The case for GMOs in the developing world – how African farmers are benefiting from biotechnology

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Abstract

Not all GM crops available for technology transfer are likely to have relevance for African growing conditions, but the only way to assess the effectiveness and appropriateness of GM planting material is to test it locally. This paper reports on the relevance of non-GM crop biotechnology and of some commercial GM crops to small farmer development in Africa. The impact of disease-free banana planting material in Kenya will be presented. Of the five GM crops approved for production in South Africa, two have shown production benefit for emerging and subsistence farmers: insect resistant cotton and insect resistant maize. A third crop, insect resistant potato, is in the testing stage, but already shows signs of providing socio-economic and development benefits for African farmers. This paper discusses the benefits and constraints of GM technology transfer to small scale African farmers and the future these crops hold for development in poor farming communities, for food security and for wealth creation.

Media summary

African farmers are using and benefiting from appropriate, approved genetically modified crops, which address important local constraints and help make farming profitable.

Key words

Maize, cotton, potatoes, banana, biosafety, intellectual property, activists

Introduction

Harnessing genetics is not a foreign concept in Africa. On a continent where farming is practiced by commercial, small scale and subsistence farmers, the value of good planting material is widely understood and accepted. Commercial farmers invest in good planting material; small-scale farmers buy good planting material when it is needed, available and affordable, while subsistence farmers retain, share and swap material that performs well in their growing environment. But planting material alone will not ensure a good crop. Commercial farmers are skilled in juggling the inputs and effort needed to produce and make profit from crops. Small-scale farmers are mostly well versed in the input requirements but constrained by factors such as a lack of land, capital, access to technology and good marketing infrastructure. Subsistence farmers are resource poor and constrained by poverty. They receive very little assistance to boost their farming outputs.

Thus, genetics alone will not address food production in Africa, but the studies presented here will show that this is not a good enough reason to ignore the benefits of biotechnology and the improved planting materials being derived through this technology. Although improved genetics is not the final solution, it has proven benefits in African farming situations at all resource levels.

While the level of biotechnology crop research is growing in all regions of Africa and the technology is being applied to constraints in a growing range of African crops, this paper focuses on the biotechnology products that are already in the hands of African farmers. The non-GM example is taken from Kenya. Of necessity, the GM examples come from South Africa, which is the only country on the continent that has approved the general use of specific GM crops.

Case studies in Africa

Disease-free Banana

One of the first benefits African farmers experienced from biotechnology was access to disease-free planting material in Kenya. While not genetically modified, this project provides evidence for the impact biotechnology tools can have on food production in the region.

These plants were produced by tissue culture in local laboratories and distributed to small-scale farmers. Coordinated, multidisciplinary implementation projects included farmer consultations; public-private partnerships; extension support; micro-lending; cooperative marketing; feedback and monitoring. This ensured that the products of the biotechnology research, disease free planting materials, reached the target group and were successfully implemented by the small scale farmers.

The results (Table 1) were significantly beneficial for the farmers. Farmers in the outreach programme reported improved socio-economic status with better access to markets and more income generation from the new planting material. The sustainability of the project has been researched and support for the production and planting of improved material is being provided by the stakeholders, primarily the Kenyan Agricultural Research Institute and ISAAA (www.isaaa.org). The plants are sold for US$1 each and the farmers have access to extension support to help grow them effectively (http://www.techcentralstation.com/010504E.html).

Table 1. Summary of the benefits experienced by small-scale banana farmers in Kenya with access to disease-free planting material. (Data from the ISAAA Virtual Exhibit at http://www.virtualexhibit.net /new/globalShowcaseTemplate.php?project_id=295&region_id=4&industry_id=3)

Area of impact	Tissue cultured plants	Conventional plants
Early maturing	12 – 16 months	2 – 3 years
Bunch weights	35 – 40 kg	10 – 15 kg
Annual yield /ha	40 – 60 tonnes	15 – 20 tonnes

Recent devastation of banana plants in the region by the rapid spread of bacterial wilt disease has given new impetus to the tissue culture projects and facilities are being established in other growing areas in Kenya and in Uganda to increase the availability of disease-free planting material (http://www.technoserve.org/africa/kenya-other.html).

Bt cotton

The first indication that commercial GM crops might provide positive input into small scale farming in Africa came from trials in 1997 with insect resistant cotton in the Makhathini Flats of South Africa. The socio-economic benefits of Bt cotton to small scale and subsistence farmers in South Africa is well documented (Isma?l et al. 2001; Kirsten J and Gouse M 2002; ISAAA). Adoption rates among small scale farmers are at 90% in certain cotton growing areas (Kirsten and Gouse, 2002). These farmers have experienced significant yield increases and profits from buying insect tolerant GM cotton seed (Table 2).

Table 2. Summary of benefits experienced over the last seven years by resource-poor, African farmers growing GM insect tolerant cotton. (Modified from ISAAA, 2002, Bt Cotton in South Africa and www.isaaa.org)

Area of impact	Benefit
Economic	Lower production costs; average higher gross margin of US$50 / ha
Agronomic	Ongoing risk of bollworm damage significantly reduced
Labour saving	Crop management easier with less labour needed for spraying. Labour is diverted to additional plantings
Health	Fewer hospital admissions for pesticide poisoning reported; less organophosphates used
Environmental	Renewed ecology around Bt cotton fields with insects, frogs and birds reported, as a result of reduced pesticide use
Socio-economic	Improved income and quality of life. Disposable income increased. More time for non-cotton activities

Bt maize

South African small scale farmers are participating in a number of socio-economic studies to determine the impact of insect resistant maize on small scale, subsistence and emerging farmers. The longest of these projects is a three year study by the University of Pretoria, which is nearing completion. These studies have lagged behind the 1998 approval for commercial planting of GM insect resistant maize because of the delay in transferring the technology to white maize, the preferred food crop in this country.

Gathering the socio-economic data on the impact of GM maize on subsistence farming has been more difficult than with cotton, where seed sales and harvest data are collected at ginneries. The data have been complicated by the:

- variety of different planting materials (5 seed sizes, 2 seed types and varying weights of packages which are sold as number of kernels);
- ongoing harvest of fresh maize throughout the season and unintentional grazing by animals;
- marked yield improvement of the conventional non-GM, hybrid germplasm over traditionally planted seed and
- variation in planting material from saved seed to purchased, open pollinated and hybrid seed.

To address the variability in planting material and field dimensions the data are being collected as kg harvest per kg planted. Considerable data are now available on sources of planting material. In the poorest areas most seed is saved from the previous harvest; in the emerging commercial areas most seed is purchased, either open pollinated or hybrid. In general, where insect pressure is high, the technology fee on GM seed (about one third higher) is not seen as prohibitive by all levels of farmers. As with commercial farmers, adoption rates are determined by the incidence of insect infection. In areas with high infection rates the adoption rate is high and is maintained year on year. There is still not enough GM seed to meet the demand in South Africa. Those involved in the studies believe the true socio-economic impact will be measured most effectively when the seed supply allows for about 50 per cent of the maximum adoption. At this point there will be a large enough GM sample size and still sufficient conventional maize for adequate comparisons (Wally Green, pers. comm.).

Studies initiated last year with subsistence farmers support these findings (www.africabio.com). Using two demonstration plots, one on a research facility and one on a subsistence farm, a group of subsistence farmers evaluated the performance of a GM insect resistant white maize variety against its conventional counterpart. The data are presented in Table 3.

Table 3. Data collected on comparative trials for subsistence farmers with GM and conventional white maize. (From **www.africabio.com)**

Trial site	Percentage damage on cobs		Percentage yield increase for GM
	Conventional	GM	
Crop research facility	19%	1%	35%
Subsistence farm	8%	1%	27%

Interviewed after the harvest, the small scale farmer who ran the one trial site said, “My experience with GM maize has been very exciting. After hearing about this technology for two years I finally had an opportunity to see this technology for myself. Now I can safely say that I believe in this technology and its ability to impact on emerging farmers like myself.”

Discussions with small scale farmers using GM seed suggest that there is a wide acceptance of the technology in areas that experience heavy insect infestation, coupled with a pragmatic evaluation of the input costs and savings where only periodic insect infections are experienced. The studies have indicated that the benefits of improved conventional planting material (hybrid and open pollinated) are making significant impact on harvests in the study areas. This supports the belief that genetic modification is a tool to add benefit to the already available, improved germplasm and agronomic practices. Access to improved planting material may provide the biggest boost to African small scale farming success in the short term without major changes to traditional farming methods. In time, both improved GM planting material and improved, appropriate changes to farming methods are expected to add additional advantage to developing farming communities.

Bt potatoes

The latest GM crop being tested for use by small scale farmers in South Africa is insect resistant potato. This crop was developed by Michigan State University and has performed well under South African growing conditions, offering significant protection against potato tuber moth. The results of the first three years of trials have indicated that the improved crop will benefit small scale farmers, the target group. Figure 1 indicates a strong level of protection in GM potato events (G2 and G3) with 100% resistance against potato tuber moth larvae in the 2004 Western Cape trial. The researchers conclude that the GM lines will withstand severe attacks of the potato tuber moth in this area. In addition, the trial results have triggered considerable interest from commercial farmers who are keen to have access to the new technology in commercial planting material.

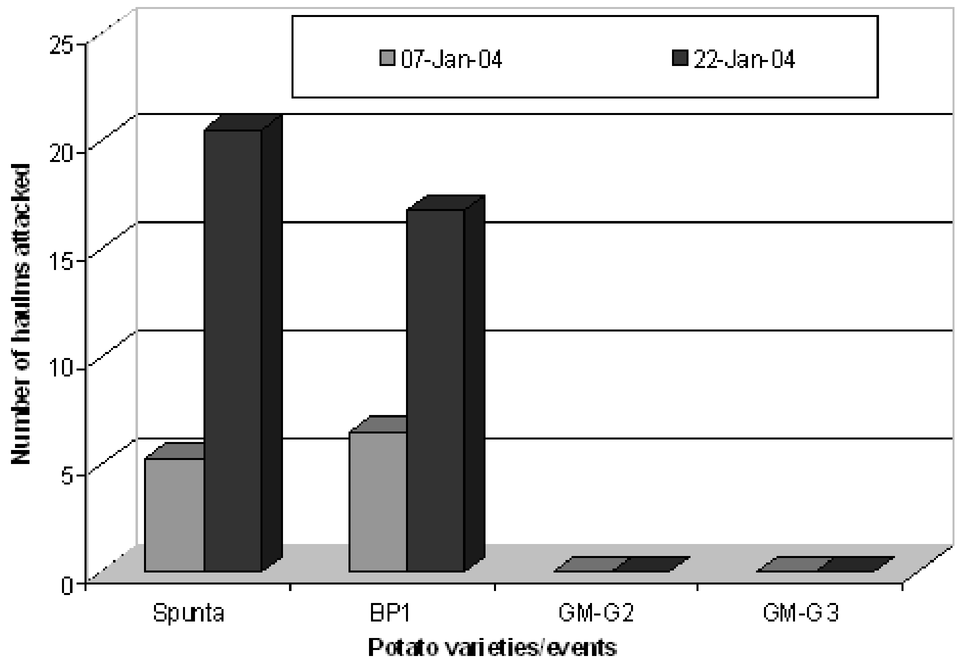

Fig 1. The mean number of haulms attacked (N=25) by potato tuber moth larvae during GM potato trials in the Western Cape in 2004. (Lombard et al. 2004.)

The Agricultural Research Council of South Africa is currently undertaking a four year research project to evaluate the safety of these GM events and to transfer the genes into local, preferred small farmer planting material. The project is also negotiating use of the intellectual property (IP) rights associated with the insect resistant potatoes; investigating viable distribution channels for the improved planting material and encouraging public response to this technology at a national and regional level.

Overview of benefits and risks

In reviewing the benefits and risks of the GM crops in South Africa, extensive biosafety review has identified minimal risks for each approved crop and identified management conditions needed to minimize harm. The major areas of review include environmental impact (including human health), social impact, economic impact and national priorities. The benefits of the approved commercial GM crops are largely accrued by the farmers who record easier management, less pesticide use, less labour and lower production costs as important factors for adoption. The multinational companies that own or license the new genes and technology benefit from a return on investment linked to intellectual property (patents, plant breeder’s rights).

The public sector benefits from input into local research. This brings funding for GM development, technology transfer into local germplasm, greenhouse and field trials and the collection locally of food safety and environmental impact data. These data are needed for applications for general release approval. Local consumers also benefit from the approved GM crops, but these benefits are less publicized and less tangible. Any decrease in the use of broad spectrum pesticides means less impact on non-target animals and lower pesticide levels in food and water. Improved production means less land is needed for farming, enabling the conservation of natural vegetation. Lower production costs should extrapolate to lower food costs and improved production should ensure greater wealth in farming communities and a more stable food supply.

Lessons learnt in GMO technology transfer to Africa

Transferring crop biotechnology to Africa is not only a scientific exercise. There are cultural, political and social aspects that are often overlooked and may be the major stumbling blocks to success. One of the frustrations of local recipients is the top-down approach taken by donors of technology. This occurs where donors have promising new technology and, understandably, want to share it with developing country communities. Arriving with a project proposal, donors are often confused by the lack of enthusiasm and slow progress in negations to run the required trials. From a local perspective, the African researchers have identified a prioritized list of farming constraints in consultation with local farmers and the donated technology may or may not address constraints on this list. Understanding this list and how the technology will benefit identified constraints will facilitate more effective and acceptable technology transfer to the region.

In addition, the successful agricultural technology transfer projects have not focused on the science only. They have included issues of farmer consultation and acceptance, affordability, distribution to farmers and market access. Included in this is understanding the socio-economic constraints in African farming areas and being sensitive to traditions of the area.

The sustainability of public agricultural research facilities in Africa is a major constraint in agricultural development. While building new facilities is frequently justified by donor agencies as extending the local capacity, the impact on research in general is often overlooked. Building onto existing scientific expertise and infrastructure appears to be a far more acceptable method for technology transfer to the region and donors and partners are encouraged to consider this in their planning.

Another challenge is the negotiation of the biosafety processes in each country, all with variations on the general approach to risk assessment and decision making. Successful technology transfer will require a functioning biosafety process in the target country. This is currently only available in five African countries. Success will also require an understanding of these systems, their complexity, and the demands of regulators who are still inexperienced and learning to balance functionality with public acceptance. At present this takes considerable time, money and perseverance.

Future opportunities

There is general consensus that biotechnology will not provide all the answers to the agronomic constraints experienced in African food production systems. While some of the Western technology may be appropriate, many of the solutions in the future will come from African research laboratories focused on African constraints. To this end the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) has had its first call for research proposals that will apply modern biotechnology to local agricultural needs. These proposals include the use of GM technology and the use of tissue culture, molecular markers and molecular breeding. South Africa has a national biotechnology strategy that supports the local development of biotechnology products that will help address national priorities such as sustainable development, food security, job creation and wealth creation. Other African countries are developing these strategies to help harness the potential value of biotechnology.

In the South of the continent the major constraints are pests and diseases, poor soils and insufficient water. All of these issues are being addressed internationally for important commodity crops, but regional research is focusing on solutions for important local constraints and local crops, often termed ‘orphan crops’, because their unimportance in the global commodity sector leads to little private or public investment.

In West Africa the crop production constraints include abiotic factors such as low soil fertility and, further north, poor rainfall. Biotic constraints, such as bacterial, fungal and insect pests and poor quality germplasm, are common. International research organisations have made progress in breeding and selecting improved germplasm for the region (e.g. the new cowpea varieties developed by the International Institute for Tropical Agriculture), but few of these have been effectively distributed to local communities and sustainable distribution mechanisms remain a problem.

In North Africa agricultural biotechnology has been spearheaded by Egyptian public agriculture undertaking considerable research and field trails with GM crops. Development of the tuber moth resistant Spunta potato was aimed at Egypt, but concerns about negative impact on exports to Europe led to a decision not to commercialize the new, improved variety (http://www.iia.msu.edu/absp/research.html). In recent years Tunisia has initiated new biosafety laws and appears intent on pursuing biotechnology to boost local crop production. It is not clear how they have addresses the impact this may have on their vegetable exports to Europe.

Assisted by internationally funding agencies, African public research is being focused on important commodity and orphan crops with a number of multinational projects on:

- marker assisted breeding and trait identification
- virus resistance in maize, cassava and sweet potato;
- fungal tolerance in banana, millet, sorghum and open pollinated maize;
- insect tolerance in potato, maize, cowpea and sorghum and
- drought tolerance and *Striga* control in maize.

As much of the best germplasm for the continent resides in public institutions, it is possible that these projects could make rapid progress towards providing affordable, improved planting material for the continent's farmers.

Constraints to accessing benefits

There are two major constraints to accessing the benefits of GM technology in developing countries. The first is the current, strong and targeted anti-GM campaign being waged by activist groups and aimed at creating a distrust of GM crops and the companies that develop them. This makes it difficult to run field trials and difficult to ensure a stable market for GM produce, even for products developed for small farmers with public funding.

The second is the overly precautionary approach being encouraged in biosafety decision-making systems. These risk review frameworks are often unable to respond to the level of risk posed by individual GM crops and so impose the most stringent review and development requirements even on activities that pose little or no identifiable risk to the environment, including human health. While this has slowed private development of GM crops, its most devastating impact will be on public research. Products produced by local scientists to address local constraints in orphan crops will buckle under the delays and costs of unnecessarily complex decision-making processes.

One of the earlier constraints to accessing GM technology in Africa was the paucity of biosafety review systems able to assess the safety of GM trials, provide permission for such studies and monitor compliance with the necessary risk management conditions. This constraint is currently being addressed by the UNEP/GEF (United Nations Environmental Programme/ Global Environment Fund) programme that is facilitating the development of biosafety systems in most African countries. This programme will be expanded to help countries implement their biosafety systems and to encourage regional collaboration in risk assessment and risk management. Decisions on whether or not to use GMOs will be taken on a case-by-case basis at national level, supported by regional technical assessment of risks and public input (Morris and Koch, 2002).

Societal conflict with IPR

There is still considerable misunderstanding of the role and impact of intellectual property rights (IRP) systems in the development and implementation of GM crops. Much of this has been obfuscated by activist misinformation, the absence of clear rebuttals and explanations on behalf of IPR experts and the low level of IPR development in most African countries. As long as the misinformation prevails, the perceived exclusivity protected by IPR will remain a popular and effective tool for anti-development activism. Understanding and working with IPR systems is an important skill lacking in many African government departments tasked with decision making on GMOs. Keeping this technology separate from other new developments, like industrial, information and communication technologies, prevents the shared learning that could address both the concerns and misinformation about the role of IP protection in biotechnology.

Conclusion

Just as an application of well rotted cow manure will boost harvest in marginal lands, the planting of genetically improved material has a marked positive effect on most farmers' yields. Whether this material is genetically modified, open pollinated or hybrid, it benefits from having the genetic background best suited to the local growing conditions. Existing experience with GM crops indicates that appropriate, improved planting material has a significant beneficial impact on small scale and subsistence farmers in South Africa and there is no reason why this benefit could not extend throughout the continent.

The major constraint to using GM crops in Africa is the persuasive mass of misinformation about the technology. This focuses on unsubstantiated claims about its negative environmental impact, its detriment to human health and its manipulation by multinational companies to control food production and, therefore, Africa. Only as scientists, regulators and the public experience the crops firsthand will they be able to break out of this coercion and make their own informed decisions about which GM products are suited to Africa and which are not.

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