Biotechnology and small-scale farmers: an industry viewpoint

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Worldwide, 1.4 billion people live in poverty – of whom 1 billion are in rural areas. The problem is particularly acute in rural sub-Saharan Africa, where more than 60 per cent of the rural population experience conditions of poverty. Recent reports show that issues of poverty can be best tackled by investment in the agricultural sector, with GDP growth in agriculture contributing twice as much to poverty reduction as any other sector.[1,2] From a global perspective, the combination of enhanced productivity and efficiency generated by GM technology already provides a major boost to farmer income. Between 1996 and 2009 it was the equivalent of adding over 4 per cent to the economic value of global production of the four main crops of soya beans, corn, cotton and canola.[3]

About 16 million farmers grow over 160 million hectares of GM crops in 29 different countries according to figures published in 2012, and over 90 per cent of these were resource-poor farmers.[4] Future projections made by the agricultural biotechnology industry indicate that advances in GM technology will have particular relevance for areas where drought is a common occurrence and access to irrigation is limited. Commercialisation of drought-tolerance technology, which allows crops to withstand periods of low soil moisture, is anticipated within five years.

Just under half of the land grown with GM varieties is in developing countries[4] – an area equivalent to the surface area of Ghana, the Ivory Coast and Burkina Faso put together. In the African continent commercialised GM crops include maize, cotton and soya beans, with the number and diversity of crops increasing all the time. Trials are currently in progress on sorghum, bananas and cassava, while other developing countries grow GM squash, papaya, tomato, sweet peppers and oilseed rape. Resource-poor farmers report that the technology increases yields through greater pest and disease resistance, and this results in lower machinery and fuel costs. But it also has other benefits.

More efficient land use and food security

The amount of arable land available for agriculture worldwide is declining, especially in the developing world. Research from the United Nations estimates that more than 70 per cent of land available in sub-Saharan Africa and Latin America already suffers from severe soil and terrain constraints. With a growing population, there is little doubt that crop productivity has to increase. Unsurprisingly, the UN estimates that 80 per cent of the required rise in food production between 2015 and 2030 will have to come from intensification in the form of yield increases and higher cropping intensities.

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Productivity gains from the application of industrial biotechnology in agriculture have had a big impact on its ability to keep pace with global demand for commodities. If such crops had not been available to farmers in 2009, maintaining global production would have required additional plantings of nearly 3.8 million hectares of soya beans, nearly 6 million hectares of maize, nearly 3 million hectares of cotton and 0.3 million hectares of canola. Between 1996 and 2009, 229 million tons of additional food, feed and fibre were produced thanks to the use of GM crops. Without this, it is estimated that an additional 75 million hectares of conventional crops would have been required to produce the same tonnage.[3] Some of these additional hectares could have required fragile marginal lands, which are not suitable for crop production, to be ploughed and for tropical forest, rich in biodiversity, to be felled.

Practical benefits to farmers

Some of the benefits of seed technology uptake are tangible; others are aspirational. For example, for 80,000 farmers in Burkina Faso working an average of 3 hectares, the advent of GM cotton has meant a huge reduction in the existing use of insecticide,[5] where up to 18 sprays may be required in a particularly bad season. There has also been an immediate and substantial yield increase as well as reduction in costs, harm to the natural environment and poisoning of the farmers and local population.

In other cases, such as the development of disease-tolerant bananas in Uganda, it remains a work in progress. In central Uganda, one of the main banana-growing regions, banana *Xanthomonas* wilt (BXW) hits up to 80 per cent of farms, sometimes wiping out entire fields. To get rid of BXW, it is necessary to dig up and burn the affected plants, disinfect all machinery and tools and allow the ground to lie fallow for six months before replanting. For small-scale farmers, leaving their gardens lying empty for as long as this is not an option so they switch to other crops.

The International Institute for Tropical Agriculture (IITA) and the African Agricultural Technology Foundation (AATF) have been developing a GM solution to the problem of BXW, in conjunction with a Taiwanese biotechnology institute, Academia Sinica (AS). The institute has issued IITA and AATF with a royalty-free licence to use a new gene technology known as hypersensitive response assisting protein (HRAP). Academia Sinica successfully transplanted the sweet pepper HRAP gene into the other vegetables where it produces a protein that kills cells infected by disease-spreading bacteria. This is the first time it has been tried with a banana. Initial trials are promising, with six out of eight strains showing 100 per cent resistance to BXW. Development of wilt-resistant bananas has now progressed to the confined field-crop testing stage.[6]

Regional differences in the response to adoption of GM technologies require close scrutiny because the technology may not be the best solution in all situations. For example, in India, where there has been wide experience of the use of GM cotton, higher yields have been particularly beneficial for women.[7,8,9] Harvesting is primarily a female activity, therefore the women hired to pick the increased production have seen increases of 55 per cent in average income, equivalent to about 424 million additional days of employment for female earners across the whole Indian crop.

GM should not be ignored as a tool for ensuring greater food security and reliability of agricultural supply

There have been complaints from some farmers in Maharashtra that the seeds have not improved yield or met expectations of resistance to pests and

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diseases. Some campaign groups have interpreted this as a cause of increased suicides among farmers who have found themselves sinking deeper into debt. Yet investigations into any increase in suicide rates have suggested little or no correlation with the use of GM cotton; there have also been increases in the costs of fertiliser, pesticides and other farming supplies together with the effects of years of drought.[10] Clearly, rigorous analysis of research is therefore essential to ensure that the technology is not being oversold and that it is being adopted in the right circumstances and environments.

Investment models that work at all scales

Research on GM crops is currently thriving in Africa, with public–private partnerships looking at everything from disease-resistant bananas to drought-resistant sorghum. But for many crops, there is no obvious payback and an alternative business model is required; quite simply, how do companies overcome the cost of developing a new product when there is little chance of recuperating costs?

If it is a commodity crop such as cotton, technology will have already been developed or partially developed for markets elsewhere in the world, with R&D costs recovered through increased seed prices. The costs of this are high, and the industry's top ten companies invest US$2.25 billion, or 7.5 per cent of sales, in R&D and innovation.[11] But the resultant GM seeds are priced appropriately for each market where they are sold. They may be more expensive than conventional seeds but the resulting savings and higher income potential make them a good investment for resource-poor farmers, through lower pesticide and herbicide costs and more reliable and higher yields.

In other cases, crop traits required for particular environmental, economic and political conditions may not be applicable on a global scale and therefore will not attract the same model of commercial investment. Such projects could not proceed without both investment and an understanding that the payback period might be extremely long. In effect it requires the establishment of public–private partnerships in which companies waive or limit their intellectual property rights to the use of specific genes and transformation techniques, allowing the benefits of this technology to be maximised. Two examples include the Water Efficient Maize for Africa (WEMA) partnership, and the development of biofortified, drought-tolerant sorghum which are described in the essays of Denis Kyetere and colleagues (pp. 51–57) and Florence Wambugu (pp. 45–50).

Conclusion

GM is not a silver bullet, but it should not be ignored as a tool for ensuring greater food security and reliability of agricultural supply in Africa. Seed technologies offer solutions and opportunities to small-scale farmers to improve rather than change fundamentally what they are doing. By meeting their subsistence needs and improving the standard of living of their households, the extra income can increase the purchasing power of farmers and promote local, regional and national economic growth.

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