MANY CHALLENGES, MANY OPPORTUNITIES

Crop biotechnology and biosafety in Africa

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Clear-cut benefits of biotechnology

Global food security needs a two-pronged attack: reducing demand for food along with increasing sustainable crop production. Both will be necessary if recent developments in plant science are to be harnessed optimally. Technological innovations will be most effective if rolled out as integrated components of agricultural systems, as the case studies in this chapter illustrate.

Agricultural biotechnology has already brought significant benefits to African farmers, but in only four countries so far – South Africa, Burkina Faso, Sudan and Egypt. Small-scale producers growing commercial genetically modified (GM) crops, in particular, have enjoyed substantial advantages: increased gross margins of 114 per cent; pesticide costs down by 62–96 per cent; and yield improvements of 18–29 per cent compared with conventional crops.

Improved pest control resulting from new plant strains is particularly noteworthy. Some African communities can lose up to 90 per cent of their food crops through diseases caused by bacteria, viruses and fungi, as well as other organisms such as plant-eating nematodes and mites that greatly impair growth and yield.

There are other benefits too from the new crops. They make farmers' lives simpler and more convenient as well as being safer for both human health and the environment. They also have the great advantage of being compatible with conservation-oriented farming practices. The opportunity to use fewer agrochemicals, for example, has a positive impact on the diversity of pollinating and other beneficial insect populations.

Underperforming agriculture

For more than 30 years, African agriculture – on which 60 per cent of the continent's labour force depends – has been underperforming compared to those parts of the developing world that benefited from improvements associated with the Green Revolution. Nonetheless, agriculture is still a major economic driver in Africa, both domestically and, in a number of countries, in terms of foreign currency earnings. There are many reasons for underperformance, including:

KEY THEMES

- Underachievement in agriculture.
- Pan-African initiatives on genetically modified organisms.
- Dramatic repositioning of investment in farming.
- Current biosafety and desirable goals.
- The need for integrated effort.

- poor-quality seeds;
- unpredictable rainfall and lack of irrigation together with climate change;
- degraded soil health and fertility;
- low-technology farm inputs;
- instability of world prices;
- a predominance of small farm holdings (1–2 hectares or even less in Africa);
- lack of farming organisations;
- poor infrastructure, such as lack of roads and bridges;
- neglecting the needs of women farmers, often the chief food producers;
- HIV/AIDS leading to a decrease in the availability of labour;
- an aging farming population;
- migration from rural areas into the cities.

Despite such limiting factors, Africa's demands and patterns of food consumption are predicted to change, with a doubling of the population from 1 billion to 2 billion by 2050, expanding urbanisation, and rising incomes likely to bring about increased overall demand, especially for high-value and processed foods. There has been a measure of agreement across Africa that more scientifically and technically trained people are needed to evaluate and further the cause of biotechnology.

Freedom to Innovate **places great emphasis on building cohorts of appropriately trained experts who can advise countries on all aspects of biotechnology.**

Common stance on biotechnology

The African Union (AU), through its New Partnership for Africa's Development (NEPAD), has adopted a common position on all issues arising from biotechnology and biosafety. The AU has also put in place the African Model Law on Biosafety to guide member states in drafting their own national legislation, and the African Strategy on Biosafety which provides member states with frameworks for regional and national biosafety initiatives and helps enhance regional capacity to carry out biosafety measures.

These guidelines complement the recommendations in AU-NEPAD's publication *Freedom to Innovate*, which places great emphasis on building cohorts of appropriately trained experts who can advise states on all aspects of biotechnology, including regulation, and food and environmental standards.

Regional priorities

Freedom to Innovate also stresses the need to identify biotech priorities that are geographically relevant to Africa's development. It suggests the following breakdown of activities:

- Southern Africa should concentrate on health biotechnology;
- North Africa on biopharmaceuticals;
- West Africa on new crop technologies;
- East Africa on animal biotechnology;
- Central Africa on forestry.

Genetic modification in agriculture

In addition to the above recommendations, the Conference of AU Ministers of Agriculture in 2006 came to a common African position, specifically on the use of GM organisms in agriculture. They recommended that member states should:

- enhance training in biosafety and biotechnology;
- establish regional GM testing laboratories;
- develop policies to enhance public-private partnerships in biotechnology;
- be encouraged to build regulatory capacity on issues surrounding biotechnology and biosafety.

Extent of commercialisation

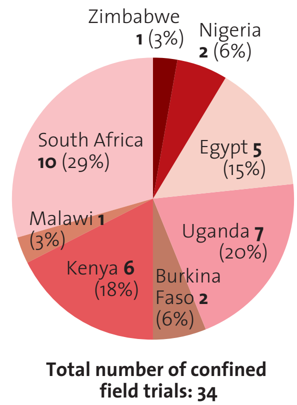
What impacts have these pan-African initiatives had? Clearly some countries have been harnessing agricultural biotech innovations and integrating them into their

Table 7.1 Confined field trials in Africa

	Crop/trait
Burkina Faso	*Bt* cotton (approved for commercialisation); cowpea (insect resistance, application pending)
Egypt	Maize (insect resistance, approved for commercialisation); cotton (salt tolerance); wheat (drought tolerance); potato (viral resistance); cucumber (viral resistance); melon (viral resistance); tomato (viral resistance)
Kenya	Maize (insect resistance); cotton (insect resistance); cassava (viral resistance); sweet potato (viral resistance)
Malawi	*Bt* cotton (insect resistance)
Nigeria	Cassava (nutrient enhancement); cowpea (*Maruca* insect resistance)
South Africa	Maize (drought tolerance); maize (herbicide tolerance); maize (insect resistance); maize (insect resistance and herbicide tolerance); cassava (starch enhancement); potato (insect resistance); sugarcane (alternative sugar); cotton (insect resistance and herbicide tolerance)
Uganda	Banana (fungal resistance); maize (drought tolerance); *Bt* cotton (insect resistance); cotton (herbicide tolerance); cassava (viral resistance); sweet potato (weevil resistance)

Source: www.nepadbiosafety.net

Figure 7.1 Numbers of confined field trials in Africa



Source: NEPAD/ABNE

national agenda. But for all the agronomic, environmental, and nutritional and health benefits of the new technologies, only four countries have commercialised GM crops: South Africa, Burkina Faso (see Case studies), Sudan and Egypt. Figure 7.1 and Table 7.1, however, show that a number of other African countries are also conducting field trials for GM crops, so the signs are optimistic.

Dramatic change in direction

Agriculture across the continent has been repositioned in the development agenda through the Comprehensive Africa Development Program. This is a visionary attempt to make radical changes to the way in which Africa sets about making future agriculture fit for purpose. African leaders, for example, agreed in the 2003 Maputo declaration of the AU to increase public investment in agriculture by a minimum of 10 per cent of their national budgets, and to raise productivity by at least 6 per cent.

Target 2015

The ultimate aims of African leaders in the near future are as desirable as they are ambitious:

- vibrant agricultural trade within and between African countries and regions;
- farmers as active players in the market economy;
- Africa to become a net exporter of agricultural products;
- more equitable distribution of wealth for rural populations;
- environmentally sound production;
- a culture of sustainable management of natural resources;
- Africa to become a major strategic player in agricultural science and technology.

While the symptoms of cassava mosaic disease are seen on the leaves, the impact on tuber growth is so severe that the virus can cause serious financial losses as well as devastating food shortages.


FAO

Challenges and constraints

For all this determination to ensure that Africa benefits fully from modern crop biotechnology, not to mention the fact that, globally, it has now been safely applied for nearly two decades, the pace of adoption has been relatively sluggish. The 2003 Maputo declaration of the AU is a very positive sign, and most countries have made significant progress towards the target of raising investment in agriculture by 10 per cent of national budgets, but only eight out of 54 (Burkina Faso, Ethiopia, Ghana, Guinea, Malawi, Mali, Niger and Senegal) have actually met or exceeded it, and only 11 have reached the 6 per cent productivity goal.

Many factors are at play here. Some are essentially political, such as the absence of biosafety regulations in most African countries and a lack of political will to

CASE STUDY Cotton in Burkina Faso

The cotton crop of Burkina Faso is notoriously prone to pests. Before 2003, farmers were spending more than US$ 40 million annually on pesticides in an effort to fight production losses of 50–70 per cent. They badly needed the benefits promised by the new technologies.

From 2003 onwards, trials began in many locations on cotton crops modified with a suitable protective gene derived from a soil bacterium, *Bacillus thuringiensis,* which produces toxins that kill many insect pests when ingested. The new *Bt* cotton worked well, culminating in 2007 in 20 demonstration tests in fields at a suitable isolation distance from conventional cotton. By 2009, commercialisation of the *Bt* cotton began, with excellent results. Today, 80 per cent of Burkina Faso's cotton production, grown on more than 350,000 hectares, is from the *Bt* variety. Other genetically enhanced crops under evaluation include insect-resistant cowpea and sorghum biofortified with vitamin A.

The planting of *Bt* cotton has paid off handsomely, giving farmers average yield increases of more than 18 per cent compared to conventional varieties, and a rise in per-hectare profits from US$ 39 to around US$ 62. On the national scale, the estimated economic benefit of growing *Bt* cotton is over US$ 100 million, as yield increases reach 30 per cent and insecticide spray use falls by at least 50 per cent.

One further by-product has been an increase in honey production in areas where *Bt* cotton is under cultivation.

embrace new technologies – as well as concerns about safety implications. Others relate to the lack of strong seed industries and weak links between industry and research and development (R&D) bodies. In addition, investment in the new technologies has been uneven. Even when national research centres have the potential to apply the new biotechnologies, greater capacity in molecular biology, biochemistry, genomics, plant breeding and bioinformatics is needed.

The reasons for this are not just a lack of skilled personnel, funding or local infrastructure. Many laboratories are concerned that the regulatory procedures governing biosafety are inadequate for this kind of innovative research.

Status of biosafety measures

Of the 54 states in the AU, only 18 have laws, regulations, guidelines or policies relating specifically to modern biotechnology. The reasons for this shortfall are many and complex. Some relate to the international obligations and national priorities of individual countries. Others turn on the state of their biotech R&D.

Peggy Greb/USDA/ARS/PD

The introduction of insect-resistant cotton in Burkina Faso has been bad news for pink bollworm – one of its major pests – but good news for local bee keepers as well as cotton farmers.

Certainly, it appears that some countries tend to focus their policy making more on the risks of the new genetics than on its potential benefits. Some also tend to evaluate it using socio-economic rather than scientific criteria, imposing risk assessment requirements that are incompatible with normal product development. Regulations are imposed that are simply unaffordable or unenforceable in practice.

There is often a lack of cooperation and coordination between the government departments responsible for biosafety measures, as well as inadequate operational budgets. Inefficiencies and delays in processing applications for permits are also common. Matters are not helped by legal complexities, with biosafety laws that are unreconciled with existing laws.

A recipe for biosafety

A United Nations University Institute of Advanced Sciences report in 2008 – *Internationally Funded Training in Biotechnology and Biosafety: Is it Bridging the Biotech Divide?* – made the following recommendations for a functional, national biosafety system. It should:

- make science-based decisions on developing and using biotech products;
- be clear, transparent and predictable for all stakeholders;
- be flexible in adopting new technologies;
- take into account inputs from the public;
- ensure that biosafety policies and regulations are workable in practice.

CASE STUDY South Africa leads the way

In both research and development and in the cultivation of genetically improved crops, South Africa is the continent's frontrunner. Its list of crops under research is impressive: insect-resistant and herbicide-tolerant cotton; virus-resistant and drought-tolerant maize; fungus- and virus-resistant grapevine; starch-enriched cassava, and sugarcane with higher yields and raised sugar content.

These new crops are being developed by various organisations: seed companies, research institutions, academia and industry. To date, no fewer than 13 genetically modified crops have been approved for commercial release – eight cotton, four maize and one soybean line.

The rise in yield for the new maize compared to conventional plants ranges from 31 per cent to 134 per cent. In addition, those smallholders cultivating genetically modified cotton have seen their yields increase by 11 per cent, which means an extra US$ 35 per hectare.

Table 7.2 Some genetic modification research and development activities under way in Africa

Country	Crop	Trait	Institutions/companies involved
South Africa	Maize	Drought tolerance, herbicide tolerance, insect resistance, insect resistance/ herbicide tolerance	Monsanto, Syngenta, Pioneer
	Cassava	Starch enhancement	Agricultural Research Council-Institute for Industrial Crops
	Cotton	Insect resistance/herbicide tolerance, herbicide tolerance	Bayer
	Potato	Insect resistance	Agricultural Research Council-Onderstepoort Veterinary Institute
	Sugarcane	Alternative sugar	South African Sugarcane Research Institute
Kenya, Tanzania, South Africa, Mozambique	Maize	Drought tolerance	African Agriculture Technology Foundation, National Agricultural Research Institutes, CIMMYT (International Wheat and Maize Improvement Centre), Monsanto, Bill and Melinda Gates Foundation, Howard G. Buffet Foundation
Kenya	Maize	Insect resistance	Kenya Agricultural Research Institute (KARI), CIMMYT, Monsanto, University of Ottawa, Syngenta, Rockefeller Foundation
	Cotton	Insect resistance	KARI/Monsanto
	Cassava	Cassava mosaic virus disease resistance	KARI, Danforth Plant Science Center
	Sweet potato	Viral disease resistance	KARI/Monsanto
Uganda	Cotton	Insect resistance/herbicide tolerance	National Agricultural Research Organisation/ Monsanto, Agricultural Biotechnology Support Project II, USAID, Cornell University
	Banana	Black sigatoka (fungal disease) resistance	NARO-Uganda, University of Leuven, International Institute of Tropical Agriculture, USAID
	Cassava	Cassava mosaic virus disease resistance, cassava mosaic and brownstreak disease resistance	National Crops Resources Research Institute, CIP (International Potato Centre), Danforth Plant Science Centre
Nigeria, Burkina Faso, Ghana	Cowpea	*Maruca* (insect) resistance	Institute for Agricultural Research, Zaria/ INERA (Institut de l'Environnement et de Recherches Agricoles)/SARI (Savanna Agricultural Research Institute)
South Africa, Burkina Faso, Kenya	Sorghum	Nutrient enhancement	Consortium of nine institutions led by Africa Harvest Biotechnology Foundation International and funded by the Bill and Melinda Gates Foundation

Table 7.2 continued

Country	Crop	Trait	Institutions/companies involved
Nigeria	Cassava	Nutrient enhancement	National Root Crops Research Institute, Umudike, Danforth Plant Science Center, International Institute of Tropical Agriculture, USAID
Egypt	Maize	Insect resistance	Monsanto, Pioneer
	Cotton	Salt tolerance	Agricultural Genetic Engineering Research Institute
	Wheat	Drought tolerance, fungal resistance, salt tolerance	Agricultural Genetic Engineering Research Institute
	Potato Banana Cucumber Melon Squash Tomato	Viral resistance	Agricultural Genetic Engineering Research Institute

Source: Bennett and Jennings, 2013

Overview of Africa's current research and development

Despite all the limitations, drawbacks and disappointments surrounding both the development and application of the new biotechnologies and the biosafety structures needed to facilitate them, the outlook definitely remains hopeful.

With the help of development partners and technology developers, African science has built the capacity to make significant progress in creating, developing and producing indigenous transgenic crops. A key event here was the creation of the African Agricultural Technology Foundation (AATF), which has overseen field testing of a number of GM crops across many institutions. Table 7.2 shows the extent of this R&D.

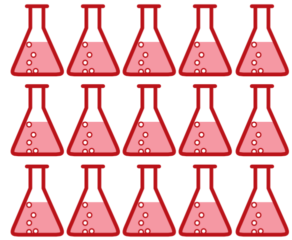
Importance of being integrated

If Africa is to realise its vision of 6 per cent annual growth in agricultural productivity with biotechnologies generating the greatest contribution, a number of issues need to be addressed.

To date, fear and scepticism have made biotechnology a sensitive trade issue across the developed and developing world. There has been a lack of information and familiarity with these innovatory methods and techniques, which has created misunderstandings and influenced public perception. The work of NEPAD is helping to break down these misperceptions, giving member states the information, training, technical support and networks necessary for their policy makers and the general public to make better-informed decisions.

There needs to be greater integration of effort. In those African countries with little or no capacity in biotechnology and biosafety, expertise needs to be pooled, data shared, and regional risk assessment and decision making distributed. Too many countries seem to be taking their own path in developing safe biotechnology, even though no country can ensure biosafety without engaging with neighbouring states. Furthermore, the cost and complexity of steering GM crops through the regulatory processes are prohibitive if approval has to be obtained for each country separately.

Africa has moved towards a critical mass of scientific expertise and can reduce both the costs and the time necessary for biotech development by sharing facilities and equipment. Coordination and cooperation will be key to success.



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