VIEWPOINTS

Africa's future ... can biosciences contribute?

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Viewpoints: Africa's future ...
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Preface

Preparing a second book after the success of the first, *Insights*, is always risky. However, the time is right for a follow-up, as the continent of Africa remains centre stage in the debate about how to feed not only a continent that expects a doubling of its population by mid-century, but the whole of humanity. Furthermore, science never stands still; ever since *Insights* was published last year, worldwide intellectual and financial investment in plant breeding has opened up remarkable new possibilities that it would be a mistake to ignore and immoral to outlaw.

This second volume reports on other pioneering events. The remarkable personal story of an African woman who, against great odds, grasped an opportunity to set up a seed company to help smallholder farmers in East Africa and beyond. Or the New Partnership for Africa's Development (NEPAD) programme, which works to better understand the genetics of African crops. NEPAD is an African Union strategic framework for pan-African socio-economic development. It is spearheaded by African leaders, and it focuses on poverty, development and Africa's marginalisation at the international level.

Questions have to be asked about the reality of the so-called global food crisis, and when it really began. In fact, one view is that the food crisis is a notion coined by donors' views on food sovereignty, an attempt to promote the right of people to choose their own food system. So, will the new technologies of food production influence trade within and beyond African boundaries, and, for that matter, will trade rather than donor aid be the way forward?

To add to the controversies, it is alarming that humanitarian aid in the form of fortified rice continues to be stalled by organised opposition, and this has continued for years since its conception, through the manifold strictures of regulation, regulation and regulation.

Some will have seen a pre-publication taster of this volume, prepared for a celebratory event – The New Africa: Biosciences and New Shoots – at the House of Lords on 9 April 2014. Now, as our immediate support from the John Templeton Foundation reaches a conclusion, we want to note the transition towards other initiatives with a more expansive volume, all pieces written by experts with a passion to help push development forward and with a commitment to lift poor people out of the poverty trap by making access to food more secure.

Brian Heap
Project Leader
Biosciences for Africa (B4FA.org)

Contents

Golden Rice: at the watershed of the genetic modification debate

Adrian Dubock

Humanitarian Board for Golden Rice/www.goldenrice.org

On 8 August 2013 a field trial of Golden Rice, one of several growing in the Philippines as part of the registration process, was destroyed by a 400-strong group of demonstrators. The Philippine Department of Agriculture (DoA) undertook to identify and prosecute those responsible for the physical damage and loss of data and the abuse of officials. The DoA said "[We have] always been at the forefront of promoting agricultural

"Efforts to lift completely the shadow of death cast by vitamin A deficiency ... in some places still entail a struggle against intractable opposition. The victims who continue to suffer under the shadow are mainly the children."[1]

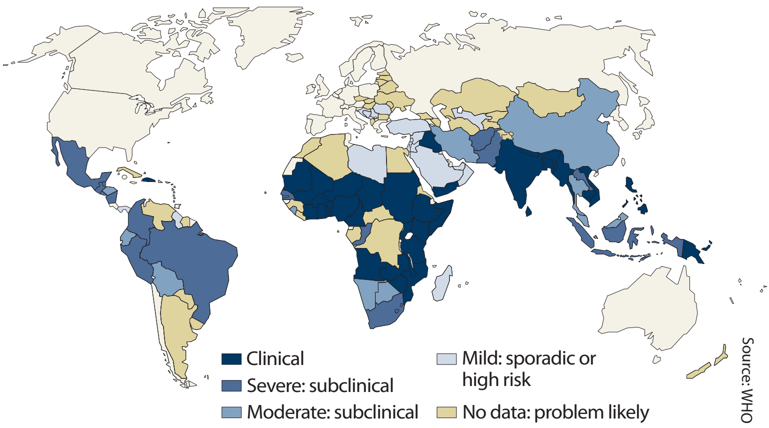
development and growth in the Bicol region. We support conventional, modern and organic farming as means of achieving food sufficiency and sustainability. We are committed to providing Filipinos sufficient, safe, affordable and nutritious food. Thus, we are an active partner for rice research (including Golden Rice) and other projects which have complied with national biosafety regulations."

What started as a humanitarian project to help the disadvantaged in less developed nations had become the worldwide focus of an ideological conflict. How had this happened and who was responsible?

Vitamin A deficiency is a killer

Food must provide a source of macronutrients, carbohydrates, protein and fats. Also extremely important for human health are micronutrients including minerals (such as iron and zinc) and vitamins (such as vitamins A, C, D and the vitamin B complex).

Public health importance of vitamin A deficiency, by country



Mortality: vitamin A deficiency compared to other major killers, 2010

Cause	Annual mortality worldwide (millions)
Vitamin A deficiency	1.9–2.8
HIV/AIDS	1.8
Tuberculosis	1.4
Malaria	0.7

In humans, vitamin A is essential for healthy skin and mucous membranes, a functional immune system, and good eye health and vision. Vitamin A deficiency is a significant health problem, widespread in the developing world, but which hardly occurs in the industrialised world.

What are available sources of vitamin A? In the diet, animal products such as milk, eggs, cheese and liver are rich sources. No plant contains vitamin A. Animals, including humans, make vitamin A from beta-carotene, a red-orange pigment found in plants, fruits and colourful vegetables.

It has taken about 200 years to understand fully the importance of vitamin A, and how it could prevent or cure many deadly diseases.[1] In comparison with the impact of other important public health problems, the mortality associated with vitamin A deficiency is stark,[2, 3, 4, 5] with 2–3 million children dying annually as a result of vitamin A deficiency, despite existing interventions.

Long recognised as the leading cause of childhood blindness,[6] only during the last 20 years has vitamin A deficiency come to be defined as "a nutritionally acquired immune deficiency syndrome".[1] It mostly affects those whose bodies are under greatest physiological stress: children and mothers. Vitamin A deficiency increases susceptibility to common childhood diseases such as measles, pneumonia, and diarrhoea. Accordingly, 23–34 per cent of deaths among children under five years old, and up to 40 per cent of maternal deaths can be prevented with a universally available source of vitamin A.[7,8,9,10]

Are vitamin A capsules the answer?

Since the 1990s vitamin A capsules have been provided to many at-risk populations. The vitamin A capsule programmes cost around US$ 1 billion a year[2] and have undoubtedly saved millions of lives. Nevertheless, they do not change the underlying vitamin A status of the targeted populations, nor are they sustainable because of the recurring cost. As the World Health Organization (WHO) stated recently[11] [vitamin A capsule supplementation programmes] "are only initial steps towards ensuring better overall nutrition and not long-term solutions ... Food fortification takes over where supplementation leaves off ... growing fruits and vegetables in home gardens complements dietary diversification and fortification and contributes to better lifelong health."

Notwithstanding WHO's comments, Semba[1] points out that it is almost impossible for young and poor children to avoid vitamin A deficiency through eating vegetables and fruit alone as a result of the low bioavailability of the beta-carotene within them. Adding vitamins or minerals to foods – food fortification – also has its drawbacks. It requires industrial food processing, food packaging and distribution infrastructure. All add incremental cost and risk remote and marginalised or impoverished families not benefiting.

Biofortified food, a new way forward for the 21st century

Conversely, biofortification aims to increase the synthesis or accumulation of micronutrients by the staple food crop itself, so that all parts of the consuming population can benefit, in the most ideal case without incremental cost.

Vitamin A deficiency mostly affects those whose bodies are under greatest physiological stress: children and mothers.

Vitamin A deficiency is particularly problematic where the staple food is rice, as white rice is almost totally carbohydrate and contains no carotenoids. Rice provides around 80 per cent of the carbohydrate daily for half the world – about 3.5 billion people – and is the staple crop in most of Asia. Even in Africa, rice is becoming more and more important: imports are the fastest growing of all food crops, and efforts are underway to increase local production.

Almost 30 years ago, shortly after the dawn of genetic engineering of crops, Peter Jennings, already a famous rice breeder, suggested that rice with yellow endosperm instead of white would be useful to combat vitamin A deficiency. This idea eventually led, 15 years later, to the publication of a landmark paper.[12]

The teams of Professors Ingo Potrykus and Peter Beyer working in Germany and Switzerland respectively had inserted three genes of interest into the rice genome of about 30,000 genes, activating the beta-carotene biosynthetic pathway in the endosperm.[13]

Golden Rice is the first purposely created biofortified crop. As there was no naturally yellow rice to improve through breeding, only a genetic engineering approach had a chance of being successful. The colour of Golden Rice very obviously widens consumer choice, without words or special packaging.

A novel agreement to fulfill an altruistic vision: Golden Rice

In 2001 the inventors of Golden Rice completed a novel transaction.[14,15] Professors Potrykus and Beyer licensed their technology to Syngenta for commercial uses. In exchange Syngenta agreed to support the inventors' humanitarian project, including technology improvements subsequently made by Syngenta scientists.[16] It was a field trial of this Golden Rice, which now includes a maize gene and one from a common soil bacterium to enhance beta-carotene levels, which was recently destroyed in the Philippines.

There has been much misinformation and misunderstanding about Golden Rice. The inventors, who are still closely involved with the strategic management of their project, aim to make the Golden Rice technology a public good, free of any cost or licence fees, available only in public-sector rice germplasm, and developed only by public-sector institutions. There will be no charge for the nutritional trait within the seed to smallholder farmers who sell locally (most rice is consumed close to where it is grown). No individual or organisation involved with the development of Golden Rice will benefit financially from its adoption.

In the Philippines, the International Rice Research Institute was the inventors' first licensee in 2001 and their breeding work is already largely complete. A regulatory data package is being developed for Golden Rice with funding principally from the Bill and Melinda Gates Foundation and involving work at the Donald Danforth Plant Science Center, USA. The data will subsequently be provided free of charge to each country's regulatory agencies.

Golden Rice seed is available to public-sector rice-breeding institutions in less developed countries where rice is the staple and vitamin A deficiency endemic. Supply is subject only to national and international regulations, and simple and free agreements. Then using conventional breeding techniques the nutritional trait can be introduced into any locally adapted and

There has been much misinformation and misunderstanding about Golden Rice.

preferred variety of rice so that its agronomy, preparation and taste will be the same. Farmers will subsequently, initially using seed from their national seed supply system, be free to plant, harvest, save seed, and locally sell Golden Rice as they wish. There is no reason Golden Rice should cost any more than white rice to the farmer or consumer, and consumer benefit is expected from its health-promoting properties.

The commitment of the public, private and philanthropic sectors to the crucial humanitarian-driven invention and development of Golden Rice has been impressive.[17] Support has been forthcoming over the last 25 years from a variety of sources including the European Union, Switzerland, India, Philippines and Bangladesh, the Rockefeller Foundation, USAID, Syngenta Foundation and, since 2011, the Bill and Melinda Gates Foundation. But in comparison with investment targeting other public health problems, the costs have been tiny.[18] For example, in 2012 the audited financial statements of the International Rice Research Institute showed an annual spend of less than US$ 2.7 million on Golden Rice.[19] Estimates have calculated the value of conservative adoption of Golden Rice in Asia as adding between US$ 4 and US$ 18 billion to Asian GDP annually.[20, 21]

Will it work and is it safe?

In adults[22] (in the USA) and most importantly children[2] (in China), careful and sophisticated research has shown that the beta-carotene in Golden Rice, following only a single meal, is very efficiently converted to vitamin A by the human body. Only a few tens of grams of dry Golden Rice, when cooked and consumed daily, is expected to combat vitamin A deficiency and save life and sight. The results show that Golden Rice "may be as useful as a source of pre-formed vitamin A from vitamin A capsules, eggs, or milk to overcome vitamin A in rice-consuming populations".[2]

In some countries, for example India, rice is seldom consumed without some oil or fat. In others, for example China, this is not always the case. The same research group has also investigated the effect of fat in the diet on the bioconversion of beta-carotene in Golden Rice to retinol. Preliminary analysis, which is subject to confirmation, shows little, if any, significant effect.[23]

The only way in which Golden Rice differs from white rice is that the endosperm contains carotenoids, principally beta-carotene, and that genetic engineering techniques were used to create it.

At the levels found in food, beta-carotene is a safe source of vitamin A.[24,25] At these physiological doses consumption of beta-carotene over several years has no adverse health effects.[26,27,28,29]

There is no evidence that genetic engineering techniques are harmful.[30,31] Golden Rice, only because it was created using genetic engineering techniques, has to complete exhaustive tests to prove its safety to humans and the environment before being registered on a country-by-country basis for use. After registration, its use as a food crop will be a decision for individual governments who will determine how quickly it is offered to that country's farmers and consumers for them to adopt.

The development process for Golden Rice is furthest advanced in the Philippines where millions of people suffer the effects of vitamin A deficiency, and where, incidentally, the government of the Republic has had significant nutrition improvement policies in place since the 1940s. It would be unsurprising if the Philippines became the first of many countries to adopt Golden Rice for the benefit of local farmers and consumers. First registrations are expected within the next 12 months.

Golden Rice, because it was created using genetic engineering techniques, has to complete exhaustive tests to prove its safety to humans and the environment.

Continuing research will clearly be necessary, after registration, to fully understand the benefits of Golden Rice to public health. Will regular Golden Rice consumption reduce the population's morbidity and mortality associated with vitamin A deficiency as expected, and as it was created to do? Of particular interest are neonates (babies under a month old). Vitamin A capsules are only recommended for children of six months and older,[32] and very young children do not consume solid food. These children are the most vulnerable to vitamin A deficiency: neonate deaths in 2011 accounted for 43 per cent (increased from 36 per cent in 1990) of all deaths among under five-year-olds.[33] Can a good source of vitamin A, such as Golden Rice, when part of the staple diet, improve the mother's vitamin A status, benefiting her health, and simultaneously via the placenta and breast milk increase the baby's resistance to disease, and reduce neonate and child mortality?

Opposition

In 2001 Greenpeace, who have long opposed all genetically modified crops, said a breast-feeding woman would have to eat 18 kilograms of cooked Golden Rice daily to obtain any benefit. In 2012 Greenpeace were again extremely critical – not surprising in the light of their 2001 position – when research was published showing that only 100–150 grams of cooked Golden Rice could provide 60 per cent of the recommended daily allowance of vitamin A for a child aged six to eight years.[2]

Criticism of this internationally very important research conducted in China is paradoxical since China, despite its rapid economic development, is still the home of hundreds of millions of very poor rice-consuming people, and where around 60 per cent of the rural population and 30 per cent of the urban population suffer from vitamin A deficiency, with 9 per cent of all children in the country severely affected.[34]

To answer the question "who was responsible for the destruction of the Philippine field trial?", we await with interest the results of the Philippine Department of Agriculture's investigation and the court's decision.

Much is at stake here, as illustrated by the former lead anti-GMO campaigner for Friends of the Earth Jens Katzek, who reported last year that his colleagues, who are implacably opposed to genetically modified crops stated: "If we lose the Golden Rice battle, we lose the GMO war."

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Victoria Seeds: changing lives through wealth creation

Josephine Okot

Victoria Seeds Ltd

It was in 2004 that I saw an opportunity to establish a company offering a full range of seeds, and was inspired to create Victoria Seeds. My aim was to deliver quality seeds to smallholder farmers in Uganda to improve both yields and livelihoods. At the time, I believed the development and dissemination of high-yielding seed varieties was the primary technological force for driving up crop productivity – hence the country's need for a robust seed market.

The majority of yields achieved by Ugandan farmers were much lower than those realised by research activities.

Accessing start-up capital from a commercial bank was out of the question because I had

We really strive to make sure that as we grow, we also have a very strong corporate social responsibility component.

no credit history, but this was not going to make me give up. I was passionate, believed in myself and, as a result, secured a small bank loan guarantee from a project under the United States Agency for International Development (USAID). With that limited amount of capital and a workforce of five people, our journey began.

The source of my initial idea was the observation that the majority of yields achieved by Ugandan farmers were much lower than those realised by research activities – at times one third lower. This underperformance could mainly be attributed to the limited availability of improved seed and the absence of extension services. I was also driven by the desire to try to make a difference to the lives of rural women in Uganda, since my own father had died when I was only six years old, leaving my mother – who was a school teacher – to bring up seven children on her own. While growing up, I had the experience of seeing women holding their families together, heading households during civil war, and taking responsibility for most of the agricultural production in Uganda.

A key growth accelerator for Victoria Seeds was the policy environment at the time of our founding. The government of Uganda had just launched the very effective Plan for the Modernisation of Agriculture. Under that policy there was a radical move away from traditional top-down government-led extension services to a privatised demand-led service. A government body – the National Agricultural Advisory Services (NAADS) – was formed to make the appropriate changes, providing a programme of subsidised input supply, and establishing countrywide technology demonstrations for proof of concept. So it was a very inspiring time, since the demand for improved seed was really growing, and there was a domestic market potential of more than 35,000 tonnes.

We are transforming subsistence-based producers into commercial farmers and enhancing the participation of women farmers in off-farm economic activities.

Victoria Seeds made a modest start with 800 tonnes marketed in 2004, reaching an annual figure of 3,000 tonnes by 2010. During the 2010 season, agro-dealers queued at our company gate to buy seed – making seed trade truly exciting. Demand for hybrid maize seed grew from just 100 tonnes per annum in 2000 to more than 2,000 tonnes in 2012. The private sector had been entirely dependent on the national programme for new hybrid maize varieties in early 2000, but by 2013 this had changed, with the National Variety Release Committee releasing and registering our own first hybrid maize varieties – Victoria 1 and Victoria 2.

Over time, our original business idea has evolved as we have adapted to market opportunities and threats. Our product range has expanded from agricultural seeds (cereals, legumes, oilseeds) to vegetable, pasture and horticultural seeds as well as crop-protection products. Our vision has also broadened in the sense that we had initially focused only on what was right for the economic side of the business. But as time went on we understood from other successful entrepreneurs that, when you focus on factors in addition to financial returns, the rewards are more sustainable and longer lasting. So we have incorporated an explicit social focus into our business model. We really strive to make sure that as we grow, we also have a very strong corporate social responsibility component, which is not generally typical of small- to medium-sized enterprises such as ours.

We ensure that at least 70 per cent of seed-producing out-growers recruited each season are female. In doing so, we are economically empowering women by engaging them in the regional seed industry supply chain and training them

Timeline

2004 Josephine Okot founds Victoria Seeds Ltd.

2006 Research and product development is underway.

2007 Victoria Seeds is named *Investor of the Year* by the Uganda Investment Authority.

2007 The second seed factory is constructed and commissioned at Gulu, northern Uganda.

2007 Okot is awarded the *Yara Prize for a Green Revolution in Africa* by the Norway-based Yara Foundation.

2008 Okot is nominated *Uganda's Torch Bearer for Millennium Development Goal 3* (to promote gender equality and empower women).

2009 Okot is awarded the *Oslo Business for Peace Prize*.

2010 Focus on capital injection, long-term loans and equity to finance growth.

2011 Victoria Seeds wins an *Africa Award for Entrepreneurship* and diversifies into crop-protection products, becoming a provider of agro-solutions to farmers.

2011 The third seed factory and a sales outlet is constructed and commissioned in Masindi, western Uganda.

2012 Construction of a new head office and factory is completed at the Kampala Industrial Park.

2013 Victoria Seeds is the proud recipient of the *Uganda Responsible Investment Award – Best Seed Company 2013*.

in seed production. We offer appropriate machinery for production and post-harvest work that eases them from the arduous and time-consuming task of using the hand hoe and other rudimentary post-harvest equipment. And we offer input credit and training in entrepreneurship to build their capacity for access to production loans. Overall, we are transforming subsistence-based producers into commercial farmers and enhancing the participation of women farmers in off-farm economic activities.

Engaging farming households in contract production with a guaranteed market was seen to reduce domestic violence by 60 per cent.

During 2012, Victoria Seeds spent US$ 1.8 million on seed procurement from 707 smallholder farmers under contract farming, enabling them to achieve annual income levels greater than those of primary school teachers. Furthermore, our annual report noted that engaging farming households in contract production with a guaranteed market reduced domestic violence by 60 per cent.

The sustained production of seed of appropriate genetic, physiological and phyto-sanitary quality, and farmers' timely access to it are the basic features of a well-functioning seed system. Cost-benefit analysis of open-pollinated varieties of maize compared to hybrid maize production in Uganda shows an average mark-up of 60 per cent for hybrid maize and only 20 per cent for open-pollinated varieties grown under optimum conditions. Hybrid vegetable mark-ups can be as much as 80 per cent of production costs. These statistics are powerful motivators for the adoption of high-input farming by smallholder farmers, and so we offer crop demonstrations to Uganda's estimated 5–6 million farming-dependent households.

Another growth driver has been the numerous accolades we received for our work from 2007 onwards , such as the Yara Prize for a Green Revolution in Africa, the Investor of the Year prize from the Uganda Investment Authority, and Africa Awards for Entrepreneurship, which cited Victoria Seeds as one of the promising enterprises in Africa – not in terms of revenue, but because it had the building blocks for a successful business, including the necessary management system for ensuring ethical business practices and for supporting, promoting and mentoring women. Our most recent award was for Best Seed Company 2013. These commendations have given us the will to continue doing what we do and provided us with valuable credibility.

Challenges

Some of the challenges we have encountered have been linked to the deterioration of the Ugandan policy environment. Weak regulatory enforcement has resulted in the uncontrolled supply of counterfeit seeds and crop-protection products, which has really undermined our market. From a business standpoint we have seen our profits stall, and the seed market has been seriously hurt over the last three years by the inability of the National Seed Certification Service to prevent fake products from entering the market. In addition, even though the situation has improved since we started, financial products structured for agribusiness are still limited and access to finance is both expensive and erratic. For instance, in 2011, inflation driven by food shortages drove the commercial bank interest rate up to 30 per cent.

The seed industry needs more flexible products from development banks – ones that factor into the terms of loans the market and environmental risks that have a particular impact on agribusiness.

The seed industry needs more flexible products from development banks – ones that factor into the terms of loans the market and environmental risks that have a particular impact on agribusiness, for example adverse weather patterns such as drought or flood. If this is not done, then entrepreneurs are left to bear the risk of climate change, which will stifle the entrepreneurial spirit and in adverse circumstances may lead to collapse of the industry.

Despite these concerns and constraints, our team of professionals is proud to have grown Victoria Seeds into Uganda's largest seed house in terms of asset value, exporting beyond national borders to the regional market.

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Changing the lives of smallholder farmers: a personal journey

Paul Seward

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My personal viewpoint has evolved from my experience of working for 20 years, most of them with Farm Input Promotions Africa Ltd (FIPS-Africa), to assist smallholder farmers in East Africa to become food secure. My journey has taken me to remote and diverse parts of the region to work with and learn from numerous farmers.

The challenge of changing the lives of smallholder farmers is immense.

I have been privileged to work with the support of donors and innovative and dynamic colleagues who have helped design our methodology. There has been no text book to guide us: we have learnt from careful observation, innovation and chance findings. In this essay, I recall some key events that helped to shape our methodology, which is now being implemented at scale to improve the livelihoods of hundreds of thousands of smallholder farmers in Kenya, Tanzania and Mozambique.

To increase farmer adoption, we needed an innovative advisory service that offered farmers a choice of farm inputs, that disseminated them equitably, and that taught farmers how to use resources in the best ways.

The challenge of changing the lives of smallholder farmers is immense. A typical farmer does not produce enough food, and her family goes hungry for up to six months per year. She cultivates by hand small plots of land ranging in size from 0.1 to 2 hectares. She grows a wide range of crops, including maize, sorghum, millet, rice, beans, cowpea, potato, banana, cassava and sweet potato, but typically plants low-yielding and late-maturing varieties, which are also susceptible to disease. Her soils have become infertile, she does not have enough manure to improve soil fertility, and she does not use inorganic fertiliser. Rainfall is becoming increasingly poorly distributed, and her crops often dry up before maturity. She complains that she is rarely visited by an extension officer, and does not know how to plant her seeds and use fertiliser the right way. She is risk averse, so only wants to try new varieties on small areas.

Improved varieties

To increase crop productivity, farmers need to use improved crop varieties and manage them well. Improved varieties of farmers' most important crops – including maize (hybrid), sorghum, millet, beans, cowpeas, greengrams, potato, cassava and sweet potato – have been bred for tolerance to disease and drought, and for early maturity and high yields. However, they are not locally accessible. A farmer has to travel a long distance at great expense to buy them, only to find that they are packed in large, unaffordable bag sizes.

To increase farmer adoption, we needed an innovative way of offering farmers a choice of farm inputs, that disseminated them equitably, and that taught farmers how to use resources in the best ways. This service also had to be self-sustaining to ensure that farmers continue to access the inputs and advice they need to become food secure with little or no external funding.

A self-sustaining advisory service

The Ministries of Agriculture in African nations that are short of extension workers and resources for offering advice need a complementary self-sustaining advisory service.

In Kenya, we used to employ staff to advise farmers but they would leave us at the end of a project. One of our ex-employees, however, established a business to sell the seed for which she had created demand. She found that self-employment was more profitable than employment. As a consequence, we developed the self-employed village-based advisor (VBA) concept.

VBAs are hard-working, selfless farmers who are trusted by other farmers in their villages. We teach them good agricultural practice, how to reach all the farmers in their villages, and how to make money from input supply and related services.

This advisory service is also required to be self-sustaining to ensure that farmers continue to access the inputs and advice they need.

Using this concept, an employee now supervises up to 50 VBAs, each of whom disseminates inputs to between 200 and

500 farmers. Most importantly, hard-working VBAs are able to generate enough income to continue their activities when donor funding comes to an end.

The promotion of diversity increases the likelihood of farmers meeting their dietary requirements from their own farms.

Offering farmers a choice

Initially, our donors – the United States Agency for International Development (USAID), the Rockefeller Foundation and the UK Department for International Development (DfID) – requested us to promote improved disease-tolerant varieties of maize from emerging seed companies, along with improved fertiliser blends.

In 2006, in response to their demands, we also distributed improved varieties of sweet potato to farmers in several villages in western Kenya. After two years, we were surprised to find that about 30 per cent and 100 per cent of the farmers had adopted the maize and sweet potato varieties, respectively. Farmers told us that maize was difficult to grow: it required expensive seed and fertiliser, and was sensitive to drought and the striga weed. In contrast, sweet potato varieties such as Mugande, SPK004, and SPK013 from KARI-Kakamega, were early-maturing, and yielded well without fertiliser. Farmers needed only the planting materials, which were easy to multiply and conserve in their own environment.

Another example of offering farmers a choice arose in 2009. Having observed high mortality among indigenous chickens due to Newcastle disease (ND), we started to offer a vaccination service. A simple drop of a thermostable vaccine, costing only a few cents, in a valuable chicken's eye, provides immunity for four months. Following vaccination, the women who owned the chickens reported a large and rapid increase in bird numbers. Chickens and eggs improve

All farmers are able to experiment with a small quantity of seed of a new variety with little risk.

the nutrition of families, and are also sold to pay for school fees, essential household supplies, and even seeds and fertilisers. Most importantly, even the poorest women benefit from this activity.

VBAs now simultaneously offer farmers a chicken vaccination service and improved varieties of their most important cereal, legume, root or tuber, vegetable, banana and fruit-tree crops. The promotion of this diversity not only increases the likelihood of farmers meeting their dietary requirements from their own farms, but also enables VBAs to generate income from their activities throughout the year. Furthermore, the simultaneous dissemination of a wide range of technologies by VBAs has the potential to reduce the cost of development work significantly and brings into question the need for a large number of projects working on a single-commodity value chain.

The small pack

In 1996, I discovered by chance that resource-poor farmers in Siaya County, in Kenya, who had never before used fertiliser, wanted to purchase it in small 100-gram packs costing only US$ 0.1. Thousands of farmers purchased the small packs, experienced the benefits on their farms in an affordable way, and then asked for larger quantities (1–10 kilos) to improve food security. This work catalysed the opening of Agrovet shops in almost every market centre in the county to supply farmers with fertiliser and seeds.

A small pack is now used by VBAs to disseminate improved varieties of farmers' most important food crops. All farmers, whether they are male or female, wealthy or poor, are able to experiment with 25–100 grams of seed, or 30 cuttings or vines of cassava or sweet potato of a new variety with little risk.

For the hybrid maize, farmers who have succeeded with their small pack request their VBAs to sell them the seed in larger quantities. For self-pollinated crops such as sorghum and cowpeas, and for vegetatively propagated crops – cassava, sweet potato and potato – farmers who select the best seed can rapidly multiply their seed to plant over larger areas.

Private-sector seed and fertiliser companies are now using the small pack to promote and sell their products, enabling many more farmers to benefit.

The small-pack approach contrasts with the "lead-farmer" demonstration approach conventionally used by most development agencies, which often causes jealousy amongst neighbouring farmers. The few lead farmers who adopt the new products may lose much of their crop to theft. The 10 kilos of seed typically granted to a lead farmer can have more impact when it is shared in an equitable way between 200 farmers in 50-gram packs.

Teaching farmers appropriately

Inputs in small packs have little effect if used incorrectly. Many farmers in Kenya conventionally place two to five seeds in a hole and, if fertiliser is used, place it directly on top of the seed. This results in low productivity. In 2005, we developed a planting string to assist VBAs teach farmers how to plant maize. It consists of a piece of string 75 centimetres long (to measure the distance between rows), four bottle tops clamped to the string at 25-centimetre intervals (to indicate where just one seed should be placed within the row), and a small card (to measure the distance between the fertiliser and the seed). It can be rigged up in a couple of minutes and costs a few

An impact assessment has shown that our methodology can take all farmers in a village from food deficit to surplus within two years.

cents. This simple and inexpensive tool has helped thousands of farmers to increase their maize crop productivity up to fivefold through better seed spacing and fertiliser placement.[1]

An impact assessment has shown that our methodology can take all the farmers in a village from food deficit to surplus within two years.[2] To date, we have created opportunities for 2,000 VBAs who are assisting about 500,000 farmers to become food secure. This is a start; there is much more to do. We estimate that we need 40,000 VBAs to reach all farmers in Kenya and Tanzania. At little cost, governments, non-governmental organizations and private companies can identify and build the capacity of VBAs to disseminate seeds of improved varieties for a wide range of crops in small packs, and advise all smallholder farmers the best way to use them to help them quickly and sustainably become food secure.

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Why I changed my mind about biotechnology for Africa

Michael J. Ssali

Michael J. Ssali

My wife and I are smallholder farmers in Lwengo District in southern Uganda. A hectare of our land is devoted to banana growing and 5 hectares are under what in our native Luganda language is referred to as *kolono* Robusta coffee. *Kolono* is our corruption of the word cloned, which means vegetatively produced from cuttings of one plant variety. Nine high-yielding varieties of Robusta coffee were identified in the 1980s by a Ugandan plant scientist, Kibirige Ssebunya, and were multiplied by cloning for distribution to

We discovered that it was impossible to sustain or increase production on our farm due to challenges such as new crop diseases and extreme weather events.

farmers. That is how they got their *kolono* name. *Kolono* Robusta coffee varieties have since been much appreciated for their high yields and they are the preferred choice of many farmers.

Coffee is our country's main foreign exchange earner, providing employment to about 6 million people directly or indirectly. Bananas are a staple food crop in central and western Uganda. Statistically, our country is Africa's most important producer of bananas and globally is only second to India. In the eastern and northern parts of the country cassava is a major food crop.

When we had just set up our farm, about 30 years ago, we used to attend seminars organised by non-governmental organisations (NGOs), where we were usually taught about organic farming and the need for minimal use of agricultural chemicals as a way of sustaining the natural fertility of the soil and increasing crop production. We would also sometimes be warned about "fake" seeds – *ensigo enkolelele* – made by scientists and carrying the risk of causing cancers and depleting the soil. We were even warned that the these seeds were to be planted only once and that it would be useless to save seed from the harvested crop for replanting in the next season because the yields would be poor. The aim of the "fake seed producers", we were further told, was to keep us going back to the same people to buy seed every planting season. We had no understanding at all of genetics and plant breeding and it was quite easy to believe what we were told.[1] But we vaguely understood such seeds to be hybrid seed, tissue culture plantlets, genetically modified (GM) crops or biofortified seed, and we developed suspicions about their efficacy and safety.

Uganda is Africa's most important producer of bananas and globally is only second to India.

Over the years, however, we discovered that it was impossible to sustain or increase production on our farm due to challenges such as new crop diseases and extreme weather events that drastically reduced crop yields.[2]

The decline in agricultural production is happening at a time when it is estimated that the world population will rise from the present 7.2 billion to 9.6 billion by 2050.

Banana bacterial wilt disease has reduced the value of Uganda's annual banana crop from US$ 550 million to US$ 350 million, according to Jerome Kubiriba, head of the Banana Research Project. Cassava, also a staple food in East and Central Africa, is under attack by pests and diseases such as cassava mosaic disease and cassava brown streak disease caused by viruses and reducing yields to less than half their potential. Maize production has declined over the years due to prolonged drought, sometimes leading to crop losses of 70 per cent. Other African food crops such as sorghum and groundnuts – as well as fodder grasses like Napier grass – are under attack from diseases and pests, and many such crops have been neglected by agricultural researchers, further aggravating the threat to food security.[3]

Coffee wilt disease has reduced Uganda's national Robusta coffee stock by 55 per cent according to Joseph Nkandu, Executive Director of the National Union of Coffee Agribusiness and Farm Enterprises (NUCAFE). The recently arrived coffee twig borer has caused a reduction of 3.7 per cent in the country's total coffee export and a loss of US$ 18.1 million in 2011 according to the Uganda Coffee Development Authority. The loss is a lot bigger today (in 2014), since the severity of twig-borer infestation is higher, at between 6 per cent and 12 per cent nationwide.

The decline in agricultural production is happening at a time when it is estimated that the world population will rise from the present 7.2 billion to 9.6 billion by

Efforts to apply biotechnology for genetic transformation and improvement of crops to make them disease or drought resistant must be encouraged and supported.

2050, and more than half of the projected extra 2.4 billion people will be in Africa. In Uganda, on average, every woman produces 6.2 children.[4] The continent's productive land is diminishing because of increased population pressure leading to land fragmentation, deforestation, soil depletion, reduced fish stocks and conversion of wetlands.

These issues are not likely to be overcome by conventional farming practices. Africa must think about other options including the application of biotechnology for genetic improvement of its crops to produce the necessary amount of food for its rapidly growing population. Major food and cash crops, as in the case of Uganda, are set for total extinction unless rapid steps are taken to reverse the situation. This is an issue that gives ordinary African farmers like my wife and me sleepless nights, worrying about our dwindling crop. Efforts to apply biotechnology for genetic transformation and improvement of crops to make them disease or drought resistant must be encouraged and supported. The cloning of high-yielding Robusta coffee varieties in the 1980s had already increased production before the arrival of coffee wilt disease, and the recent identification through conventional plant breeding of wilt-resistant Robusta coffee varieties by the National Agricultural Research Organization (NARO), and their multiplication by tissue culture technology at AGT Laboratories in Uganda, is welcome news. The process must be hastened so that the plantlets are available to all interested farmers.

Genetic engineering by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) to prepare drought-resistant maize is ongoing in Kenya.[5,6] GM research is also in progress to introduce genes that give resistance to the cassava mosaic and brown streak diseases and banana bacterial wilt disease but, unfortunately, due to lack of correct information and the activities of some NGOs, most African governments are taking too long to accept GM technology and regulate its use in an appropriate manner.[7,8]

Most African governments are taking too long to accept genetic modification and regulate its use in an appropriate manner.

The British Secretary of State for Environment, Food and Rural Affairs, Owen Paterson, has said recently: "Used properly, the advanced plant-breeding technique of GM promises effective ways to protect or increase crop yields. It can also combat the damaging effects of unpredictable weather and disease on crops. It has the potential to reduce fertiliser and chemical use, improve the efficiency of agricultural production, and reduce post harvest losses."[9] Yet it is the words of a Brazilian soybean and maize producer that I prefer to end with because they come from someone who lives in a developing country which has adopted GM crops in a big way and who knows their value in a practical way: "A good night's sleep: the main benefit from biotechnology to myself."

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Enhancing resistance to coffee wilt disease in Uganda – the conventional way

Africano Kangire

Today, much emphasis is placed on the prospects of using genetically modified (GM) crops to withstand pests and diseases or other environmental pressures such as water stress, and to modify them so that they withstand herbicide treatment that kills weeds. Yet we should not overlook the great strides in overcoming pests and diseases that continue to be made with conventional plant breeding. In recent years, the story of breeding for resistance to coffee wilt disease (CWD) is an important reminder that conventional plant breeding still has a place in the armamentarium of the modern plant breeder.

Conventional plant breeding ... has had a tremendous impact on agricultural productivity.

Coffee contributes about 20 per cent of Uganda's foreign currency earnings and about 64 per cent of earnings from traditional export crops alone.

Conventional plant breeding in open pollinated crops including Robusta coffee (*Coffea canephora* Pierre), which is a self-incompatible diploid,[1] has had a tremendous impact on agricultural productivity over the last decades.[2] This has been based on a process of genetic inheritance through back-crossing and selection for features such as faster growth, higher yields, pest and disease resistance or consumer quality, and has dramatically changed domesticated plant species compared to their wild relatives.

Conventional breeding using genetic inheritance was first discovered by Gregor Mendel in 1865 following experiments with crossing peas, where he provided the first evidence of hereditary segregation and independent assortment.[2,3] According to Manshardt,[4] conventional breeding is better suited for improving many traits simultaneously, or improving traits controlled by many genes, or traits for which the controlling gene has not been identified. The advantage of this breeding is that it is relatively inexpensive, technically simple and free of necessary government regulation. However, it is estimated that with conventional breeding it takes about 7–10 years (or even longer) to complete and/or release a variety of an annual cultivar such as corn, wheat or soybeans.[2] For tree crops such as coffee, it takes much longer – up to 30 years.[5] For this reason, genetic engineering might be applied as a choice to circumvent the shortcomings of sexual reproduction.[4]

The importance of coffee in Uganda

More than 1.3 million Ugandan households derive their livelihoods directly from coffee,[6] the majority of them being rural smallholder farmers. Coffee contributes about 20 per cent of Uganda's foreign currency earnings and about 64 per cent of earnings from traditional export crops alone.[7]

Uganda relies on two types of coffee, Robusta (*Coffea canephora* Pierre) and Arabica (*Coffea arabica* Linnaeus), of which Robusta accounts for 80–85 per cent of the exports by volume and 65–80 per cent of total earnings. However, Uganda has a higher competitive advantage for Robusta coffee production due to the fact that the country's general altitude is higher (more than 1,000 metres above sea level) than that of most countries where the crop is grown, thus conferring exceptionally high consumer quality. The devastation of Robusta coffee by coffee wilt disease (CWD) caused by the fungus, *Fusarium xylarioides* Steyaert, during the last two decades (1990s to late 2000s) led to losses of up to 45 per cent and greatly undermined government efforts to increase coffee production from 3.15 million bags in 2001/2 to 12 million bags by 2007/8.[8]

The coffee wilt disease menace

By 2002, CWD had affected at least 90 per cent of Robusta coffee farms and destroyed more than 45 per cent of Robusta coffee trees all over the country.[8,9] The overall effect was a significant reduction in export volumes, from 4.2 million 60-kilo bags of green coffee beans exported in 1996[10] to 2.0 million bags in 2006.[9] This implies that Uganda could have lost about 50 per cent of the revenue expected from coffee exports as a result of the disease itself or related factors such as farmers' abandonment of coffee production as an enterprise.[11]

Many rural smallholder Robusta coffee farmers were left in abject poverty due to losses in coffee, leading them to change their lifestyles and reduce expenditure on their education, health and food consumption as well as social welfare. As a result, 27 per cent of households liquidated their assets, including land, communication equipment (radios and television), bicycles and large livestock such as cattle, and opted to invest in non-crop farming enterprises to meet household needs such as food, medical expenses or burial arrangements. New ventures included starting poultry farms and purchasing motor bikes to launch transportation businesses.[11]

Coffee-wilt disease also undermined previous research efforts that had developed six high-yielding and good-quality Robusta coffee varieties, popularly known as clonal coffee.[12] However, these varieties may have been inadvertently selected for higher yields without considering their susceptibility to CWD, as the disease had not been reported as a serious impediment to coffee production in the country.

Efforts to manage coffee-wilt disease

The role of research

The Coffee Research Centre (COREC), based at Mukono under the National Agricultural Research Organisation (NARO), played a leading role in correct diagnosis of CWD and in educating farmers to identify early symptoms and then manage the disease.[8,13] Through research, it was established that infected plant parts such as stems, branches, leaves, roots and coffee husks, as well as infected seedlings, were the primary sources of new infection and spreading of the disease to new sites.[8,14] It was also found that the pathogen did not survive for more than two years in infected dead plant parts and soil under field conditions. Besides infected plant parts, the disease was also found to spread through contaminated soil, running water and contaminated tools. Genetic studies of the isolates of the pathogen from different parts of the country confirmed that *F. xylarioides* from

Coffee-wilt disease undermined previous research efforts that had developed six high-yielding and good-quality Robusta coffee varieties.

Uganda belonged to one strain which exclusively affects Robusta coffee.[15,16,17] All this information was utilised in the formulation and dissemination of cultural management strategies for controlling the disease.

Management interventions also included massive replanting of disease-free clonal coffee seedlings by the Uganda Coffee Development Authority.

Cultural control recommendations

Once research had established the mode of transmission of CWD, farmers were massively sensitised and advised to uproot and burn infected coffee trees *in situ*[8,9,13] when the first signs of infection were detected. They were also encouraged not to use farm tools that had been used in infected farms. Together with other stakeholders, coffee scientists went into overdrive to train farmers in Robusta growing areas through farmer-field schools, coffee production campaigns and the training of trainers on cultural methods of CWD management.

Under this arrangement, extension officers and more than 40,000 farmer trainers were informed through participatory research, using farmer field schools in all Robusta coffee growing districts.[8,13,18] This had a multiplier effect, as trained farmers were able to train others by hosting farmer field days with other coffee farmers at their farms, guided by researchers and extension officers. In addition, this was amplified by dissemination of training materials under a regional project funded mainly by the Common Fund for Commodities and the government of Uganda, in the form of brochures and posters prepared in different languages – including English, Luganda, Lusoga and Runyakitara – for extension workers, farmers, primary and secondary schools as well as higher institutions/universities where agriculture is taught. The farmer field schools attracted other players such as non-governmental organisations, who in

It has been estimated that if losses due to coffee wilt disease had been avoided, Uganda would currently be exporting more than 5 million bags of green coffee beans worth above US$ 600 million per annum.

addition multiplied and distributed clean and disease-free coffee planting materials. Furthermore, it was emphasised that organic manures (applied at 20 kilos per tree), mulching and the application of herbicides such as glyphosate (Round-up) rather than using machetes ("slashers") for controlling weeds in coffee plantations could, if significantly adopted, reduce the rate of disease infection and spread.

Management interventions also included massive replanting of disease-free clonal coffee seedlings by the Uganda Coffee Development Authority and information dissemination through coffee production campaigns involving other partners.[8] Over time, coffee production and exports started to improve, rising from the earlier figure of 2.0 million bags to reach 2.73 and 3.15 million bags of green coffee beans by 2011 and 2012 respectively.[6] It has been estimated that if losses due to CWD had been avoided, Uganda would currently be exporting more than 5 million bags of green coffee beans worth above US$ 600 million per annum.

Despite the fact that disease management played a vital role in containing CWD, it was still considered to be a short-term measure: permanent solutions had to be sought. Developing CWD-resistant varieties was therefore deemed the most cost-effective and sustainable option.

Development of resistant varieties

The use of resistant varieties is considered to be the most appropriate, cost-effective and sustainable method of controlling CWD in Uganda. However, it is important that this is done without compromising yield, quality and resistance to other diseases. Since CWD first appeared in Uganda in 1993, the resistance of the available commercial varieties (Robusta and Arabica) had to be ascertained and new varieties developed.[1,16]

The search for Robusta coffee varieties resistant to CWD was initiated at COREC in 2001. This involved screening all coffee germplasm from naturally infected fields and following artificial inoculations in the screen house. In this regard, Arabica coffee was found to be totally resistant to the *F. xylarioides* strain in Uganda but Robusta coffee was significantly susceptible.[1,16]

Using this approach, seven CWD-resistant Robusta clones were identified and released for further multiplication and dissemination to farmers, while more than 1,500 resistant clones were identified through large-scale screening of germplasm using artificial inoculations in the screen house at Kituza;[1] these continue acting as a gene pool for further selection of more multi-lines. The 1,500 clones identified through artificial inoculations were planted in mother gardens at COREC, Kituza, and thereafter were cloned and planted in CWD-infested field trials for further evaluation for other diseases, tree stature and cup and bean qualities. Multiplication of the seven released lines has been going on, using both cloned rooted cuttings and tissue culture, and a number of mother gardens have been established in many parts of the country in order to involve other stakeholders and make the plants available to more farmers. However, the process of generating sufficient planting materials for all farmers in the

The process of generating sufficient CWD-resistant planting materials for the affected households is still a big challenge and will require concerted efforts involving both the public and private sector.

country will take a long time, as this will involve supplying plants to more than 500,000 households involved in coffee cultivation. It has been estimated by the government that Uganda will need more than 200 million plants to rejuvenate its intended production capacity.

The process of generating sufficient CWD-resistant planting materials for the affected households is still a big challenge and will require concerted efforts involving both the public and private sector. To bridge this gap, COREC and UCDA initiated a partnership with the private sector, using one of the most vibrant local laboratories[19] to generate at least 2 million planting materials through tissue culture. In addition, the capacity of private nursery operators as well as the COREC tissue culture laboratory was enhanced for the generation of planting materials by vegetative propagation through rooted nodal cuttings. More planting materials have already been supplied to about 100 private nursery operators distributed throughout the major Robusta coffee-producing regions of the country. Other nursery operators are also being identified to receive plants and be trained to further multiply the planting materials through cloned rooted cuttings.

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Genetically modified crops: how long before Africa benefits?

Graham Brookes

UNEP

The technology of genetic modification (GM) has now been utilised globally on a widespread commercial basis for 18 years and by 2012, 17.3 million farmers in 28 countries had planted 170 million hectares of crops using this technology.[1] Some 90 per cent of these are resource-poor farmers in developing countries.

Genetically modified crops have brought very significant gains at farm level.

During this period, GM technology has delivered important positive socio-economic and environmental benefits for both farmers and citizens in the adopting countries.[2,3,4] These have arisen even though only a limited range of GM agronomic traits – largely herbicide tolerance and insect resistance – have so far been commercialised, and only in a narrow selection of crops (mostly cotton, canola/rapeseed, maize and soybeans).

Genetic modification has made important contributions to increasing global production levels of the four main crops – maize, cotton, rapeseed and soybeans.

There have been very significant net global economic benefits at the farm level amounting to US$ 116.6 billion for the 17-year period 1996–2012, and US$ 18.8 billion in 2012 alone (in nominal terms).[2] These economic gains have been divided equally between farmers in developed and developing countries. Adopting farmers in developing countries have also seen the highest yield gains associated with use of the technology and derived the largest financial gains on a per-hectare basis.

Genetic modification has also made important contributions to increasing global production levels of the four main crops, having for example added 122 million tonnes and 230 million tonnes to the global production of soybeans and maize, respectively, since the introduction of the technology in the mid-1990s.

In terms of key environmental impacts, the adoption of the technology has reduced pesticide spraying by 503 million kilos (a global reduction of 8.8 per cent) and, as a result, decreased the environmental impact associated with herbicide and insecticide use on these crops by 18.7 per cent as measured by the Environmental Impact Quotient indicator (EIQ). The EIQ distils the various environmental and health impacts of individual pesticides in different GM and conventional production systems into a single "field value per hectare", and draws on key toxicity and environmental exposure data related to individual products. Developed at Cornell University in the 1990s, it provides a better measure to contrast and compare the impact of various pesticides on the environment and human health than weight of active ingredient alone. It is however, an indicator only (primarily of toxicity) and does not take into account all environmental issues and impacts.

The new GM technology has also facilitated a significant reduction in the release of greenhouse gas emissions from the cropping area through reduced fuel use and the facilitation of no-tillage production systems that allow more carbon to be stored in the soil. In 2012, this resulted in 26.7 million tonnes of carbon dioxide no longer being released into the atmosphere, which is a saving equivalent to removing 11.9 million cars from the roads for a year – equal to 41 per cent of all cars registered in the UK.

Adoption in Africa

To date, the commercial adoption of crop biotechnology in Africa has been very limited. South Africa first embraced the technology in 1998 and applies insect-resistance technology in its maize and cotton crops and herbicide-tolerance technology in maize, cotton and soybeans. The incomes of farmers using the technology increased by US$ 1.15 billion during the period 1998–2012, and resulted in savings of more than 1.2 million kilos of insecticide active ingredient and a reduction of about 0.9 million kilos of herbicide active ingredient.

The new technology has facilitated a significant reduction in the release of greenhouse gas emissions from the cropping area through reduced fuel use and the facilitation of no-tillage production systems.

Only two other African countries have – more recently – adopted biotech crops: Burkina Faso, where farmers using insect-resistant cotton since 2008 have seen farm income gains worth US$ 187 million, and Sudan, which first used the same technology in its cotton crops in 2012 and where adopting farmers are reported to be benefiting by up to US$ 400 per hectare from significantly higher yields.

So why has Africa been slow to adopt crop biotechnology?

A primary reason has been the way in which African governments have chosen, or are choosing, to regulate the technology.[5] Many African governments have adopted the European approach to regulating genetically modified organisms (GMOs). This requires new and separate laws, new institutions, and applies a very cautious approach to approvals in which non science-based decision-making occurs. This inevitably leads to delays.

Establishing biotech systems is time-consuming because of the need to identify local experts with relevant knowledge and skills to develop and implement the new laws and institutions. This is followed by the requirements to pass new biosafety laws through parliaments followed by new implementing regulations, and to establish a functioning biosafety committee that can review applications. The whole process, where started, has also been undertaken in an environment of suspicion and concern about possible negative environmental and human health, fuelled by anti-technology activist groups, typically located outside Africa, which are ideologically opposed to GMO applications in agriculture.

Proceeding with caution is a valid and virtuous principle to apply to the regulation and application of crop biotechnology in African countries.

This adds up to high costs and uncertain regulatory systems, which are a recipe for stifling innovation. This is especially discouraging when the new technology involves locally adapted applications for the

It matters much less to European farmers than to African farmers if they are denied access to productivity-enhancing technology.

benefit of the farmers themselves – such as combating crop losses due to viral, bacterial, insect and fungal infestations of major African crops including so-called orphan crops like bananas and cassava. It is therefore not surprising that few GMO crop applications have completed the regulatory approval process for commercialisation in African countries, especially as strong political support is required to overcome organised anti-science-based opposition.

Proceeding with caution is a valid and virtuous principle to apply to the regulation and application of crop biotechnology in African countries. However, largely copying the overly precautionary approach commonly applied in Europe has resulted in Africa losing out much more than food-secure Europeans. The "losses" experienced from lack of access to GMO agriculture in Europe manifest themselves in higher production costs and prices of non-GM derived foods, lower rates of growth in agricultural productivity and declining competitiveness relative to GMO-adopting countries, plus the foregoing of environmental benefits. As European citizens are generally well-fed (many increasingly overfed) and well-off relative to their African counterparts, it matters much less to European consumers if the price paid for food is higher than it could be if GM crop technology were more freely applied to European agriculture. Similarly, it matters much less to European farmers than to African farmers if they are denied access to productivity-enhancing technology because European farmers still have access to relatively generous agricultural income support systems and subsidies.

The future in African countries

Some positive signs of progress can be seen. Confined field-trial approval has been granted in Ghana, Nigeria, Cameroon, Kenya, Uganda and Malawi for traits of direct relevance to local crops including insect-resistant cowpea, nitrogen-efficient and salt-tolerant rice, wilt-resistant banana and bio-fortified sorghum. Biosafety legislation also moves forward in some countries. The Ugandan government, for example, has endorsed the 2012 Biosafety Bill, which has been tabled for ratification by Parliament. Regional initiatives are also progressing, for example the Common Market for Eastern and Southern Africa (COMESA) initiative to help countries with limited resources share information and implement international biosafety standards.

However, there remain a number of challenges to be overcome before African farmers and citizens can share in the benefits of crop biotechnology. Progress continues to be slow, even for GM crop technology that has already been widely adopted around the world such as insect-resistant cotton, which continues to experience delays to commercialisation in countries like Kenya and Uganda. New crop biotechnology innovations specifically targeted at African problems and crops have not yet progressed beyond confined trials, and remain at best five and more likely ten years away from possible farm-level adoption.

If African countries are to see any of the potential benefits that crop biotechnology has to offer at anything other than a very slow pace, there is an urgent need for both citizens and politicians to recognise that their countries have much more to lose from shunning an important agricultural technology that enhances productivity and contributes sustainably to food security than their European counterparts. If this recognition can rapidly become a broader consensus in Africa, it may help deliver the political will to move forward with legislation and to apply

African countries have much more to lose from shunning an important agricultural technology than their European counterparts.

a science-based system to facilitate the approval and availability of crop biotechnology in many countries. There is also an urgent need for continued capacity building to adapt new GM technologies to African crops and growing conditions, and to redress the lack of trained scientists with experience of working with African agriculture.

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The African Orphan Crops Consortium: a NEPAD-led initiative

Diran Makinde


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One of the primary thematic areas of the New Partnership for Africa's Development (NEPAD), the development arm of the African Union, is agriculture, food security and nutrition because of the value of agriculture in eliminating poverty, hunger and malnutrition. The Comprehensive African Agricultural Development Programme (CAADP), an integral part of the NEPAD Agency, is Africa's agriculture development policy framework. CAADP's aim is to accelerate the annual agricultural productivity growth rate to at least 6 per cent by 2015. Member states are implementing CAADP with technical support from the NEPAD Agency.

About 200 million of Africa's children under five years of age are stunted as a result of inadequate diet.

The challenge

Hunger and malnutrition are both real issues for Africa's population, with compounding consequences on livelihoods and socio-economic advancement. About 200 million of the continent's children under five years of age are stunted as a result of inadequate diet.[1] This places huge responsibilities on agriculture to produce not just the volumes, but also the nutritional diversity required for the continent's food basket. Africa needs to harness its biodiversity potential more actively to provide the desired quantity and quality of food.

African orphan crops: potential contributions to food and nutritional security in Africa

Africa's biodiversity is rich, with a wide range of fauna and flora including plant (crop/tree) materials highly adapted to local agro-ecological conditions. However, most of these crops remain underused and scientifically unimproved[2]. They are not economically important at global level and hence are largely ignored by scientists. Such crops, generally referred to as "orphan crops", are vitally important in meeting Africa's food needs and providing industrial raw materials.

More than 250 million smallholder households in Africa depend significantly on orphan crops for food security, nutrition and income. These crops are important because of their potential role in mitigating risk in agricultural production systems, as well as maintaining ecosystem health and promoting cultural diversity.[3]

It is expected that the products of this initiative will be better able to withstand climate changes, pests and diseases.

In this regard, the NEPAD Agency is leading a multi-partner initiative to bring increased scientific and economic attention to orphan

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crops. This is focusing on expanding and accelerating the development of higher-yielding varieties while at the same time ensuring protection of the genome base of these crops. This has led to the establishment of the African Orphan Crops Consortium (AOCC) involving the NEPAD Agency; Mars, Incorporated; the World Agroforestry Centre (ICRAF); Beijing Genomics Institute (BGI); Life Technologies; the World Wildlife Fund; University of California, Davis; The iPlant Collaborative; and Biosciences eastern and central Africa International Livestock Research Institute.

The AOCC: strategies, goals and expected outputs

The AOCC was officially launched at the Clinton Global Initiative (CGI) annual meeting in 2011 by its two founding partners, Dr Ibrahim Mayaki, CEO of the NEPAD Agency and Dr Howard-Yana Shapiro of Mars, Incorporated as an effort to improve the nutrition, productivity and climatic adaptability of some of Africa's most important food crops. The initial AOCC work programme is supported through in-kind partner contributions worth US$ 40 million.

The AOCC's strategic approach is twofold: first to train 250 African plant breeders and technicians in genomics and marker-assisted selection for crop improvement over a five-year period. For this purpose, the African Plant Breeding Academy (AfPBA) has been set up at ICRAF in Nairobi, Kenya. The training session involves a six-week programme that will be delivered in three two-week classes; the first session started on 2 December, 2013. The second strategic approach is to use the latest scientific techniques to genetically sequence, assemble and annotate the genomes of 100 traditional African food crops to guide the development of more robust produce with higher nutritional content. It is also expected that the products of this initiative will be better able to withstand climate changes, pests and diseases through marker-assisted breeding and/or genetic engineering.

The genetic data gathered will be made available to the public with the endorsement of the NEPAD Agency. This will be done through a process managed by PIPRA (Public Intellectual Property Resource for Agriculture), which provides intellectual property rights and commercialisation strategy services to increase the impact of innovation, particularly for developing countries and speciality markets, on the condition that the data will not be patented.

Why sequence orphan crops?

The scientific basis of all crop improvement is identification of the genes that encode and regulate specific phenotypic characteristics or traits of benefit. This has been exploited in marker-assisted selection and genetic engineering technology, which has primarily been used to improve production of major world crops such as maize, soybean and cotton. These technologies can be adapted to improve African orphan crops, particularly the many – including banana, cassava, potato, sweet potato and yam – that cannot be improved by conventional breeding because they are vegetatively propagated. However, such improvements can only happen if the appropriate genetic data are made available through sequencing. Molecular approaches such as marker-assisted selection and genetic engineering have the potential to speed up breeding and domestication; they are more precise and faster.

Orphan crops to be sequenced: baobab as an iconic crop

The first batch of orphan crops and trees identified under this initiative includes but is not limited to the following: African plum, allanblackia, amaranth, baobab, *New, improved varieties of orphan crops will mean increased yields and greater disease resistance.*

cashew, cocoyam, finger millet, pearl millet, fonio, groundnut, horned and water melon, marula, moringa, okra, peppers, plantains, teff, shea butter and sweet potato. The work will start with the baobab tree. The fruit of this non-timber forest product is used as food and for medicinal purposes. Baobab is known as the wonder tree in Africa because its fruit has 10 times the antioxidant level of oranges, twice the amount of calcium as spinach, three times the vitamin C of oranges and four times more potassium than banana, has antiviral properties and is gluten-free – to mention a few of its characteristics.[4]

Links with other agricultural NEPAD programmes

Within the CAADP framework the AOCC will support efforts to expand agricultural production and productivity potential including broadening the nutritional value of the continent's food basket. Through CAADP, the AOCC will be able to embrace and respond to local needs and aspirations. The national CAADP implementation processes provide the central framework to raise public awareness and stimulate public-private partnerships for the desired expanded investments in and work on orphan crops. A number of African national agricultural research centres, universities and sub-regional research organizations will participate in this initiative.

Concluding thoughts

The new, improved varieties of orphan crops will mean increased yields and greater disease resistance. However, such varieties could be unaffordable by the target group. It is therefore critical that the NEPAD Agency in liaison with national governments support the design of policies to give smallholders access to the improved seed. The NEPAD Agency will assist member states to formulate policy guidelines on African orphan crops, underlining African (local) ownership and investment in relevant science, and will help them maintain meaningful partnerships and build the required capacity for African scientists.

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Knowledge sharing and the role of farmers

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In 1991, Mount Pinatubo in Central Luzon, Philippines, erupted and was recorded as the second most devastating volcanic eruption of the 20th century. The volcano spewed many tonnes of lava and molten rocks, killing thousands of people and animals. Lava flows wiped entire houses and communities off the map and reduced rich agricultural lands to barren, unproductive areas, including the fertile plains of the province of Pampanga.

Farmer leaders or village cadres have become local champions of biotechnology.

For years, not a single crop grew on the lahar-covered areas, but when the land surface stabilized more than a decade later, farmers tried again to coax the land into producing crops. Among the very first seeds planted was *Bt* maize. Today, the province of Pampanga is one of the major maize-producing areas in the country. It is home to Carlos Guevarra, an early adopter of genetically modified (GM) maize who became a National Farmer of the Year awardee, feted by the Department of Agriculture. A risk taker and innovator, Guevarra is an inspiration to other farmers in his community who have tried the technology and reaped the benefits that have changed lives and communities. Filipino farmers planting *Bt* maize have registered unit yield increases of as much as 37 per cent, with a reduction in insecticide expenditure of 60 per cent.[1]

Li Wenjing, a Chinese farmer from Hebei Province, was persuaded by his village council to grow *Bt* cotton. He tried planting the crop and, compared to the traditional variety, he noticed a significant reduction in the cotton bollworm population and in the use of pesticides. As a result, his higher income enabled him to renovate his house and buy a new tractor and television set. Seeing the benefits and the potential of the technology, Wenjing did not hesitate to recommend it to relatives and farmer-friends in other villages. Similarly, Mohammad Habibbudin, an Indian farmer from Andhra Pradesh, changed to *Bt* cotton after suffering a huge loss in yield due to bollworm infestation. The decision proved to be a wise choice as his yields increased from 160–200 kilos per hectare using traditional varieties to 400–490 kilos per hectare using *Bt* cotton. Quite significantly, farmers in his village reduced the number of pesticide applications from 10–12 times on non-*Bt* cotton, only needing to spray the *Bt* cotton two or three times for the control other pests.

About 85 per cent of the 18 million farmers planting genetically modified crops worldwide are small landholders from the developing countries of China, India and the Philippines.

In China, more and more women are attracted to the commercialisation of genetically modified crops as there is less labour involved.

Carlos Guevarra, Li Wenjing and Mohammad Habibbudin are just three of an estimated 18 million farmers planting GM crops around the world. Contrary to the notion that only farmers from developed countries are reaping the benefits of biotechnology, about 85 per cent of these farmers are small landholders from the developing countries of China, India and the Philippines.[2] This is the major highlight of a research project on the adoption and uptake pathways of GM crops by farmers in the three countries.[3,4,5,6] Higher economic and yield benefits, freedom from high infestation rates of cotton bollworm or corn borer, and dramatic reduction in pesticide use and frequency of spray applications are the principal motivators for adoption.

A further, intangible, benefit is peace of mind in knowing that a dreaded pest would not wreak havoc. More interestingly, it is not the government agricultural extension service that is crucial in farmer adoption of new technology. Rather, farmer-leaders or village cadres have become local champions of GM crops as they take frontline action in testing the technology after seeing a demonstration field trial, sharing their knowledge, and demonstrating commitment to spread the benefits with fellow farmers within and beyond their community.

Who are the farmers using GM crops?

Traditionally, farming has been stereotyped as backbreaking, not commensurate to the efforts exerted, unprofitable, and particularly unappealing to youth. But farmers planting biotech crops paint a different picture. While *Bt* cotton production is still male-dominated, there is growing involvement of women in GM

Farmers believe that they owe it to themselves and their fellow farmers to share what would benefit everyone in the community.

crop commercialization in China. Based on focus group discussions, more and more women are attracted to it as there is less labour involved due to the reduction in pesticide application.

In the Philippines men dominate the planting process, but wives control the purse and thus are major decision makers in the choice of crop to plant and the inputs to buy. In Indian households, planting of *Bt* cotton has become a family affair, with the household head taking the more strenuous activities, and mothers and children helping to pick and clean cotton bolls.

In India, it is a positive sign that the cultivation of *Bt* cotton is attracting the young, with more than 50 per cent in the 21–40 age bracket among those surveyed in the cotton-growing areas of Punjab, Andhra Pradesh and Maharasthra. And in the Philippines, even college graduates are venturing into GM maize production, thus finding it a viable income-generating opportunity. Farmers in China and the Philippines report two to three times higher income from planting GM crops, while Indian farmers obtain twice the income compared to traditional varieties.

Uptake pathways of genetically modified crops

Early-adopting farmers in India and the Philippines take the risk of a new technology by evaluating a biotech crop which they initially heard about from a demonstration field trial set up by seed companies or from progressive village leaders. Other farmers in the community have a "wait and see" attitude: they take time to see how things progress, but become easily motivated once they see convincing results of the early adopters' higher yields and bountiful harvests.

Instead of keeping the new information from which they have reaped rewards to themselves, early adopters are committed to sharing the benefits with their relatives and peers. Among the farmers and other actors in the farming system, knowledge-sharing about biotech crops is highly interpersonal and face-to-face. This is due to the strong prevailing peer system among farmers and the belief that they owe it to themselves and their fellows to share what can benefit everyone in the community.

In China, the role of village cadres is quite important in that they coordinate with technicians to arrange training and convince farmers to participate in farm-related activities. Hence, the factors that facilitate early adoption are three-fold:

- getting support for GM crop production from trusted village leaders;
- close ties and good communication between farmers;
- avoidance of heavy losses incurred by farmers cultivating non-GM crops.

Conclusion

The champions of GM crops are the farmers. It is not scientists, institutional advocates, extension officers or other government agents who play key roles in making farmers adopt a new technology in the first place. At the end of the day, it is the individual farmers who makes the crucial decision of whether to plant a crop or not, decide on the variety to plant, and adopt new techniques and cultural practices. They have tilled the land for so long and have a wealth of experience, allowing them to decide what is best for them and their community. Farmers are naturally risk-averse and may need progressive village leaders to convince them to try new technologies, but once they see the benefits there is no turning back.

It is not scientists, institutional advocates or government agents who play key roles in making farmers adopt a new technology ...

The farmer is indeed the master of his fate.

Yet, as with any technology, there are also factors that limit or slow down the adoption and uptake of GM crops, including lack of capital and the high cost of farm inputs, especially in India and the Philippines. In China in the initial years of commercialization, local seed companies could not meet the demand for GM seeds, and a lack of knowledge and wrong information about GM crops also contributed to delayed adoption.

Nevertheless, farmer adoption of *Bt* cotton is now more than 95 per cent of total cotton production in China and India, while 80 per cent of Filipino yellow corn farmers are planting GM maize.

The farmer is indeed, to borrow William Ernest Henley's words, the master of his fate.

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Better seeds, better yields

Tinashe Chiurugwi and Sean Butler

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Food and nutrition security is a major challenge facing the world's governments, especially in developing countries. Sustainable improvement of crop productivity is necessary to address this challenge, and this relies on using species and varieties that are adapted to the growing environment and provide products suitable for the intended end use. Considerable effort is put into breeding improved varieties in developing countries and around the world – in terms of yield and tolerance to production limitations such as drought,

Most farmers lack information about the range of species and varieties suitable for their farms, and still grow a narrow selection of old, inferior varieties.

diseases and pests. However, challenges remain in transferring knowledge about these advances to the wider agricultural sector and supplying actual seed for farmers to grow. As a result, most farmers lack information about the range of species and varieties suitable for their farms, and still grow a narrow selection of old, inferior varieties.

To help address these issues in developing countries, the National Institute of Agricultural Botany (NIAB) recently completed a year-long scoping project funded by the John Templeton Foundation's Biosciences for Farming in Africa initiative (www.B4FA.org). The foundation, which is based in Philadelphia, USA, is an independent charity with no association with the plant-breeding industry.

The project assessed how showcasing genetic innovation in crop breeding could help smallholder farmers in African countries in their choice of improved varieties by raising farmer awareness and adoption rates of improved varieties in three target countries. The work was carried out in Ghana, Kenya and Uganda. We had

Box 1. Informed farmer choice

Species: A recent article in the newsletter of the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT)[1] highlighted how shifting from growing sorghum and mungbean to sweet sorghum enabled a smallholder farmer to increase her income significantly. Such progress is only possible when farmers know of the species suitable for their situation, so that they can take decisions about how to grow, harvest, use and sell a new crop.

Variety: Choosing the right variety of an appropriate species can enable smallholder farmers to more than double their productivity, even under very limiting conditions.[2] Information about which variety to choose needs demonstration/trial fields that showcase and compare available varieties, explaining what inputs are needed to grow them.

previously applied a similar approach successfully to improve the adoption of plant genetic innovation in the UK through the model of the NIAB Innovation Farm (Box 2).

Case study: maize in Ghana

While improved varieties are available for almost all staple crops in Ghana, the majority of smallholder farmers (more than 70 per cent) use seed of a narrow selection of varieties from their previous harvests or other unregulated sources. This leaves farmers uncertain about variety identity and seed quality such as disease and pest infestation, genetic and physical purity and germination rate. This makes it difficult for them to adopt optimum production practices – seeding rate, fertilisation, disease and pest control – and realise the full potential of their investment. At the same time, the formal seed sector can only provide for a fraction of the certified seed requirements for most species.

Box 2. NIAB Innovation Farm, Cambridge, UK

Established in 2009, the NIAB Innovation Farm (www.innovationfarm.co.uk) is a unique knowledge exchange facility. It helps bridge the gap between scientific research and agricultural practice in the UK, building on NIAB's unique knowledge and skill base.

The facility helps address drivers and constraints to innovation application; including policy, legislation, market and economic factors. Its themed plant genetic innovation exhibitions and workshops help broker connections between farmers, the general public, small to medium-sized enterprises, policy makers and researchers, amongst others.

Annually, the NIAB Innovation Farm attracts about 2000 visitors to its purpose-built demonstration and conference facilities established with funding of £ 2.7 million (€ 3.3 million) from the NIAB Trust and the European Regional Development Fund.

We propose an approach that addresses the whole seed system rather than individual players.

As a result, the market for maize seed, the most important cereal crop in Ghana, is dominated by open-pollinated varieties, mainly Obatanpa. This variety, released in 1992 after development from material originally generated by the International Institute of Tropical Agriculture (IITA) and the International Maize and Wheat Improvement Center (CIMMYT), accounted for more than 90 per cent of all certified maize seed production in 2012, two decades after its release.[2] This is despite the fact that 18 other maize varieties have been released since then. In addition, using certified seed of improved hybrid varieties has been shown to be more profitable than using certified open-pollinated varieties or farm-saved seed.[2]

Knowledge exchange for better yields

To improve awareness about improved staple crop varieties and their use among farmers, key players in Sub-Saharan African seed systems – comprising interrelated components for variety selection and breeding, seed production and marketing, and rules and regulations governing these two activities – need to work together for better provision of plant variety evaluation, demonstration and knowledge dissemination. On the basis of our findings in the three countries, we propose an approach that addresses the whole seed system rather than individual players, incorporating the input of various stakeholders – farmers, seed merchants, input dealers, researchers, public bodies, product dealers and processors, amongst others.

The proposed approach has the following three practical aspects:

1. *Research and development (R&D) and training to improve procedures and processes for variety registration and seed certification*. In line with the

possibility of private-sector involvement in some aspects of seed certification presented by seed regulations in many Sub-Saharan countries, there is room for working with the seed trade in the liberalisation of seed regulatory services. Structures could be established that offer or coordinate the provision of private plant inspection and seed testing services, following the South African National Seed Organization (SANSOR) model.[3]

2 *Optimisation of crop variety performance assessment and cataloguing.* Neutral-variety advisory literature is virtually non-existent for most crops in Sub-Saharan Africa, and is only made available for specific projects and crops or is replaced by marketing material from individual seed companies. There is a need to establish objective and regularly updated descriptive catalogues of all registered varieties. This initiative will build upon existing comparative multi-location trials which test new crop varieties in most Sub-Saharan African countries. It will depend on independent systems for producing datasets on agro-economic performance of plant varieties and cultivation systems relative to farming conditions.

3 *Dissemination of know-how, communication with stakeholders and training of farmers.* There is a need to publish annually updated recommended lists of varieties, based on trials that assess the balance of features such as agronomic performance, yield and quality, likely to be of benefit to the industry. These should be published in useable formats and ensure wide accessibility to farmers, farmer advisors, researchers and seed companies. An important part of this activity would be farmer training and advisory services delivered through a network of trial and demonstration sites, an experience we have learned at the NIAB Innovation Farm.

Conclusion

We have found a willingness to address the proposed approach highlighted above in all three target countries. Several governmental and non-governmental initiatives already trial or showcase plant varieties to farmers in Ghana, Uganda and Kenya. However, the initiatives mostly revolve around demonstration plots, field days, media campaigns and printed promotional material. They are in need of better resourcing and coordination to improve message accuracy and coverage, and impact on the development and adoption of plant varieties.

The approach we propose is for the public and private sectors to engage with these practical issues together. In this way farmers' efforts will not be let down by growing the wrong species or variety in the wrong place, or sowing poor-quality seed and reaping disappointment.

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The great misunderstanding of the global food crisis

Philipp Aerni

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Agricultural productivity growth rates in Africa have lagged behind the rest of the world due to lack of investment in agriculture in general and in agricultural research and development (R&D) in particular.[1,2] Low productivity has especially affected basic food crops such as sorghum, millet, cassava, sweet potato and cowpea, which are barely traded internationally and which benefited very little from the advances in plant breeding of the Green Revolution.[3] But it is not just African crops that have been overlooked; livestock and aquaculture have also suffered benign neglect, and their potential remains largely underexploited.

Global commodity markets do not reach the rural poor, who largely live from non-tradeable subsistence crops.

Lack of investment in agriculture largely accounts for the fact that nearly 850 million people, most of them living in South Asia and Sub-Saharan Africa, were suffering from hunger and malnutrition even before the global food crisis in 2008.[4]

How is it then possible that hardly anyone was calling it a crisis before the globally traded food commodity prices peaked in 2008 and put an additional 50 million people at risk? There are two main reasons: first of all, the newly vulnerable people were mostly part of formal urban economies and therefore depended to a great extent on the purchase of food products that are traded internationally. Thus they suffered most from the price peaks on the global commodity markets. Fortunately, they were also in a better position to mobilise public protest and put pressure on governments than their countrymen in rural areas. Second, it is the persistent narrative in affluent countries – which states that food insecurity in the least developed countries is a consequence of technological change induced through agricultural modernisation and liberalisation – that may have made the mass media less inclined to call the situation a crisis prior to price peaks in 2008. Global change in agriculture, so the narrative goes, could destroy traditional sustainable small-scale farming systems and thus undermine food sovereignty.

Productivity growth rates in agriculture decreased over the previous two decades, mainly due to a general drop in public investment in agricultural research and development.

This view is not just highly popular among food sovereignty advocates, but also among politicians – as well as corporate sustainability and development experts in donor countries – who seek to win favour with their voters, customers and taxpayers. The narrative is, however, hardly compatible with the fact

The increase in global stocks and the globally traded food supply has largely been achieved through a massive expansion of land under cultivation by large corporate and sovereign investment funds.

that the global commodity markets do not even reach the rural poor, who largely live from non-tradeable subsistence crops.[5]

The causes of the food crisis in 2008

There are numerous short-term factors that contributed to the global price peaks of food commodities in 2008 – and one important long-term trend: the growing mismatch between global demand and global supply of tradeable food products. While the demand for more (higher average calorie intake) and better (more animal-based proteins) food grew rapidly, mainly due to emerging middle classes in Asia, productivity growth rates in agriculture decreased over the previous two decades, mainly due to a general drop in public investment in agricultural R&D. When this trend was confronted with harvest failures in major exporting countries and other supply shocks in 2008, price increases escalated to a level that had not been seen since the oil crisis in the 1970s.

Understanding the situation in 2014

Even though the global situation improved following another peak in food prices in 2011, the increase in global stocks and the globally traded food supply has largely been achieved through a massive expansion of land under cultivation by large corporate and sovereign investment funds. This is not sustainable because colonising new land often takes place at the expense of forests and other precious ecosystems, and it does nothing to address the challenges of the informal rural population who already suffered from hunger and malnutrition even before the global food crisis. More helpful would be international and domestic institutional reforms that encourage home-grown agricultural innovation, rural off-farm employment and structural change. This would enable poor rural people to move out of precarious semi-subsistence farming by becoming productive farmers who supply the growing formal markets or by finding work in the growing formal manufacturing or service economy.

As was the case in Europe in the 19th century, poor African farm households today are characterised by a large number of offspring and ever-shrinking parcels of arable land. The average farm size in poor rural areas of Eastern Africa tends to be around 0.4 hectares, and the average productivity of these farms is in decline. Despite numerous efforts to make low-input agricultural systems more sustainable, small-scale farming has become a big environmental problem due to deforestation, soil-nutrient deficiency, soil erosion and water contamination. It is therefore not surprising that most of these small farms are unable to survive without having at least one family member lucky enough to find off-farm employment in a city nearby, or without counting on the assistance of charities and foreign non-governmental organisations (NGOs). These are clear indications that informal traditional economies characterised by low-input semi-subsistence farming and pastoralism are becoming unsustainable from an economic, social and environmental point of view.[6]

This insight stands in strong contrast to the attention that many foreign donor agencies, international organisations and NGOs give to the protection and preservation of low-input small-scale farming in Africa, which they tend to consider as a freely chosen lifestyle rather than an unfortunate destiny, as the increasingly educated offspring of these poor farm households see it.

Many foreign donor agencies, international organisations and NGOs tend to consider low-input small-scale farming in Africa as a freely chosen lifestyle rather than an unfortunate destiny.

The patronising attitude of the food sovereignty movement is well disguised in an anti-imperialist language.

Small-scale farming as a sort of idealistic pursuit of life in harmony with nature and traditional culture is a persistent attitude in affluent non-farming societies, one which explains the willingness of taxpayers to support costly agricultural subsidies and trade protection. Since overseas development assistance and foreign NGOs must primarily please taxpayers and donors back home, it is quite clear from a political economy point of view that pleasing the stereotypical views in donor countries matters more than effectively addressing the agricultural challenges in recipient countries.[7]

Food sovereignty: a persistent narrative that shapes donor priorities

The persistent narrative in affluent donor countries on the global food crisis starts with identification of the supposed culprit. According to many popular documentary movies and even the Special UN Rapporteur on the Human Right to Food (a lawyer by training), the source of all evil is the "neo-liberal" global food system that disenfranchises consumers and producers of food in developed and developing countries alike for the sake of corporate profits. The proposed alternative to this evil system is provided by the popular concept of food sovereignty, which would embrace "the right of people to choose their own food system". Food sovereignty activists in affluent countries are, however, reluctant to stand back and let governments choose what kind of agricultural policies they think might work best in view of the socio-economic and bio-physical constraints their country faces. Instead they reveal a surprisingly missionary zeal to persuade governments in developing countries that there is only one good choice, namely shunning agricultural trade, pursuing agro-ecological approaches without the use of the modern tools of biotechnology, and focusing on the improvement of informal small-scale farming. In essence, they radically simplify the complex challenge of making agriculture work for development by proposing a dualistic world view that promises a sustainable and equitable world for everyone, if "the right path" is chosen.

The patronising attitude of the food sovereignty movement is well disguised in an anti-imperialist language. For example, by sponsoring local activist groups in developing countries that fight agricultural trade and foreign investment in agriculture, the call for food sovereignty could be framed as an expression of cultural self-defence. This helps to explain why the food sovereignty movement proved to be as popular on the far political right (for example nationalist concerns about potential dependence on agricultural imports) as it is on the far political left (rejection of agricultural modernisation as a Western project). Both sides belong to affluent urban elites who have developed a purist ethic which considers all things that have been imported to be a source of contamination of local culture and the environment. Ironically, they themselves are a product of globalisation and most of the things they eat stem from global industrial agriculture, including the organic agriculture industry.

The political alliances that have merged under the umbrella of food sovereignty have made the intergovernmental IAASTD Report[8] *(International Assessment of Agricultural Knowledge, Science and Technology for Development*) their flagship report, partially sponsored by the World Bank. The report was criticised for being unbalanced[9] and for not making the politics of knowledge more explicit, and particularly came under fire for its claim that NGOs represent local farmers in developing countries.[10]

The affluent urban elites have developed a purist ethic which considers all things that have been imported to be a source of contamination of local culture and the environment.

Priorities with regard to food security and agricultural policies should be set by the respective governments in recipient countries and donors should then align their funding accordingly.

Yet, the popularity of the report in the Western mass media made even pragmatic politicians realise that rejecting the use of genetic modification and supporting small-scale organic farming initiatives at home and abroad is a cheap vote winner. It also felt good to affluent urban consumers who consider sustainability to be a lifestyle that contributes to personal wellness. "Wellness sustainability" is about feeling right with regard to what we eat, say, read or think. Clever marketing strategies by global retailers are increasingly focused on selling goodness rather than just goods, ensuring that we are never exposed to contradictions that could make shopping a less pleasant and reassuring experience.[11]

Unfortunately, wellness sustainability has caused considerable collateral damage in many countries in Sub-Saharan Africa. For example, thanks to the fact that Europe is the largest donor to Africa as well as the largest importer of food from Africa, it has considerable clout in imposing its views on the continent's governmental and non-governmental organisations. The result is that institutional capacity development of national agricultural innovation systems has been further neglected; highly needed public-private partnerships to increase food production in a sustainable way are hardly encouraged; the use of modern biotechnology in agriculture remains a taboo for many African governments; and off-farm employment in poor rural areas is generated not by a flourishing private sector but by the proliferation of public-sector bodies and foreign NGOs.

European aid must surely have met some important needs among the poor of Africa, and it may almost unintentionally generate a lot of local businesses

"Wellness sustainability" is about feeling right with regard to what we eat, say, read or think.

that sell goods and services to these institutions with high purchasing power. But is all this financially sustainable? And does it help improve food security on the continent in the long run? Probably not, because everything stands and falls on the strong presence and funding of these external actors. The trend is also contrary to the spirit of the Paris Declaration on Aid Effectiveness, which was jointly signed in 2005 by members of the Organisation for Economic Co-operation and Development – the OECD.[12] They agreed that priorities with regard to food security and agricultural policies should be set by the respective governments in recipient countries and that donors should then align their funding accordingly. A recent needs assessment on capacity development for agricultural innovation in Africa[6] revealed that most local stakeholders think that foreign aid is not really aligned with the principles of the Africa-led Comprehensive African Agricultural Development Programme (CAADP), which focuses on the revival of domestic agriculture through the mobilisation of investment, research, entrepreneurship and innovation for agricultural development.

Collaboration as an engine of sustainable change in agriculture

Whereas the food sovereignty movement has a strong presence in the Western media and considerable influence on policy making in donor countries, it is South-South and triangular (South-North-South) cooperation that is currently transforming agriculture in Africa. South-South is mainly associated with the increasing presence of China in Africa and viewed with great skepticism. However, there are strong indications that China will be able to make a big difference in Africa in terms of poverty reduction and economic development – judging from its own success story back home. China's poverty incidence decreased from 31 per cent in 1978 to just 2.5 per cent in 2008. During this period income per farm household increased on average by 7 per cent per year.[13]

The advantage of China is that its people still remember how they developed. They know that it was the political will to enact and enforce institutional change that ultimately strengthened capacities in agricultural innovation, improved the transmission of new knowledge from research to teaching at universities and from agricultural service providers to farmer cooperatives and agribusinesses. This resulted in the creation, tailoring and rapid adoption of innovation in management and technology. The resulting process of endogenous development contributed significantly to the reduction of poverty in rural areas, enabled rural empowerment and led to an increase in agricultural productivity and competitiveness. Moreover, unlike governments in OECD countries that allowed their budgets for agricultural research to shrink substantially after the end of the Cold War, China strongly increased public-sector R&D in agricultural as well as agricultural biotechnology research.[14] The same trends can be observed in tropical emerging economies such as Brazil, where the research organisation EMBRAPA has become the global leader in agricultural R&D with a focus not just on the improvement of cash crops but also of basic food crops that are relevant to Africa.

Food security and rural empowerment require collaboration and enhanced involvement of public- and private-sector institutions that jointly create an enabling environment.

South-South collaboration alone will, however, barely be able to facilitate sustainable agricultural change through institutional reform, entrepreneurship and innovation in Sub-Saharan Africa.[15] That also requires support from the North through selected partnerships with leading research institutes, foundations, agribusiness companies and progressive NGOs. Such types of triangular partnerships are focused primarily on institutional capacity development for agricultural innovation. As such, they also help to make national agricultural innovation systems more business- and innovation-oriented. All this contributes to endogenous development in rural areas, a process that is strongly endorsed by the G20 Interagency Report[16] as well as the African Union (AU) and the New Partnership for African Development (NEPAD).[17]

Building bridges is more conducive to sustainable agriculture than burning them.

Behind these initiatives is the belief that food security and rural empowerment require collaboration and enhanced involvement of public- and private-sector institutions that jointly create an enabling environment for the mobilisation of science and technology for development. Actors in the public and the private sectors may pursue different interests, but it is their specific expertise that produces synergies which neither of them could achieve on their own. This is vastly different from the food sovereignty movement and its dualistic approach, as it tends to abstain from collaboration with the private sector unless its potential partners appear like-minded.

It is therefore time to agree that building bridges is more conducive to sustainable agriculture than burning bridges. If leading advocates of the food sovereignty movement could see this – realising that the private sector is not just about the large multinational corporation but also the local entrepreneur in Africa who wants to grow through innovation – it will be a huge step towards a comprehensive, sustainable and holistic approach to rural development.

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New plant breeding techniques: prospects for the future

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Science never stands still and the skill-set of plant breeders through the centuries proves the point. Especially during the last decade, several new plant breeding techniques have been developed which now make it possible to perform genome modifications with an even greater degree of precision than was previously thought possible following earlier breakthroughs in producing genetically modified (GM) plants[1]. One effect is that the distinction

New plant breeding techniques are of special interest because they allow for precise genome modifications and do not necessarily involve the transfer of entire genes from one organism to another.

between the new techniques and the previous GM technologies, which led to GM plants by transferring genes (transgenesis), has led to some confusion about whether plants produced using the new techniques should be classified as GM plants or not according to the existing nomenclature. First, let us look at the technologies in question.

Exploring these new genome-editing techniques allows not only even more precise plant breeding but also a remarkable range of new opportunities.

The new plant-breeding techniques (Box 1) are of special interest because they allow for precise genome modifications and do not necessarily involve transferring entire genes from one organism to another. Two of them, site-directed nuclease mutagenesis (SDN) and oligonucleotide-directed mutagenesis (ODM), introduce genetic modifications at specific sites in the genome. Another, RNA-dependent DNA methylation (RdDM), introduces a genetic modification in chemical molecules associated with DNA to produce what are called epigenetic modifications.

All three techniques modify the plant DNA sequence in different ways, either by mutation, insertion or deletion of a different sequence, by gene replacement or by stable silencing of a gene or its promoter (or other regulatory elements). Exploring these new genome-editing techniques allows not only even more precise plant breeding but also a remarkable range of new opportunities for future crop improvement and production.

Following these techniques further, when molecular biologists want to produce a mutation in the genome using SDN, they design proteins that recognise and target a specific DNA sequence. They use a single protein chain which recognises, binds and cuts a specific sequence in the DNA, or use two proteins artificially connected by a peptide linker. In the latter case, the protein responsible for DNA recognition and binding can be designed in various ways for different specific DNA sequences, whereas the single protein cuts non-specifically any DNA sequence. Using SDNs, a mutation in the genome is induced by editing, deleting, inserting or replacing genes. SDN is also very useful

Box 1. Creating genetically modified organisms with new plant breeding techniques[2]

Transgenesis (GM): transfer of a gene (DNA coding region) from another organism.

Cisgenesis: transfer of a gene to a plant of the same or closely-related species (inter-fertile).

Intragenesis: insertion of a reorganised, full or partial gene derived from the same species (usually combined with a promoter or terminator from another gene of the same species).

Targeted mutagenesis: a specific mutation produced by an SDN technology that uses, for example, a zinc-finger nuclease or a transcription activator-like effector nuclease.

Transient introduction of recombinant DNA: mutations directed by oligonucleotides or infiltration techniques, giving rise to end products that can be similar to, and indistinguishable from, plants derived through conventional plant breeding.

Other techniques: RNA-induced DNA methylation (gene silencing) and reverse breeding, where intermediate products are genetically modified but end products are indistinguishable from plants obtained through conventional breeding. Grafting a non-genetically modified scion onto a genetically modified rootstock results in a chimeric plant where only the lower part carries the genetic transformation.

because it can also be a way of introducing multiple genes with different functions, which is known as molecular trait stacking. In the past two years, a new kind of SDN has emerged using a protein called CRISPR/Cas9 (clustered regularly interspaced short palindromic repeats) nuclease. In the first potential applications, this nuclease was guided to a genomic sequence by a specific guide-RNA, which defined by its sequence the part of the genome to which it would bind specifically.

The basis of the second technique, ODM, is the application of a modified DNA or DNA/RNA molecule (oligonucleotide), which has from 20 to 100 nucleotides and is delivered into plant cells in tissue culture by standard methods that have been exhaustively tested. The sequence of the oligonucleotide resembles a (homologous) sequence in the plant's genome but is designed to differ in one or a few nucleotides. After the homologous sequence binds to the DNA a mismatch pairing occurs which will be corrected by the repair system of the host cell, and this leads to new and specific mutations. The sequence of the oligonucleotide can be used as a template for new DNA synthesis during the repair process. In this way ODM can be used to target the editing of the genome (targeted editing), as is required for the introduction of herbicide resistance into plants by specific point mutations.

The third method, RdDM, enables gene expression to be modified by switching off genes (gene silencing) or enhancing their function without bringing about any change in the genomic sequence itself. This can be achieved by altering the methylation patterns of molecules associated with DNA by the introduction of double-stranded RNAs. These latter molecules are processed by different host enzymes of the RdDM machinery

A vast amount of safety research has been performed on genetically modified plants.

There is no evidence that genetically modified plants possess a greater adverse impact on health and the environment than any other crop developed by conventional plant-breeding technologies.

and lead to epigenetic changes in gene expression which can be stably inherited for at least a few generations. A feature of this method is that RdDM can be used to modify the expression of one or more genes.

These spectacular advances in the different ways that genes can be controlled in plant (and bacteria and animal) cells mean that the plant products derived by new plant-breeding techniques may be indistinguishable from wild-type crops using available diagnostic tests. This raises the key question about future prospects – do the new techniques really require testing under existing rules for making genetically modified organisms (GMOs)?

In its recent report *Planting the future: opportunities and challenges for using crop genetic improvement technologies for sustainable agriculture*[2], the European Academies Science Advisory Council (EASAC) used the general term "crop genetic improvement technologies". The term covered the new plant-breeding techniques as defined by the European expert group in 2007 referred to above (and those developed subsequently)[3], and the better known GM techniques defined in the Cartagena Protocol on Biosafety. The Protocol came into force in 2003, had been signed by 166 countries by 2013, and covers the measures that relate to the intentional release of GMOs into the environment and the regulations that apply to the transboundary movement of GMOs for food, feed and production.

Technology-specific GMO regulations have been developed in several countries and have proved to be especially restrictive in the European Union (EU). Since the

The regulatory framework of genetically modified crops is "expensive, time-consuming and inappropriately focused on the technology rather than the product".

first field releases, a vast amount of safety research has been performed on GM plants. This research was both sound and necessary for scientific reasons, as only limited data concerning the potential impact of GM plants in the environment existed previously. Also, they addressed public concerns and fears at an early stage. By now, a huge amount of data on the safety of GM crops for humans has been reviewed repeatedly, leading to the conclusion that there is no evidence that GM plants possess a greater adverse impact on health and the environment than any other crop developed by conventional plant-breeding technologies.

Thus, from a scientific point of view the products of GM crop technology that have been reviewed are safe and there is no evidence of a general risk related to this technology *per se*. The recent EASAC report[2] came to the conclusion that the regulatory framework of GM crops is "expensive, time-consuming and inappropriately focused on the technology rather than the product", and that there was common agreement in the scientific community that an alternative regulatory system should focus on the risk assessment and regulation of the trait and/or the product rather than the technology used to produce it. This would mean taking the risk-benefit analysis into account rather than focusing on risk alone.

All this bears on the future of the new plant-breeding techniques and the ongoing debate about whether the resulting plants and their products have to be regulated as GMOs.[3,4] The new techniques do not necessarily involve the transfer of entire genes from one organism to another and the products may be indistinguishable from wild-type crops using standard available diagnostic tests.

Therefore the new products would not qualify as GM crops. Obviously, coverage by GMO legislation would hamper severely the use of the new techniques because GM plants have to pass approval procedures which are costly and time consuming, especially in the EU.

The OECD programme on the Harmonisation of Regulatory Oversight in Biotechnology initiated an international discussion on NPTBs, aiming to ensure that the information used in risk-safety assessment of GM crops and other organisms of commercial interest, as well as the methods used to collect this information, are as similar as possible between different national regulatory authorities. It could be that the list of new plant-breeding techniques defined in 2007 from a European perspective might be shortened (or extended) as a result of this international discussion process.

Recently, Professor Anne Glover, Chief Scientific Adviser to the President of the European Commission, provided the following commentary: "Our obligation as citizens is to look at the evidence presented and have the courage to reposition our views as that evidence accumulates. All of us, scientists and non-scientists alike, must guard against confirmation bias where we choose to look at only that evidence that fits our opinions."[5]

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Agricultural delivery systems: some options for East Africa

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In 2012, the Center for Strategic and International Studies (CSIS) set out to answer the question: can genetically engineered crops improve food security? We conducted field work in Tanzania, Uganda and Kenya, and looked particularly at the potential impact for smallholder farmers and rural households. This question is an important one because the need for investment in agriculture in these three countries is tremendous; but resources are few and must be husbanded carefully.

The need for investment in agriculture is tremendous; but resources are few and must be husbanded carefully.

After 18 months of research, interviews and discussion, we concluded that genetic engineering and biotechnology have the potential to play an important role in battling pernicious pests and diseases, as well as improving nutrition and reducing the use of water and chemicals, all of which can benefit farmers. In addition, scientific progress will be enhanced if researchers have the opportunity to push their research and findings into new areas of discovery.

However, there is an important challenge to achieve the potential benefits of genetically engineered crops: how will the farmers get them, and once they have them, how will they know what to do with them?

Focus on delivery

Without a major focus on agricultural delivery systems, the benefits of genetically modified (GM) crops will never be fully realised. This is important not just for GM crops, but also because any investment in agricultural delivery systems, from education and extension to seed multiplication and distribution, will ultimately be required for the entire agricultural sector to develop. Pathways for farmers to secure productivity-boosting inputs and information will benefit farmers, regardless of their choice of seeds. Given that these countries have very low rates of adoption of even hybrid seeds – less than 30 per cent – and low fertiliser use, it is vital to increase the use of improved inputs in order to achieve larger, more predictable harvests and reduce hunger and poverty.

With people around them who are knowledgeable and able to share new approaches, farmers will be more likely to experiment.

Cellphones: vehicles for communication

While a good deal of discussion has revolved around the promise of cellphones as distributors of information and hubs of knowledge, they can be but a part of the answer to this challenge. Cellphones are not systems in and of themselves. They are vehicles for communication and information to be passed between people who like to use them. Their utility will depend upon who is involved in farming – are there local leaders within communities who can gather and share updates and information, and explain them in the local context? Are there young people who are inclined to experiment and try new approaches? If so, then cellphones and data will have much greater potential.

Re-energising old habits

In addition to experimenting with cellphones and other technologies, it is time to find new ways to use the old approach – talking to people. Farmers all around the world, and in this region in particular, want to talk to each other, share advice and ideas, and find answers to their questions. With people around them who are knowledgeable and able to share new approaches, farmers will be more likely to experiment with some of the techniques and inputs that have driven up production and farming success elsewhere.

Suggesting that the future lies with people talking with and teaching each other may seem old-fashioned; but it need not be the way it was in the past. To realise the potential for high-productivity and problem-solving crops, both GM and non-GM, we should embark on a major re-think of extension and education; it needs updating and refreshing, and there needs to be far more of it, especially in East Africa. Extension is criticised in many countries, as it has tended to be underfunded by governments, too focused on male farmers, and lacking in reach and quality. So the question is how to reach farmers with good information and

The question is how to reach farmers without replicating an outdated system that relies on major financial outlays and large staffs.

continued engagement, but without replicating an outdated system that relies on major financial outlays and large staffs. Uganda, for example, revamped its system, but it still does not reach an adequate number of people, or provide adequate information.

A much more intense focus must be placed on developing the agribusiness sector.

Promoting leadership

There is still an important role for government expertise and credibility in connecting with farmers; in addition, non-governmental organisations and other groups have had success in reaching farmers and engaging in communities through local farmers, who serve as leaders and cheerleaders, and receive ongoing training and education. Having team leaders, or community members who are viewed as good and knowledgeable farmers, can be a lower-cost approach to providing information. As with other sectors, such as the health sector, providing training and stipends to community members serves the purpose of developing an information distribution system and network, and also creates a larger base of community-owned knowledge about good farming practices. Having a hub of information and activity creates an environment where change can occur, and where new practices are more likely to stick, as people can share their experience and remind each other of the steps they are supposed to take for each new approach to intercropping, soil amendment or use of hybrid or GM seed.

Training

A mix of engagement including short seminars, training days and field days, should be explored to both educate and train farmers to serve as resources for their communities, and tie communities into a broader system of knowledge that the government and independent organisations could best provide.

The role of agribusiness

The agribusiness sector must be a key part of the system as well; seed varieties are publicly developed and approved by the government, and the seed sector is not as robust as it needs to be to breed, multiply and distribute enough seeds to meet demand. If supply is uncertain, demand will be stunted because farmers will focus on the most reliable source of seed – their own seed, saved from the previous year's harvest. A much more intense focus must be placed on developing the agribusiness sector, focusing on beefing up skill and capabilities around production and distribution, as well as the important but sometimes-overlooked skill of marketing. Without a more sophisticated agribusiness sector, the necessary "push" of supply will not be able to drive the "pull" of demand.

Service provision

Innovation and development in the agribusiness sector must not only be focused on development and distribution of inputs. It must also be packaged with technical services; for without financing and advisory services, good seed will fall short of its potential yield. For-profit advisory services could build upon a community-based model, and could train and employ community members and farmers to assist in the distribution of information.

There is no clear path to better productivity for smallholder farmers. But it is evident that far greater emphasis is needed for the product and information systems that will push farmers to greater success. And there is room for enormous creativity and skill that puts person-to-person communication at the centre.

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From aid to trade: the African elephant in the room

David Bennett

C.L. Erbaugh/UNEP

SciDev.Net's Spotlight *Ensuring food security for the future*[1] featured a number of first-rate articles from various viewpoints. Yet one, it seems to me, sorely lacking, is that encapsulated in the famous catchphrase of Bill Clinton's presidential campaign in 1992: "It's the economy, stupid!" As so often, food security is seen as being achieved by a combination of long-term research-based and short- term low-tech initiatives. And these, in one way or another, are dependent on funding from donor agencies, whether foreign governments – either directly or via their support for research – or charitable foundations or non-governmental organisations.

For any solution to food security to be sustainable, people have to move from depending on aid to depending on trade.

Philanthropy is a crucial safety net in the face of human tragedies of conflict, famine and natural disasters – like the situation after Typhoon Haiyan in the Philippines. But for any solution to food security to be truly sustainable, particularly in Africa, people have to move from depending on aid to depending on trade – both local trading and international import/export trade. That is the elephant in the room, clearly evident but all too frequently ignored.

The issue is not new – many Africans are fully aware of the problem even while the solution remains elusive. Dambisa Moyo, for example, Zambian economist, former Head of Economic Research and Strategy for sub-Saharan Africa at Goldman Sachs and World Bank consultant, railed against the tide of money that, however well-intentioned, has only promoted corruption in government and dependence in citizens. She cited in contrast such countries as Argentina and Brazil, where a policy of investment has worked to grow their economies.[2]

Hunger and poverty are inextricably linked. Paradoxically, almost ironically, most of the many hundreds of millions of poor and hungry people, especially in Africa, are farmers, albeit on a small scale. Agriculture currently employs close to 70 per cent of the population, with women playing the principal role, while nearly 60 per cent of the world's available arable land is in Africa. But people go hungry because they cannot grow enough food for themselves and their families or make enough money from selling what they do produce. This itself needs money – for better seeds and fertiliser, a water pump to irrigate the crop and a bike to take it to market, a radio and a mobile phone to find out about crop prices and information on cultivation, and so on. In other words, it *is* the economy, stupid, and that means moving from donor-dependency

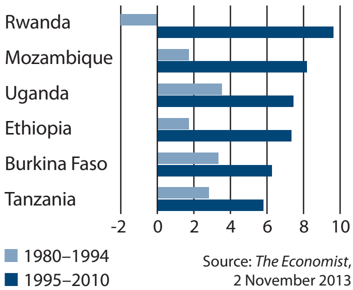
Some African economies are now among the fastest growing in the world.

to trade-based self-sufficiency and self-reliance – which is what people say they want anyway. A Harvard University study led by Professor Calestous Juma showed that Africa could feed itself by making the transition to self-sufficiency. "African agriculture is at the crossroads," he said. "We have come to the end of a century of policies that favoured Africa's export of raw materials and importation of food. Africa is starting to focus on agricultural innovation as its new engine for regional trade and prosperity."[3]

Some African economies are now among the fastest growing in the world. In its 2 November 2013 edition, *The Economist* cited an International Monetary Fund study showing that six countries – Burkina Faso, Ethiopia, Mozambique, Rwanda, Tanzania and Uganda – had a GDP growth of at least 5 per cent on average from 1995 to 2010.[4] To these countries should now be added Nigeria, with GDP growth between 2009 and 2012 of 7–8 per cent, mainly because of oil revenues.[5] The article made the key point that these have not relied on the resource and investment boom driven by China. They have achieved this by controlling public finances, curbing inflation and, crucially, improving the climate for entrepreneurism and small businesses by sweeping away price controls and state monopolies. As Jim Adams, a World Bank veteran with long experience in Africa and Asia pointed out in a commemorative lecture on 14 November 2013, as long ago as in the early 1980s the World Bank "argued for underlining the need for trade and exchange rate adjustments, more disciplined budgets, reductions in government controls, a reduced role for parastatals,[6] and an

Change in GDP in Africa

Selected countries, average annual change (%)



Source: *The Economist*, 2 November 2013 increased role for the private sector and for major investments in education and in health". He added, however, that "the NGO community rejected the dominant economic focus of the Bank, questioning the likely impact of many of the proposed reforms; and in-country vested interests affected by the reforms worked hard to undermine proposed policy changes".[7]

Significantly, the World Bank kind of approach of these six African countries in turn attracts further inward investment in the form of grants or cheap loans, including – and importantly – from the diaspora throughout the world. A conference of the African Development Bank on 29 May 2013 was told that there are around 140 million Africans living abroad. "About one third are middle class," noted Olivier Eweck, Director of the Financial Technical Service Division at the AfDB, "... total savings by the diaspora are estimated at US$ 50 billion."[8] *Africa Review* reported a recent study as "revealing that the money sent by Africans in the diaspora was more than the amounts remitted by donors through official development assistance. A large portion of these remittances is sent informally to avoid high bank fees". Notably it also reports Professor Mandivamba Rukuni, former Professor of Agricultural Economics at the University of Zimbabwe and Chairman of the Agricultural Research Council of Zimbabwe, as saying: "Africa has the potential of being the world's food basket in the next three decades but for us to maximise on this potential we have to fully engage those in the diaspora."[9]

There remains, however, the massive conundrum of urbanisation that faces African farming and its youth in the flight from the countryside to the cities. This is coupled with the fact that half of all the people in Africa now are under 20 years old and more than half of all global population growth between now and 2050 is expected to occur in Africa. According to the United Nations' latest medium-variant projection, its population could more than double by mid-century, increasing from 1.1 billion today to 2.4 billion in 2050, and potentially reaching 4.2 billion by 2100.[10] This cannot be ignored.

There is need for a fundamental change in the mindsets of African youths to view themselves as key players in the food production chain.

As Dr Margaret Karembu, Director of the International Service for the Acquisition of Agri-biotech Applications (ISAAA) Africenter graphically describes: "Migration of young people from rural to urban areas has left food production in the hands of their elderly parents, most of whom are incapable of adjusting to modern high-tech farming systems. The *status quo* has only served to further demotivate the youth as farming is portrayed as a punitive, inferior and non-profitable enterprise. As well, young people do not view themselves as part of the solution to the food insecurity problem. Yet their population is increasing at an alarming rate, higher than that of economic growth. The majority throng to cities in their millions, ending up in slums and on the streets doing menial jobs and hawking all manner of counterfeit imported goods."[11]

There is need therefore for a fundamental change in the mindsets of African youths to view themselves as key players in the food production chain. This can be possible if farming becomes profitable with a supportive infrastructure to make it worthwhile and recognised as an important cornerstone of the modern African economy and society.

All this is to be set against what has come to be called, somewhat pejoratively, "the donor-dependency syndrome". While a small number of initiatives are designed to help local communities through self-help projects, traditionally and still today, the majority of donors and/or projects simply hand out donations or effectively their equivalents in a top-down manner. This includes many ostensibly aimed at enhancing food security in one way or another. The result is depressingly common and predictable. It creates, encourages and perpetuates a culture tailored to, and indeed expert in, obtaining funding and expending it in a dependent fashion. It thereby distorts and distracts effort away from self-sufficiency. Most such funding is short term, which has many consequences, including an inability to establish longer-term planning and programmes, inevitable insecurity and uncertainty, and the expenditure of a great deal of time, effort and money in obtaining more donor money which could be better spent. Lengthy reports are regarded as the products rather than results on the ground, so that the means displaces the end. Participatory approaches are more difficult to implement and take longer than top-down approaches so are not carried out or, if they are, fail because of lack of time, money and expertise.

Where donors can help is in supporting people to escape dependency and achieve self-reliance by funding well-governed things that really do that:

- effective agricultural extension services, especially by women for women, that provide up-to-date, practical information to farmers in the distant countryside on new seed varieties and how to grow them in local conditions, and on how to market their crops;
- demonstration farms that link advances in plant breeding and agriculture with farmers and farming networks so that they actually reach small-holder farmers;
- micro-financing and credit unions so that farmers can buy the new seeds, fertiliser and other things needed;
- business advice and capital to help community cooperatives, small firms, agribusinesses and “spin-outs” from universities and research institutions to help bridge “the valley of death” to financially self-

standing profitability that attracts further investment from such as the diaspora.

These are surely the kinds of ways that donors can help – and then bow out and move on to do it again elsewhere.

Donor dependency is pernicious, a vicious circle. It is small wonder therefore that Lord Cameron of Dillington, for example, said in the UK House of Lords in his address during the Queen's Speech Debate on 15 May 2013 that: "The end game of DfID[12] must be to help developing countries become self-sufficient and eventually not to need our aid. To quote Justine Greening, we must 'help create economies that stand on their own two feet'."[13,14]

The elephant in the room must lead the big parade out from aid to trade in Africa!

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Will trade barriers prevent the adoption of genetically modified crops in Africa?

John Komen and David Wafula

Susan Beccio/IFAD

Concerns over export markets are often cited in Sub-Saharan Africa as a reason for taking a precautionary approach to the adoption of genetically modified (GM) crops. In some countries, this is exacerbated by trade restrictions on GM commodity imports, thereby having a negative impact on food security in times of production shortfalls or famine. Trade-related effects and access to export markets are often emerging as a concern since developments in

Several African policy makers have been preoccupied with the notion that the adoption of genetically modified crops would attract a wholesale rejection of agricultural exports by trade partners.

Contrary to popular belief, countries in the European Union are not against GM products, nor are they "GM free".

potential markets such as those in the European Union (EU), where the level of caution around modern biotechnology and consumer skepticism are still high, have attracted attention. More specifically, several African policy makers have been preoccupied with the notion that the adoption of GM crops would attract a wholesale rejection of agricultural exports by trade partners.

While we recognize that decisions around the adoption of GM crops in Africa are often surrounded by controversy, the present essay provides insights on key trade aspects of GM adoption based on recent research.

GM commodities are widely accepted in international trade

Almost 20 years after their introduction, and despite well-publicized opposition in some countries, the four main GM products – maize, soybeans, cotton and canola – are widely traded and consumed internationally, as the largest agricultural exporting countries are the largest GM crop adopters. For instance Brazil, which has high GM adoption rates for soybeans, maize and cotton production, has benefited from strong increases in the yield and export values of those crops. Closer to home, South Africa's maize exports (including white and yellow maize), of which around 80 per cent is GM, have readily found their way into export markets including many countries in Sub-Saharan Africa. In Burkina Faso, another GM adopting country, cotton production and exports soared in recent years due to the rapid adoption of GM cotton (currently more than 50 per cent of total acreage). Prior to approving commercial production of a GM crop, those agricultural exporting countries carefully assess the likely impact on export markets. In a very few cases, this has resulted in delayed or rejected GM releases due to trade considerations; for example, for GM insect-resistant potato in South Africa, which is traded with neighbouring countries like Mozambique and Zimbabwe.

Genetic modification and the European Union

Contrary to popular belief, countries in the EU are not against GM products, nor are they "GM free", though they do have elaborate and stringent regulations. While the cultivation of GM crops is limited to insect-resistant maize, which is predominantly planted in Spain, the EU has approved a wide range of GM products for direct consumption by humans and animals despite a lengthy and unwieldy approval procedure. This includes GM soybeans, cotton, maize, oilseed rape and sugar beet. Consequently, the EU trading bloc imports massive quantities of GM commodities mainly for use as animal feed. About 70 per cent of soybean meal consumed in the EU is imported and 80 per cent of this meal is produced from GM soybeans. On average, EU imports of soybean meal and soybeans amount to US$ 9 billion and US$ 6.5 billion per year, respectively. Although it has to comply with very strict labelling rules, and long-drawn-out decision-making procedures, trade involving GM products with EU countries has clearly not been deterred. In addition, nine EU member countries continue to conduct experimental field trials on a range of GM crops with improved agronomic traits, contributing to an ever increasing pipeline of GM crop cultivation proposals under consideration by EU authorities.

The degree of trade risk associated with the commercial adoption of GM crops ... is first and foremost an intraregional issue and poses little cause for concern.

Trade concerns: analysis from East Africa

While commercial adoption of GM crops is lagging in Sub-Saharan Africa, a steadily increasing number of GM food crops are being tested in various countries. A previous, detailed analysis in East Africa (Komen and Wafula, 2013) concludes that the degree of trade risk associated with the prospective commercial adoption of GM crops such as maize, cassava, cotton and bananas – which are among those currently being tested in confined field trials in Kenya and Uganda – is first and foremost an intraregional issue and poses little cause for concern. First, as argued above, various GM varieties of maize and cotton are traded worldwide and are generally accepted for processing as food, feed and fibre. Moreover, the value and volume of exports to GM-sensitive destinations, such as the EU, are very small and in most cases negligible.

The trade analysis points to a high concentration of agricultural trade (exports as well as imports) within the East African region and the rest of Sub-Saharan Africa. Clearly, agricultural trade involving GM crops can be addressed early enough by regional regulatory dialogues and by accelerating the processes of developing common, Pan-African biosafety policies, in order to mitigate any market access bottlenecks. Given that the regional integration initiatives in Africa pay much attention to trade in key agricultural commodities and the need to minimise tariff and non-tariff barriers, matters concerning decision making on GM crops can be adequately mainstreamed into the regional integration policies and instruments.

It is essential for countries to establish their own policies on modern biotechnology and biosafety, and on associated regulatory frameworks.

International agreements, decision making and regional collaboration

An often heard argument in regional discussions on biotechnology and trade is that the capacity of individual countries in handling and regulating GM products widely differ, and that some may not be ready to take decisions on releases and trade.

In many cases, biosafety regulations have unduly stringent provisions that will undermine efforts to meet broader national food security and developmental goals.

However, as national regulatory frameworks governing modern biotechnology are still evolving, international agreements such as the Cartagena Protocol on Biosafety (CPB) and agreements under the World Trade Organization are practical starting points for countries considering adoption of GM crops and their likely trade impacts. These treaties provide internationally accepted guidelines and procedures regulating trade in agricultural commodities involving GMOs. International instruments can be used as an interim measure by importing countries that do not yet have a fully functional national regulatory framework. A case in point includes Annex III of the CPB dealing with *Risk Assessment of GMOs*, which can be used in domestic decision making. International agreements encourage information exchange, regional collaboration and harmonisation between signatory countries on the basis of internationally accepted scientific standards and are therefore a cornerstone for any regional harmonisation efforts.

Clear and workable policies are essential

While international agreements and standards may provide important guidance, and could be used on an interim basis, it is essential for countries to establish their own policies on modern biotechnology and biosafety, and associated regulatory frameworks. Clear policy goals and regulations have proven to facilitate informed decision making on GM adoption and trade. Where adopted, the national biotechnology policies of Sub-Saharan African countries generally contain policy statements that recognize the potential and contribution of modern biotechnology in meeting socio-economic development goals. In contrast, in many cases, their biosafety regulations have unduly

Bold decisions are critical to allay any remaining fears over trade barriers and to boost intraregional trade.

stringent provisions that will undermine efforts to meet broader national food security and developmental goals. In addition, they hinder efforts towards regional integration and trade agreements to which they have subscribed in regional bodies. The discrepancy between national biotechnology policies and biosafety laws and regulations is a crucial agenda item that needs to be addressed as a matter of urgency.

Concluding note

In September 2013, the Fifth COMESA (Common Market for Eastern and Southern Africa) Joint Meeting of the Ministers of Agriculture, Environment and Natural Resources endorsed a proposed common COMESA Policy on Biotechnology and Biosafety for adoption, taking into account the sovereign right of each member state. In addition, the meeting called to support member states to implement the policy through communications and outreach, development of operational guidelines and establishment of regional biosafety risk assessment structures. When operational, the COMESA policy will provide a common decision-making framework for trade in GM crops between member states. Such bold decisions are critical to allay any remaining fears over trade barriers and boost intraregional trade.

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Can a growing world feed itself without genetically modified crops?

Brian Heap

Getty

Global agriculture produces enough to feed everyone if we take 2,720 kilocalories (kcal) per person per day as the intake that would satisfy most people who lead a moderately active lifestyle. Yet there are still 925 million who are undernourished, or about 13 per cent of today's world population, and nearly all live in the less developed countries.[1,2] The Global Hunger Index[3] has fallen from 19.7 in 1990 to 14.7 in 2012 (less than 4.9 is low hunger; 5–9.9 moderate; 10–19.9 serious; 20–29.9 alarming; and more than 30 is considered extremely alarming), but some 19 countries are in the alarming

Population pressure is an underlying factor because it can lead to the collapse ... of individual societies.

or extremely alarming categories, and urgent action is called for in Burundi, Eritrea and Haiti.

The long-term effects of malnutrition cause one in three children to have stunted growth with risks of learning disabilities, mental retardation, poor health and chronic diseases in later life. Hunger can lead to even greater hunger because of an inability to work and learn.[2] Population pressure is an underlying factor because it can lead to the collapse, or nearly so, of individual societies.[4,5] Capability-deprivation is another because it is not only a question of how people actually function that matters but their capability of functioning in important ways, if they so wish.[6] Food price volatility is a further concern due to market uncertainties, whether driven by speculative future trading of agricultural commodities or the demands of renewable fuels for land.

How can we feed more people?

Moving large supplies of food around the world would be one possibility, but it is expensive, is often the wrong type to meet the dietary needs of those in greatest need, and adds to the burden of greenhouse gases. So if we fail to feed everyone today, what are the chances we can feed an extra 2 billion people by the middle of this century, many of whom will live in the urban areas of less developed countries? Can food be produced with new technologies? Can global trade be improved through better policies? Can we reduce waste so that over 30 per cent of food is saved from being discarded and instead used to feed hungry people?[7]

Global food productivity has been a success story over the past 200 years. Science and technology have given humans power over nature through a mix of technological advances and social change.[8] Per capita food production has been raised in many parts of the world by between 1.5 and nearly 3-fold through the application of a wide range of conventional practices.[9,10] The relative global production of main grains has increased 2.5-fold over the past 50 years (wheat, barley, maize, rice, oats) and coarse grains and root crops nearly 1.5-fold (millet, sorghum, cassava and potato). Chicken numbers are up nearly 4.5-fold and pigs 2.5-fold, though cattle, buffalo, sheep and goats have increased less than 1.5-fold.[10]

In Africa, however, growth of cereal production per capita has been almost stagnant because of limitations in technology availability, investment, transportation, access to markets and security of land rights.[11] In India, by comparison, M.S. Swaminathan has described how within a half century innovative steps were taken to maximise rice and wheat yields in districts where irrigation was available, building the Green Revolution. His appeal for an "ever-green" revolution through ecologically sound and sustainable policies went largely unheeded,[2] and poverty still presents a substantial problem in many parts. Nonetheless, a persuasive case has been strongly argued by Gordon Conway for a "doubly-green revolution" as the basis of a theory of change for developing countries.[8]

High-input agriculture is criticised for its intensive practices that result in environmental costs, including the loss of 20 per cent of topsoil due to erosion, desertification and salinity; 20 per cent of agricultural land degraded by overgrazing and the generation of marginal land; and 33 per cent of forests denuded by overexploitation. Climate change, decreased water availability, loss of biodiversity, urbanisation and dietary upgrading (greater numbers of people obese than suffering malnutrition and starvation) are all recognized as a drain on food productivity. However, encouraging

Sustainable intensification – growing more from less – has become the new rallying cry.

scenarios paint a picture of 100–180 per cent more food becoming available for consumption, provided food production is achieved through sustainable systems[13] which do not have to mean a reduction in yields or profits.[14]

Sustainable intensification – growing more from less – has become the new rallying cry.[10,14,15] Each hectare of land will need to feed five people by 2050 compared to just two in 1960, and with less available water. Whereas in the past the primary solution was to bring more land into production and to take a greater quantity of fish, such options are no longer straightforward, as little additional land suitable for agriculture remains and many fisheries have been diminished.

Bright spots, as they are called, will be noted, for example integrated management schemes for pest control, livestock, forestry and aquaculture, along with conservation of soil nutrients and water supplies by reduced tillage and harvesting, respectively[14].

Currently, the best yields that can be obtained from cereal crops are significantly greater than those typically obtained by farmers.[10] Wheat yields in the UK were 2.8 tonnes per hectare in 1948 and have increased to 8 tonnes per hectare now. The best wheat growers can achieve 10–12 tonnes per hectare, limited only by water availability. This yield gap, as it is called, reflects the influence of plant breeding on yields over the last 25 years, as well as agronomic improvements, but there is little prospect of a comparable increase in the future unless the performance of crops can be radically advanced.

Will new advances in genetics help?

Closure of the yield gap has to be one of the major opportunities for the future since the gap can be as great as 50–60 per cent in countries in Asia and South America. Accelerated breeding has become a reality through new knowledge

Enhanced productivity has provided a major boost to farmer income ... with significantly reduced environmental impacts.

of plant genomes, the discovery and cloning of key genes, and the use of marker genes to aid selection. Breeders have improved their understanding of the genetics of crop yield and the capacity to manipulate determining complex characters.

First-generation biotechnological techniques consist of non-transgenic (biochemical and genomic screening, marker-assisted selection) and transgenic procedures (genetic modification by exogenous DNA sequences). They have successfully modified a few simple input traits in a small number of commercial commodity crops leading to a reduction of chemical usage in the control of destructive pests and diseases. GM cotton as a cash crop has had qualified success, but has increased overall the incomes of farmers and processors. Where lessons have been learned, plant biotechnology programmes sustained by substantial investments show significant progress.[16]

As an agricultural innovation, the adoption of GM crops worldwide has expanded rapidly. In 2012, 17.3 million farmers (out of the 525 million estimated by Global Agriculture to be farming around the world) cultivated 170.3 million hectares in 28 different countries. For the first time, developing countries grew more (52 per cent) biotech crops globally in 2012 than industrial countries (48 per cent). Enhanced productivity has provided a major boost to farmer income and to the economic value of the four major crops – soybeans, corn, cotton and canola – with significantly reduced environmental impacts through both lower pesticide use and lower carbon emissions.[17] Second-generation GM technologies are waiting in the wings with the aim of enhancing consumer benefit through increased food availability and improved nutritional quality.

It would be foolhardy to dismiss a genetic toolbox that has a unique role to play in feeding a growing population.

Genetics can be used to overcome deficiencies in dietary micronutrients such as iron, zinc and vitamin A (biofortification).[18] The best known transgenic approach is Golden Rice fortified with provitamin A. After a prolonged period in the regulatory process it is expected to be available in the Philippines within the next two years.[19] The HarvestPlus consortium has breeding programmes using available biotechnologies for six of the most important staple foods crops. The Vitamin A partnership for Africa (VITAA) works on enhancing provitamin A in the sweet potato. Industry's portfolio includes over 20 future novel traits with potential benefits for human health including omega-3 stearidonic acid (for cardiovascular disease) and low Raff-starch (for diabetes).

Encouraging signs are also emerging in Africa,[1,16] where the need is greatest. The regulatory pipelines include over 20 applications for plants with traits that provide resistance to drought, salinity, fungi and viruses, as well as enhanced nutritive value. Net economic benefits have been demonstrated but the results are variable depending on crop, trait, location and producer. They are a reminder that the science is not simple, and that time is in short supply in view of the alarming effects of global climate change. These modern planting materials have the potential to increase yields and reduce labour costs, and therefore offer the prospect of greater economic independence and social development for farmers otherwise locked into subsistence agriculture.

As with many new technologies, people are keen to identify and embrace the benefits, but continue to have concerns about the potential risks. Multiple reviews by independent councils and academies[21,22,23] and long-term studies in animals[24,25] have found no evidence of human health hazards. A new study from France initially raised concerns,[26] until, after close scrutiny, it was seen to be flawed because it "appeared to sweep aside all known benchmarks of scientific good practice and, more importantly, to ignore the minimal standards of scientific and ethical conduct in particular concerning the humane treatment of experimental animals".[27,28,29] Ethical concerns also continue[30] regarding governance of the technology, the influence of the corporate sector, the significance of a precautionary approach, and the provision of consumer choice. In the European Union, but not in California, if a food contains or consists of GM organisms, or contains ingredients produced from GM organisms, this must be indicated. One outcome has been that retailers withdraw such products from the shelves, thereby removing consumer choice.[31]

In Europe it is the manner of introduction of these new technologies and the associated regulatory regime coupled to a lack of coherent political policy that has led to polarisation and a loss of consumer confidence. This has also had negative effects in developing countries, particularly in Africa.[32] But, as Richard Flavell has commented, "crops did not evolve to serve humankind and many crops are not well designed for agriculture ... Man must continue to seek to make the crops he needs".[33]

Conclusion

We urgently require the best of options and the engagement of the natural, social and political sciences. After all, food security should be for everyone and embraces production, environment, social justice and cultures.

The Malthusian polemic of the 19th century has been replaced today by a different metaphor, the Perfect Storm.[10,34] Godfray *et al.* point out that not only is this an apt descriptor of the challenge of feeding a growing population, it also encompasses the urgent battle to mitigate rising greenhouse gas emissions and global warming, to preserve the Earth's resources, and to provide for intergenerational needs. "There is no simple solution to sustainably feeding 9 billion people, especially as many become increasingly better off and converge on rich-country consumption patterns."[10] So while the Millennium Development Goal of halving hunger by 2015[35] and efforts to restrict global warming to only a 2°C rise look to be beyond our reach, it would be foolhardy to dismiss a genetic toolbox that has a unique role to play in feeding a growing population and reducing chronic malnutrition, particularly in less developed countries.[36,37] It is no longer a Pandora's box. It has become part of the essential kit for those whom Nobel Laureate Sydney Brenner calls "natural engineers".

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Josephine Okot founded Victoria Seeds Ltd in 2004, and grew the company from a struggling start-up unable to get bank financing to become Uganda's leading seed house, marketing varieties of cereal, legume, vegetable, oil and forage crops in the domestic and regional market. She was awarded the prestigious YARA Prize 2007 for a Green Revolution in Africa in recognition of her work in reversing Africa's declining agricultural productivity. She was recognised as African Woman of the Year at the 2011 Africa Awards for Entrepreneurship for supporting, promoting and mentoring women and for demonstrating the qualities required to succeed in business. Victoria Seeds Ltd is the proud winner of the Uganda Responsible Investment Award, Best Seed Company of the Year 2013. More recently, she was nominated the 2014 Business Woman of the Year in Kampala.

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Michael J. Ssali is a smallholder coffee farmer in Uganda. He was originally a Secondary School teacher of English but in 1984 he and his wife, Mary, who was a Primary School teacher, decided to become coffee farmers. At around the same time, he started writing articles about farming that he sold to different newspapers as a freelance writer before becoming fully retained by the *Daily Monitor* – Uganda's local independent daily – in 1992. He is today the paper's Bureau Chief in the Masaka region and a columnist writing every Wednesday about farming issues. He introduced the column "Farmers Diary" in March 2008.

Index

A

B

C

DEF

GH

IJK

LMN

OPQ

RS

TUV

WXYZ

By 2050 **the world's population will rise to 9 billion. To satisfy demand, the Food and Agriculture Organization of the United Nations (FAO) has predicted that food production will need to increase by 70 per cent. Meanwhile, land and water resources are increasingly being degraded and depleted, which has serious implications for developing countries, and in particular for the African continent. These are huge challenges, but one possible solution is for farmers to combine their expert local knowledge with recent advances in biosciences.**

While growing up, I had the experience of seeing women holding their families together, heading households during civil war, and contributing most of the agricultural production in Uganda.
Josephine Okot, Founder and Managing Director, Victoria Seeds, Uganda

Biotechnology represents a powerful tool that augments conventional approaches to tackling the future challenge of food security. Professor Walter S. Alhassan, Forum for Agricultural Research in Africa (FARA), Ghana

The food sovereignty movement proved to be as popular on the far political right (for example, nationalist concerns about potential dependence on agricultural imports) as it is on the far political left (rejection of agricultural modernisation as a Western project).
Dr Philipp Aerni, Center for Corporate Responsibility and Sustainability (CCRS), Switzerland

Orphan crops are vitally important in making up Africa's food basket and industrial raw materials. Professor Diran Makinde, African Biosafety Network of Expertise (ABNE), NEPAD Agency, Burkina Faso

New plant breeding technologies do not necessarily involve the transfer of entire genes from one organism to another. Professor Dr Joachim Schiemann, Institute for Biosafety in Plant Biotechnology, Germany

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