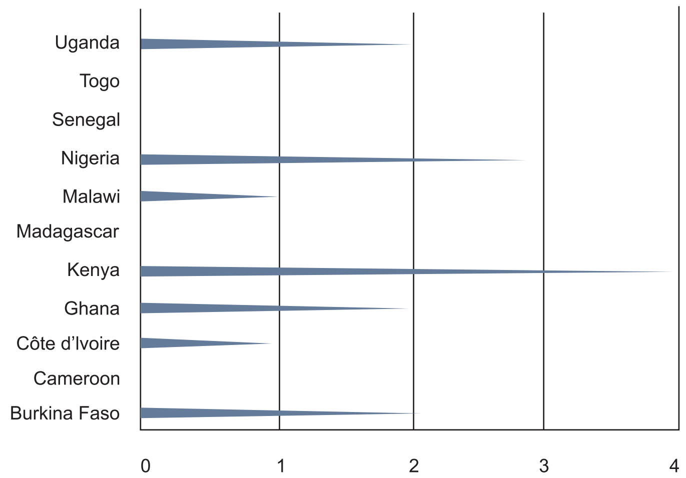

Figure 11. Number of biotechnology companies operating in sampled countries

institutions working on biotechnology agreed that little awareness was being created on the pros and cons of GE technology. About 60% of the respondent African institutions agreed that the level of awareness on GE was low (Figure 12). They stressed the need for the technology to be more widely known in spheres beyond research laboratories and technical conference halls.

All the respondents agreed that GM technology debates should go beyond laboratories to the common users of technology. They emphasised the need for communications that could be channeled through specialised newspapers, radio and TV transmissions (see Figure 13) to the public, targeting policymakers and NGOs. The proponents of GE technology were seen as less vocal than the anti-GE NGOs. The respondents recommended policymakers should make more pronouncements on the safety and usefulness of GE.

Commercialisation of GE products

The respondent institutions believed that the research and commercialisation of GE crops in Africa (see Figure 14) needed to be far more widespread for the much-desired gene revolution for Africa to be realised. Burkina Faso was the only SABIMA-project country to have started to commercialise GE products. South Africa and Egypt (two non-SABIMA countries) had commercialised both home-grown and imported GE products. Tissue culture planting materials (including banana, plantain (*Musa* spp), cassava, pineapple (*Ananas comosus*) and yam (*Dioscorea* spp) are being marketed in several African countries.

There are prospects for future regional trade in GE crops, especially between countries that have enacted biosafety laws. Such prospects could become brighter with the establishment of GE food safety assessment facilities in various countries. None of the SABIMA-project implementing countries had established such food safety assessment facilities at the time of the current study. Future projects need to include building capacity in food safety assessment in these countries. Multinational biotechnology companies could assist countries to strengthen their capacities for GE food-safety assessment.

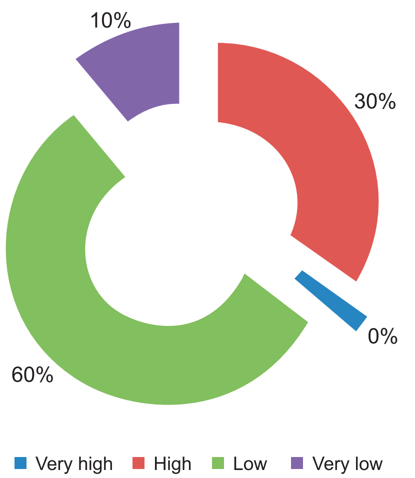

Figure 12. Level of biotechnology awareness in sampled countries

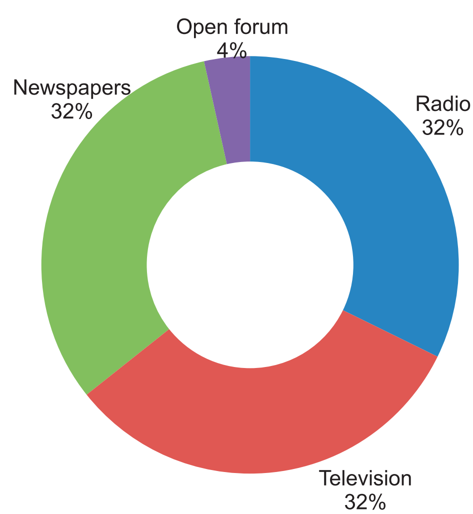

Figure 13. Channels used to create awareness of biotechnology by institutions in sampled countries

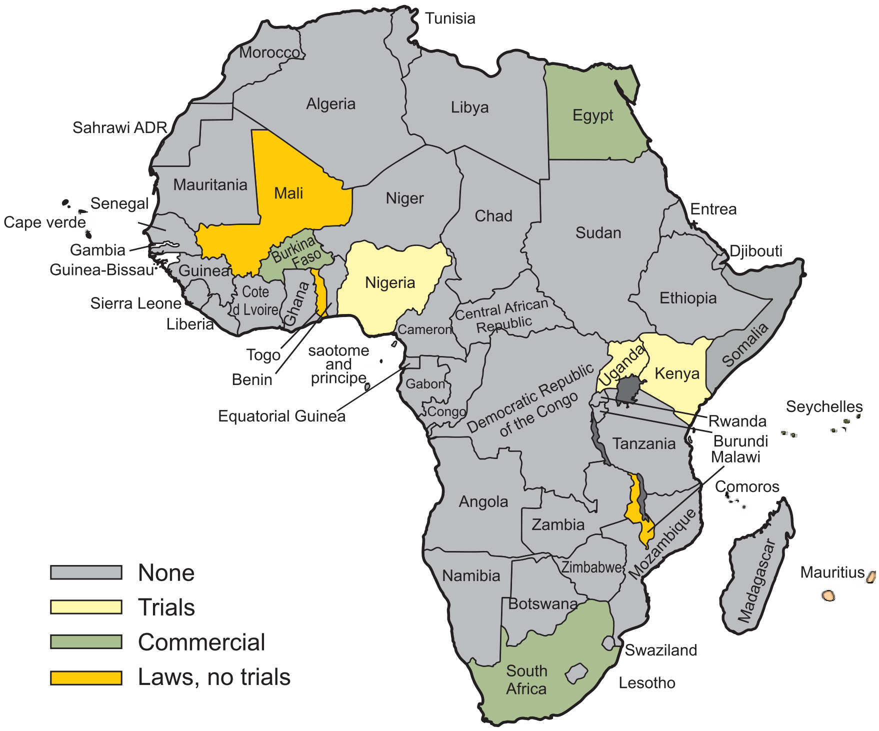

Figure 14. Status of GM crop trials and commercialisation in Africa

Participation in regional GE research activities

The current FARA-led SABIMA project involves six countries: Burkina Faso, Ghana, Kenya, Malawi, Nigeria and Uganda. Burkina Faso, Mali and Togo were found to be involved in a CORAF/WECARD-led Bt cowpea project. Burkina Faso, Kenya and South Africa were involved in a regional project on the bio-fortification of sorghum; Nigeria and Uganda were involved in research on bacterial wilt resistance in banana. Malawi and Namibia were participating in joint Bt cotton trials. Malawi was working with South Africa. and Uganda on CFTs on the production of pathogen-free potatoes.

Donors funding biotechnology research and biosafety

Donors identified as funding biosafety and general biotechnology research included: African Development Bank (ADB), Bill and Melinda Gate Foundation, Department for International Development (DFID), European Union (EU), International Fund for Agricultural Development (IFAD), Rockefeller Foundation, UNEP/GEF, United States Agency for International Development (USAID), World Bank, Belgium, Canada, China, Denmark, France, Germany, Japan, Norway, Sweden, Monsanto and Syngenta. African national governments provided the basic investments in infrastructure and human resources. Most of the respondents were not aware of any interrelationships between the donors in terms of GE research. However, it will be necessary to harmonise donor intervention in GE research. Such harmonisation should aim to synergise the activities of the various actors, and streamline investments in GE research for development.

Gaps and opportunities for agrobiotechnology interventions

The general lack of resources – human, material and financial – and the inequitable distribution of these resources for GE research for development constituted the main concern of all the countries participating in the current study. There were also wide information gaps between scientists, policymakers, farmers, NGOs, etc. on the safety of GE technology. The creation of GE information hubs and the development of appropriate communication strategies to address the concerns of each stakeholder group should increase the buy-in to the technology. Whereas some of the countries had enacted their biosafety laws, there were still gaps in their development of appropriate regulatory frameworks. Adequate capacity for credible GE risk assessment was lacking in many of the countries as evidenced in their lack of robust food safety assessment facilities. It was also observed that most of biotechnology legislation in Africa focuses mainly on crops, with little attention to livestock. This was noted as a significant gap in legislation that needs to be effectively closed, since livestock cloning is also gaining global prominence. Such gaps restrained the practical implementation of GE research and the marketing of its products. Some of the respondents also stressed the need to create appropriate linkages between public research and private entrepreneurships so as to ensure eventual commercialisation of GE products.

Notice at a confined field trial site, Makutopa, Tanzania.

Summary and way forward for FARA and partners in safe biotechnology support

Signing a register to enter a Confined Field Trial Site, Thika, Kenya Agriculture Research Institute (KARI).

1. Generally, the GE research capacity of most of the institutions studied was marginal. In many centres research programmes were found to be dependent on a handful of individuals, thus creating fragile programmes that could easily collapse. Several of such programmes could barely implement promising initiatives beyond a pilot scale. It is therefore recommended that FARA and its constituent SROs develop a strategy for networking the identified research institutions to optimise their research capability and outputs with respect to GE research. GE research requires advanced research capability, accompanying infrastructure, and dynamic links with policymakers and users of the technology.

2. The absence of bio-containment infrastructure and food safety assessment facilities were found to be impeding GE trials and food safety assessments in several countries. South Africa and Tunisia were the only non-SABIMA countries that had such facilities. It is recommended that FARA and the SRO's GE research capacity strengthening activities should in future also include aspects on development and management of both bio-containment and food safety assessment facilities.

3. The present study uncovered inherent weaknesses in both formal and informal seed systems. While it was gratifying to note that most of the GE research activities were in

food security crops, there remained the need to develop appropriate channels for seed distribution for both GM and non-GM seed. The situation was more critical in the area of seed supply to small-scale farmers. Greater in-country and donor support is needed to address this gap. FARA should coordinate efforts to seek support for this sector. It is recommended that future FARA biotechnology projects go into partnerships with other continent-wide initiatives such as: Alliance for Green Revolution in Africa (AGRA); Africa Seed Trade Association (AFSTA); West Africa Seeds Alliance (WASA) etc. with the aim of strengthening African countries' capacity to distribute GE seeds. SFSA and other donor agencies could be approached to partner FARA in addressing this lapse.

4. Biotechnology and biosafety policy development capabilities should be strengthened to enable countries chart their future course in biotechnology. The policy will define the countries' commitment to modern biotechnology and the accompanying legislative framework that will govern its engagement. As for the biotechnology stewardship policy it has developed a guide to countries engaged in biotechnology product development. FARA should provide guidelines for the formulation of biotechnology policy and implementation guidelines to countries that require such support.

5. The present lack of inter-institutional/inter-country collaboration in GE research in Africa is retarding the much-desired rapid adoption of the technology. To fast-track the adoption of this technology there is therefore a need to initiate and consolidate networking of African research institutions conducting GE studies. The experiences from collaboration should create impact-oriented spillover to sister African countries that need such agricultural biotechnologies to kick-start their productivity growth. The FARA–SABIMA project, the NEPAD–ABNE initiative, the Africa Harvest Foundation, the BecA Hub and similar Africa-based initiatives should seek to catalyse and sustain inter-institutional collaboration. This collaboration should be particularly encouraged, given that most African countries presently lack the full capacities (human, infrastructural and financial means) for a sustained GE programme. FARA should seek closer partnerships with all identified continental and sub-regional initiatives on biosafety and biotechnology. Such collaboration could lead to the creation of a *Platform on Safe Biotechnology for Africa*, where regular consultations between members of the Platform could take place.

6. FARA, its partners and the SROs need to continue to advocate for increased investments in agricultural research in general, and in GE research in particular. It is recommended that AU/NEPAD, FARA and the SROs should examine the possibilities of creating some professorial chairs in Genetic Engineering. Such chairs, to be held in renowned Africa universities, should be made to attract the same motivating remunerations and conditions of service as those in advanced countries. Local and external donors could be lobbied to fund such positions. This should enable the local strengthening of GE research capacity in Africa. Such an initiative should be a motivating incentive for Africans in Diaspora and for expatriate scientists wishing to impart knowledge to and mentor colleagues in Africa.

7. All the survey countries reiterated the need for increased funding for modern biotechnology research and development activities. The regional economic communities (RECs) should mobilise more regional funding to ensure that regional approaches to GE research take sustainable roots in Africa. It is recommended that FARA and the SROs lobby the RECs for a modern biotechnology research trust fund for each sub-region.

References

Alhassan WS. (2003) Agrobiotechnology application in West and Central Africa. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria ISBN 9781311959. 107pp.

Anonymous. (2003) UNEP–GEF Projects on Implementation of National Biosafety Frameworks: Information Paper 16 October 2003. Retrieved 22 October 2009 from: http://new.unep.org/biosafety/Documents/ImpinfopaperOct2004.pdf

Bosman L. (2008) GM Crop production up 30% in RSA. Retrieved 27 October 2009 from: http://www.africabio.com/pdf/MEDIARELEASE%20ISAAA.pdf

Clark N, Mugabe J and Smith J. (2007) Biotechnology Policy in Africa. African Centre for Technology Studies (ACTS) Press, Nairobi, Kenya.

Clive J. (2003) Preview: Global Status of Commercialised Transgenic Crops. International Service for the Acquisition of Agri-biotech Applications (ISAAA) AfriCenter, Nairobi, Kenya.

Clive J. (2008) Global Status of Commercialised Biotechnology/GM Crops. International Service for the Acquisition of Agri-biotech Applications (ISAAA) Brief No. 39. ISAAA AmeriCenter, Ithaca, New York, USA.

Cohen JI. (2005) Poorer nations turn to publicly developed GM crops. Nature Biotechnology, 23(1): 27–33.

Goldberger J, Merrill J and Hurley T. (2005) Bt corn farmer compliance with insect resistance management requirements in Minnesota and Wisconsin. AgBioForum, 8(2and3): 151–160. Retrieved October 27 2009 from: http://www.agbioforum.org/v8n23/v8n23a12-hurley.htm

Hayami Y and Ruttan V. (1985) Agricultural Development, An International Perspective. (Revised and expanded edition). John Hopkins University Press, Baltimore, USA.

Karembu M, Wafula D and Waithaka M. (2008) Status of Biotechnology Policies and Biosafety Legislation in the COMESA Region. COMESSA Policy Brief. International Service for the Acquisition of Agri-biotech Applications (ISAAA) AfriCenter, Nairobi, Kenya.

Karembu M, Nguthi F and Abde-Hamid I. (2009) Biotech Crops in Africa: The Final Frontier. International Service for the Acquisition of Agri-biotech Applications (ISAAA) AfriCenter, Nairobi, Kenya.

Martin T, Chandre O, Vaissayre M and Fournier D. (2002). Pyrethroid resistance mechanisms in the cotton bollworm Helicoverpa armigera (Lepidoptera: Noctuidae) from West Africa. Pesticide Biochemistry and Physiology, 74(1): 17–26.

Mansour S. (2009) Egypt Biotechnology: Gain Report of USDA Foreign Agricultural Services – Global Agricultural Information Network. Retrieved 14 January 2010 from: http://www.sciencedev.net/Docs/Biotechnology_cairo.pdf

Mokyr J. (2002) The Gifts of Athena: Historical Origins of the Knowledge Economy. Princeton University Press, Princeton, USA and Oxford, UK.

Nwalozie M, Sereme P, Roy-Macauley H and Alhassan W. (2007) West and Central Africa: Strategizing biotechnology for food security and poverty reduction. In: The Gene Revolution: GM Crops and Unequal Development (Fukuda-Parr S ed.). Earthscan, Sterling, Virgina, USA. 248pp.

Oerke E C. (2002) Crop losses due to pests in major crops. In: Crop Protection Compendium 2002: Economic Impact. CAB International, Wallingford, UK.

Tebourski F and Ammar-Elgaaied AB. (2004) The developing country reactions to biomedical techniques and plant biotechnology: The Tunisian experience. .Journal of Biomedicine and Biotechnology, 2004(3): 124–129

Vitale J, Boyer T, Uaiene, R and Sanders JH. (2007) The economic impacts of introducing Bt technology in smallholder cotton production systems of West Africa: a case study from Mali. AgBioForum, 10(2): 71–84. Retrieved 27 October 2009 from http://www.agbioforum.org/v10n2/v10n2a02-vitale.htm#R31

Yartey CA. (2008) Tackling Burkina Faso's cotton crisis. International Monetary Fund (IMF) Survey Magazine 25 February, 2008. Retrieved 27 October 2009 from: http://www.imf.org/external/pubs/ft/survey/so/2008/CAR022508B.htm

Glossary of terms

Biosafety: The goal of ensuring that the development and use of transgenic plants and other organisms do not negatively affect plant, animal or human health, or the environment.

Biotechnology: The industrial use of living organisms or biological techniques developed through basic research.

Commercial release: The last regulatory stage during which products are marketed to farmers through private or publicly owned seed companies or other institutional mechanisms.

Confined field trial (CFT) regulatory stage: The regulatory stage that follows the laboratory/greenhouse/glasshouse stage in which genetic transformation events express stable traits in small-scale, single or multilocational, confined trials.

Genetic engineering (GE) or genetic modification (GM) (Transformation Event): This is the process whereby foreign DNA can be introduced into a living organism (plant, animal or microbe).

Genetic resources: Any genetic material of plant, animal or microbial origin.

Genetic material: Any material of plant, animal or microbial origin, including reproductive and vegetative material, containing functional units of heredity (genes).

Laboratory/greenhouse/glasshouse stage: Enclosure or containment of plants in units designed to control the escape of genetic material (e.g. pollen, seeds or vegetative material) into the external environment.

Totipotency: The ability of normal meristematic cells in the plant body to reproduce asexually to generate an entire plant.

Abbreviations and acronyms

AATF	Africa Agricultural Technology Foundation
ABBPP	African Biotechnology and Biosafety Policy Platform
ABNE	Africa Biosafety Network of Expertise [NEPAD]
ABSF	African Biotechnology Stakeholders Forum
ABSP	Agricultural Biotechnology Support Project
ABSPII	Agricultural Biotechnology Support Project II
ACMV	African Cassava Mosaic Virus
ADB	African Development Bank
AFSTA	African Seed Trade Association
AGERI	Agricultural Genetic Engineering Institute
AGRA	Alliance for Green Revolution in Africa
AHBFI	Africa Harvest Biotechnology Foundation International
ALDE	Alliance of Liberals and Democrats for Europe
ARC-IIC	Agricultural Research Council Institute for Industrial Crops
ARC-OVI	Agricultural Research Council Onderstepoort Veterinary Institute
ASARECA Central	Association for Strengthening Agricultural Research in Eastern and Africa
AU	African Union
BBP	Botechnology and Biosafety Program
CAADP	Comprehensive Africa Agricultural Development Program
CBD	Convention on Biological Diversity
CERAAS	Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse
CFT	confined field trial
CGH	confined greenhouse trial
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIRAD pour le	Centre de coopération internationale en recherche agronomique développement
CIRDES	Centre international de recherche-développement sur l'élevage en zone subhumide (Burkina Faso)

CITES Fauna and	Convention on International Trade in Endangered Species of Wild Flora
COMESA	Common Market for Eastern and Southern Africa
CORAF/WECARD	Conseil ouest et centre africain pour la recherche et le développement agricole/West and Central Africa Council for Agricultural Research and Development
CPB	Cartagena Protocol on Biosafety
CSIR-CRI	Council for Scientific and Industrial Research–Crop Research Institute (Ghana)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
DEAT	Department of Environmental Affairs and Tourism (South Africa)
DFID	Department for International Development (UK)
DNA	deoxyribonucleic acid
DoA	Department of Agriculture
ECOWAS	Economic Community of West African States
ESA	Eastern and Southern Africa
EU	European Union
FARA	Forum for Agricultural Research in Africa
GDP	gross domestic product
GE	genetic engineering
GMO	genetically modified organisms
IAR	Institute for Agricultural Research (Nigeria)
IFAD	International Fund for Agricultural Development,
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Institut de l'environnement et de recherches agricoles (Burkina Faso)
IRD	Institut de recherche pour le développement
ISRA	Institut sénégalais de recherches agricoles
ICGEB	International Centre for Genetic Engineering and Biotechnology
KARI	Kenyan Agricultural Research Institute
LNERV	Laboratoire national d'élevage et de recherches vétérinaires
NaCRRI	National Crops Resources Research Institute
NARI	national agricultural research institute
NARO	National Agriculture Research Organisation (Uganda)
NARS	national agricultural research system
NBF	National Biosafety Frameworks

NEPAD	New Partnerships for Africa's Development
NGICA	Network for the Genetic Improvement of Cowpea
NGO	non-governmental organisation
NRCRI	National Root Crops Research Institute (South Africa)
OECD	Organization for Economic Co-operation and Development
PBS	Program for Biosafety Systems
REC	regional economic community
SABIMA	Strengthening Capacity for Safe Biotechnology Management in sub-Saharan Africa
SASRI	South African Sugarcane Research Institute
SFSA	Syngenta Foundation for Sustainable Agriculture management in Sub-Saharan Africa
SHESTCO	Sheda Science and Technology Complex (Nigeria)
SOFITEX	Société Burkinabè des fibres textiles
SRO	sub-regional organisations
SSA	sub-Saharan African
UNEP-GEF	United Nations Environment Programme –Global Environment Facility
USAID	United States Agency for International Development
WASA	West Africa Seed Alliance
WCA	West and Central Africa

Front view of NaCRRI, Namulonge, Uganda

Bt Cotton confined field trial at KARI, Thika, Kenya

About FARA

FARA is the Forum for Agricultural Research in Africa, the apex organization bringing together and forming coalitions of major stakeholders in agricultural research and development in Africa.

FARA is the technical arm of the African Union Commission (AUC) on rural economy and agricultural development and the lead agency of the AU's New Partnership for Africa's Development (NEPAD) to implement the fourth pillar of the Comprehensive African Agricultural Development Programme (CAADP), involving agricultural research, technology dissemination and uptake.

FARA's vision: reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises.

FARA's mission: creation of broad-based improvements in agricultural productivity, competitiveness and markets by supporting Africa's sub-regional organizations (SROs) in strengthening capacity for agricultural innovation.

FARA's Value Proposition: to provide a strategic platform to foster continental and global networking that reinforces the capacities of Africa's national agricultural research systems and sub-regional organizations.

FARA will make this contribution by achieving its *Specific Objective* of sustainable improvements to broad-based agricultural productivity, competitiveness and markets.

Key to this is the delivery of five *Results*, which respond to the priorities expressed by FARA's clients. These are:

1. Establishment of appropriate institutional and organizational arrangements for regional agricultural research and development.
2. Broad-based stakeholders provided access to the knowledge and technology necessary for innovation.
3. Development of strategic decision-making options for policy, institutions and markets.
4. Development of human and institutional capacity for innovation.
5. Support provided for platforms for agricultural innovation.

FARA will deliver these results by supporting the SROs through five Networking Support Functions (NSFs):

NSF1. Advocacy and resource mobilisation

NSF2. Access to knowledge and technologies

NSF3. Regional policies and markets

NSF4. Capacity strengthening

NSF5. Partnerships and strategic alliances

FARA's donors are the African Development Bank (AfDB), the Canadian International Development Agency (CIDA), the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), the Danish International Development Agency (DANIDA), the Department for International Development (DFID), the European Commission (EC), the International Development Research Centre (IDRC), the Syngenta Foundation, the United States Department of Agriculture (USDA), the World Bank and the Governments of Italy and the Netherlands.

Forum for Agricultural Research in Africa
12 Anmeda Street, Roman Ridge
PMB CT 173, Accra, Ghana
Telephone: +233 302 772823 / 779421
Fax: +233 302 773676 / Email: info@fara-africa.org

www.fara-africa.org