Africa's Fight for Freedom to Innovate and the Early Signs of Embracing Biotechnology Especially Genetically Modified (GM) Foods

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Background

On 1 July 1999, my article *Why Africa needs agricultural biotech* was published by Nature.[1] In retrospect, this was a watershed article that was to later open a vicious battle for the hearts and minds of the African people regarding the genetic modified (GM) technology. My thesis was simple: Africa did not just need the GM technology, it needed it urgently. I argued and urged Africa to enthusiastically join the biotechnology revolution. "There is urgent need for the development and use of agricultural biotechnology in Africa to help to counter famine, environmental degradation and poverty," I argued.

By this time, I was the Director of the Africa Regional Office of the International Service for the Acquisition of Agri-Biotech Applications (ISAAA AfriCentre), which I had established in Nairobi. The *Nature* article provided a watershed moment; it opened the floodgates for Africa to seriously evaluate where the continent stood on the GM debate. The attacks by the anti-GM lobby especially from Europe came fast and furious.

Clutching straws, those opposed to the technology accused me of claiming that the GM technology was the only answer to world hunger. In the cacophony of noise that followed, anti-GM activists did not want to hear that GM crops—within a bouquet of other agricultural technologies—had the potential to contribute to the reduction of poverty and hunger in the developing countries. The *Nature* article thrust me into the centre of the GM technology debate in Africa. This came at a time when people outside the continent were speaking for Africa. Now the Africans had a voice.

[1] http://www.nature.com/nature/journal/v400/n6739/full/400015a0.html.

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About 2 years after the *Nature* article was published, the then Kenya Agricultural Research Institute (KARI), approved trials to develop a virus resistant sweet potato. Within 3 years, anti-GM activists were trumpeting the trials as a failure. Those who know that it takes over 10 years to develop and commercialize a GM crop were petrified; but the anti-GM activists did not want the facts or technical details to get in their way.

The anti-GM activists quoted two researchers, Dr Francis Nang'ayo, and Dr Ben Odhiambo saying: "There is no demonstrated advantage arising from genetic transformation using the initial gene construct." The fact that initial GM work was done at the Monsanto labs in the US made an excellent narrative. Monsanto had developed a coat protein responsible for virus resistance and donated it to KARI, royalty free, to use in its sweet potato improvement programme.

"The transgenic material did not quite withstand virus challenge in the field," a report by Drs Nang'ayo, and Odhiambo said, casting doubt on whether the gene expression was adequate or it failed to address the diversity of virus in Kenya. The "failed" experiment "corresponded" with an earlier study released by the Third World Network Africa, a well-known anti-GM organization. Their study, "Genetically Modified Crops and Sustainable Poverty Alleviation in Sub-Saharan Africa: An Assessment of Current Evidence," by Aaron deGrassi, of the Institute of Development Studies, University of Sussex, UK, warned that the GM sweet potato introduced in Kenya did not address the crop's major problem—weevils. The TWN study offered "new evidence" against claims of the miracle potential of GM crops for dealing with famine and poverty in Africa.

At the time the stories about the "failure" of the GM sweet potato were unravelling, I had moved from ISAAA and started Africa Harvest, a non-profit organization whose vision is to be a lead contributor to fighting poverty, hunger and malnutrition. The GM sweet potato project started as my Ph.D. project at the University of Bath in the United Kingdom. Later, on a post-doctoral assignment in Monsanto through a joint USAID Sponsorship, I did further work on the GM sweet potato. The reports of failure were therefore of concern to me, not just because my name was being dragged in the mud, but because of the falsehoods peddled by the anti-GM groups.

I came out strongly to demonstrate that the reports had been completely misinterpreted and distorted. Contrary to what anti-GM activists were saying, the GM sweet potato has been a success in many ways. As indicated, it takes over a decade to initiate, develop and commercialize a GM crop; under careful biosafety approval processes, the molecular biology research laboratory work moves to confined greenhouse trials (CGT) and, subject to further approvals, to Confined Field trials (CFTs) before Open Field Trials (OFTs), which is the first part of the deregulation process.

Typically, the first generation products are not intended for commercialization. The GM sweet potato variety tested in Kenya was meant to develop a genetic transformation system which did not exist globally. It contained a reporter Gus gene which is a 'tell-tale' gene commonly used to indicate to scientists whether a plant is indeed transformed. Reporter genes like the Gus gene are not included in final commercial products and are out-bred once the final product has been established.

The sweet potato variety produced in Kenya's was the first generation product developed for the system. The field trials results were meant to identify the level of protection needed for the final product in Kenya. The purpose of the field trials was also to shed some light on how to improve the system used to transform the sweet potato. The "failure" was merely a *scientific finding* that indicated the extent to which sweet potatoes were vulnerable to disease in the region in which the trials were carried out.

As the anti-GM activists were obfuscating the issues, scientists, in anticipation of field trials' results, were already working a second generation product which included a gene construct from the most virulent Kenyan potato virus strain. The Muguga virus strain had been identified after extensive screening. Future research was designed to produce a second generation GM sweet potato variety equipped with double protection. The protective feature of this GM variety would have both the coat protein (CP) gene and its replicase gene which had the special ability to prevent the sweet potato feathery mottle virus (SPFMV) from replicating upon infection, thereby rendering the virus harmless. An additional cloning site to the gene construct had been made, which would make it much easier for scientists to add the gene that gives it resistance to weevils, if and when this was discovered. At the time, it was thought that the final GM sweet potato product would be tailor made for African environmental conditions.

Although it was never commercialized, in many ways, the GM sweet potato project more than achieved its goals, including the development of a scientifically sound genetic transformation system for sweet potato. Being the first GM crop variety in Sub-Saharan Africa, the pioneering nature of the project demanded adherence to strict international standards. The trials were carried out after close consultation and in close collaboration with the rural communities where the sites were located.

In less than 15 years since the project was started, many Kenyan scientists have been trained through the project and many other GM projects have been initiated and are ongoing. The human and infrastructure capacity development created the starting point that has over the years, enabled the country to define its nature of engagement with the GM technology. Kenya now has a bio-transformation lab where other crops—other than the sweet potato—have been developed. The lab puts Kenya in a position to form vital collaborations and further build the country's scientific, and more specifically, GM technology capacity.

The country is also a beacon of light in the region with regard to biosafety and GM technologies. Organizations such as Kenya Plant Health Inspection services (KEPHIS) developed initial expertise and experience on how to regulate GM Crop field trials, out of the GM sweet potato project. KEPHIS monitored all field trials, collected and analysed data to ensure compliance with internationally accepted standards. Today, the country has a fully-fledged, pro-science biosafety law and an operational National Biosafety Authority (NBA). At the time of writing, NBA is evaluating several applications on GM Crops that could see the commercialization of GM crops.

Leveraging South Africa's Early Foray into the GM Technology for the Rest of the Continent

Africa's history with the GM technology is less than two decades. Although research was on-going in various countries, it was not until the passage of the Biosafety law in parliament allowing commercialization in South Africa (GMO Act, 1997) that the continent can claim to have staked its claim. Shortly after passage of the law, South Africa commercialized Line 531/Bollgard (Bt. Cotton) and MON810/Yieldgard maize. The anti-GM activists may have been caught unaware by the momentum building in South Africa.

My *Nature* article, coming 2 years after passage of the South African law and commercialization of both cotton and maize seemed to have provoked the hornets' nest. Its premise was that this technology was needed, not just in South Africa, but throughout the continent. In South Africa, GM activism increased and in 2003, The Biowatch Trust appealed a decision against the Executive Council to authorise commercial growing of maize event Bt11. They lost the case. The upholding of the decision of the Executive Council confirmed the effectiveness of the country's biosafety regulatory system.[2]

The following year, Biowatch sued the National Department of Agriculture (NDA)—under which the GMO Council falls—demanding access to all documentation relating to the administration of the GMO Act. The NDA was open to providing some of the information while protecting the confidential business information contained in many of the documentation requested at that point. Biowatch considered this information as inadequate and therefore sought relief from the High Court. Although the court ordered the directorate to provide the information requested, it is important to note that the ruling confirmed the department's responsibility to protect confidential information.

These interactions framed the early GM debate in Africa. It was about this time that I left ISAAA to start Africa Harvest Biotech Foundation International (AHBFI, or simply Africa Harvest). In 2002, barely months after the Foundation was launched, we were involved in the United Nations (UN) World Summit on Sustainable Development (WSSD). Prior to the meeting, I made a presentation on African Biotechnology issues for WSSD Regional Parliamentarians meeting held at the White Sands Hotel in Mombasa, Kenya.

At the Johannesburg meeting, I "stressed the need to combine the use of biotechnology with good governance in Africa."[3] I also proposed that Africa look to regional markets as an alternative to Europe, which was non-committal or opposed to the GM technology. More significantly, I presented an Africa biotech stakeholders position on the GM technology, declaring it immoral for African

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[2]Annual Report of the Executive Council of the Genetically Modified Organisms Act, 1997 (Act No. 15 of 1997) for the period 2004/05 http://www.nda.agric.za/docs/GeneticResources/gmo%20res%20act%20.pdf.

[3]http://www.iisd.ca/2002/wssd/enbots/pdf/enbots1006e.pdf.

governments to reject genetically modified (GM) crops and foods when people were dying from hunger. This was in reference to Zambia's rejection of food aid containing GMOs.[4] We later travelled to Zambia and held high-level meetings regarding this issue and were assured that it has been blown out of proportion, but over time, because of politics, the government hardened its position. In recent years, Zambia has build capacity and could be an important player in the technology in future.

Given the context within which Africa Harvest was established, our focus was to ensure a coherent African position on the GM technology. We adopted a three-pronged approach: international, pan-African outreach and focus on specific countries, where we saw potential for fast-tracking the acceptance of the technology. At the international level, we, for example, submitted a statement to the Committee on Agriculture United States House of Representatives Hearing[5] on "Review of Artificial Barriers to United States Agricultural Trade and Foreign Food Assistance."

At the pan-African level, we focused on ensuring a progressive position on the GM technology at the highest levels. As a founder of Executive Committee member of Forum for Agricultural Research in Africa (FARA), we were involved in the drafting of the Comprehensive African Agricultural Development Program (CAADP) Pillar 4 on agricultural research. Within it, biotech and the GM technology were identified among the key drivers of African agricultural research. This was a precursor of the African Union (AU) and the New Partnership for Africa's Development (NEPAD) position on the GM technology captured in the *Report of the High-Level African Panel on Modern Biotechnology*.[6]

On a country-to-country level, we worked, with support from Croplife International (CLI), in African countries that we thought had the greatest potential to adopt biosafety regulations, paving the way for acceptance and commercialization of the technology. Working in an extremely challenging and complex environment, our efforts have focused on ensuring policy makers create an enabling policy framework for the GM technology. We work with different stakeholders to avoid delays in the adoption of the technology on the continent.

Among Africa Harvest successes—working with a myriad of international and local stakeholders—is the passage of pro-science Biosafety laws in Kenya, Nigeria and Ghana. Although only four countries (South Africa, Burkina Faso, Sudan and Egypt) have commercialized GM crops, many others have the necessary legal framework and human capacity to do so. More specifically, Ghana and Kenya are evaluating applications for various crops that could lead to commercialization. I have argued that the key to fast-tracking the GM technology on the continent is political will, because the GM technology regulatory system has become highly

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[4]http://www.telegraph.co.uk/news/worldnews/africaandindianocean/zambia/1411713/Starving-Zambia-rejects-Americas-GM-maize.html.

[5]http://www3.bio.org/foodag/action/20030326.asp.

[6]http://belfercenter.ksg.harvard.edu/files/freedom_innovate_au-nepad_aug2007.pdf.

political. Purely establishing the food and environmental safety of a GM-Product in Africa does not lead to regulatory approval as the EU position has to be considered as well as other external factors. Therefore it is obvious to conclude that "Unless and until as African country has the political will and support for biotechnology application, investments made in biotechnology will not be fully realised.[7]"

Using Tissue Culture (TC) Biotechnology to Show Case the Benefits of Biotechnology to Smallholder Farmers in Africa. The Case of Tissue Culture Banana

Securing the political will of African leaders and policy makers requires a deep understanding of their concerns and fears. Since most politicians have to resolve complex, poverty-related needs, it's imperative to step-down the scientific language and to demonstrate the benefits of the biotechnology. This has been an important part of our strategy.

This challenge has also allowed me to continue focusing on my passion, which is to help increase agricultural productivity for resource-poor farmers. For me, GM technology is only one of the tools in a large arsenal of technologies available to scientists and farmers. Of course conventional technologies still have an important role to play; What Africa needs is the freedom to chose whatever agricultural technologies will address its challenges.

We have also found it critical to push for agricultural R&D to incorporate home-grown ideas and innovations. Forced by years of limited success, development players are now searching for how best to tap farmers' indigenous knowledge and innovations. Africa Harvest's Tissue Culture Banana projects have captured the imagination of farmers, politicians and policy makers and become a smooth entry point from a discussion on biotechnology to the GM technology.

In a country like Kenya, where approximately 75% of the total population (33 million of the estimated 45 million) lives in the rural areas[8] and the most important economic activity is smallholder farming, discussions about the GM technology can be removed from real or immediate needs. The challenge is compounded by the fact that in most African countries, most of the population lives in abject poverty with incomes of less than US$1 per day.

Africa Harvest vision and mission strategy is focused on addressing the issue of poverty, hunger and low incomes[9] using existing convention technologies, before

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[7]Biotechnology in Africa: Emergence, Initiatives and Future, Editors: Wambugu, Florence and Kamanga, Daniel (Eds.).

[8]Kenya's Central Bureau of Statistics (CBS), 2004.

[9]Low incomes translate to poverty and hunger, compounded by a vision cycle of poor crop yields, poorly functioning markets and inefficient pricing. Eventually, these vulnerable groups are unable to purchase food and have to receive food assistance during times of severe food shortages.

or alongside the discussion on the GM technology. The problem of low incomes is linked to value-chain inefficiencies[10] especially with regard to food and 'orphan crops' such as banana and sorghum. Addressing the issues facing the smallholder farmers has given Africa Harvest the required trust to discuss opportunities offered by the GM technology.

For example, the fact that banana is the most widely grown fruit in Eastern Africa means[11] significant investments have been made in the tissue culture (TC) banana technology transfer. Africa Harvest is a trusted technology disseminator. Over the last 10 years, the International Development Research Centre (IDRC), the Rockefeller Foundation and DuPont Pioneer have jointly made investments through funding Africa Harvest to the banana sub-sector. Generally, funding has focused on technology transfer to increasing banana production accompanying interventions along the whole value chain. In 2002, the Rockefeller Foundation expanded its support to the banana sub-sector to include access to markets and 2 years later, DuPont Pioneer funded an Africa Harvest project, which focused on the Whole Value Chain (WVC) strategy.

The TC banana project clearly demonstrates that technology seedlings derived from the lab can benefit small holder farmers positively synthesizing key stakeholders in agriculture—local and national leaders, politicians and policy makers—appreciate the important role biotechnology can play if well targeted and is need based. Partnership with multinational companies like DuPont Pioneer for the common good with a non GM-crop also demonstrated good will against the accusations of "always seeking opportunity to sneak in GM Crops".

The ABS Project's Role in Consolidating Africa's Experiences and Lessons Learnt in GM Technology

The Africa Biofortified Sorghum (ABS) Project (www.biosorghum.org)—with the vision to develop sorghum varieties targeting critical nutritional deficiencies—has probably made the biggest difference in biotech experiences & lessons learnt in Africa. The project was initially funded by the Bill and Melinda Gates Foundation (BMGF) from 2005 to 2012. During the period, the project included a consortium of nine partnership institutions in Africa and USA, many collaborator organizations & stakeholders. The ABS included a network of over 70 scientists spread over five countries in Africa (South Africa, Kenya, Burkina Faso, Egypt & Nigeria), and

[10]Limited access to, and when available, high cost of credit as well as lack of information and poorly functioning markets (International Monetary Fund, IMF, 2005).

[11]Total area under banana: 40,000 ha (MOA, 2004).

USA as well as in several regional bodies. Other funding has been received from the Howard G. Buffet Foundation through the Danforth Center, with additional in-kind and monetary support from DuPont Pioneer.

The project has made major technological breakthroughs that include achieving 70 μg/g of β-carotene accumulation, 140 times higher than that of wild-type sorghum (TX430) and more than double than that of Golden Rice-2®. The project has also demonstrated that co-expression of vitamin E could improve stability of β-carotene in sorghum during storage and increase the β-carotene half-life in grain from about four to 10 weeks. Based on conservative estimates, currently achievable biofortified sorghum has the potential to contribute from 35 to 60% of the recommended daily allowance (RDA) of vitamin A for children in Africa. The focus has now expanded to achieving enhanced bioavailability of zinc and iron and improving protein digestibility.

This success should be viewed against the fact that sorghum is the world's fifth most important cereal and serves as the major food staple for the world's poorest 300 million people who reside largely in sub-Saharan Africa and southern India. Among other major achievements, the ABS project has:

- Increased pro-vitamin A content in sorghum
- Increased zinc and iron bioavailability through phytate reduction
- Reduced time required for sorghum transformation by 60% to 4 months
- Increased transformation success rate in sorghum 100 times over previous capabilities
- Improved protein digestibility levels after cooking
- Adhered to transgenic biosafety principles and best practices specific to Africa
- Conducted nearly a dozen confined field trials in Kenya and Nigeria with strict adherence to stewardship and compliance protocols
- Continued capacity building among African scientists and researchers.

As a public-private consortium actively working to improve the health of millions of people who rely on sorghum as their primary diet by enhancing its nutritional quality through biofortification, the project has helped demonstrate potential benefits of the GM technology. Working with DuPont Pioneer, Africa Harvest has helped build scientific and biosafety leadership in several African countries. The project has trained over 20 African Scientists in the USA on advanced GM technologies and other relevant skills including biosafety and regulatory assessment. Although the consortium has changed over the years, the core partners remain; these are the Kenya Agricultural and Livestock Research Organization (KALRO), Nigeria's National Biotechnology Development Agency (NABDA) and the Institute for Agricultural Research (IAR) and DuPont & Africa Harvest. It is important to acknowledge the early contribution of South Africa's Agricultural Research Council (ARC), the Council for Scientific and Industrial Research (CSIR) and the University of Pretoria. The University of California Berkerly (UCB) was also involved in the early stages of the project. In Burkina Faso, the Institut de l'Environnement et de Recherches Agricoles (INERA) was also involved in the project; the institute remains interested in rejoining the project, subject to strategic and funding imperatives.

The ABS Project, is a forerunner to several other African GM projects, and has helped to consolidate the enormous work of many scientists, local and international organizations. Many individuals have fought and continued to fight for GM technology acceptance in Africa. There is no doubt there is light at the end of the tunnel as several Africa Countries have commercialized GM crops and will continue to do in the future, gaining from the now 20 years of experience since the first GM crop was planted in 1996.