IRMA: a case study of a science- and technology-based intervention to reduce hunger

by Seife Ayele, October 2006

This case study is about the Kenyan Insect Resistant Maize for Africa project (IRMA), which aims to increase maize production, and thereby improve food security in Africa. The study explores maize production problems, the use of genetic engineering in maize seed production, and the contested views over the genetic engineering of this crop. It also sets out the complex agro-ecological and socio-economic landscape affecting the choice of the project and its implementation: and considers the ways the project was assessed. Finally, it highlights the challenges that project staff, particularly scientists and development managers, face in the design and implementation of science- and technology-based agricultural interventions.

The key development management issue that this case study examines is the contested nature of project evaluation, and the way in which corporate interests become entwined with a 'public' project. This case study should enable you to:

- understand the nature of maize production problems which have led to the application of genetic engineering
- understand the agro-ecological and socio-economic conditions that play a part in determining the outcome of scientific interventions
- recognise some of the often conflicting and polarised views over genetic engineering in general
- appreciate conflicting positions that circulated around this project and the contestations around its evaluation.

1 Background: IRMA's origins, objectives and progress

1.1 IRMA 1 (1999–2003): origin and objectives

Maize is a widely grown major food crop in large parts of Africa. In Kenya it is a leading dietary staple accounting for 40 per cent of the calories consumed, mainly by the poor, most of whom are women and children.[1] Given the rapid population growth, the demand for maize in sub-Saharan Africa is expected to rise by 3.0–3.5 per cent per annum over the next 20 years. Sub-Saharan Africa currently imports around 2–3 million tons of maize annually and this amount is likely to rise sharply, especially through

[1] See: http://www.cimmyt.org/ABC/InvestIn-InsectResist/htm/InvestIn-InsectResist.htm accessed 25 July 2006.

food aid programmes. Maize yields are low due to biotic and abiotic stresses such as pests and diseases, drought and low soil fertility. In particular, stem boring insects inflict huge damage on maize – an estimated 13.5 per cent of the crop may be lost annually, equivalent to 417,000 tons of maize valued at US$80 million per year. IRMA originated as a response to this problem and aimed to reduce the damage caused. If successful, it would play a major role in improving yields and thereby food security.

The project started in 1999 and was publicly launched on 3 March 2000. A collaborative effort between the International Maize and Wheat Improvement Centre (CIMMYT), the Kenyan Agricultural Research Institute (KARI) and the Syngenta Foundation. The Syngenta Foundation for Sustainable Development is a charity established and funded by Syngenta, an agribusiness company. The Syngenta Foundation works mostly with rural communities in semi-arid regions to increase production and productivity of farming (see Box 1 for more details).

Box 1 Syngenta and the Syngenta Foundation

1) Syngenta

Syngenta is a world-leading agribusiness committed to sustainable agriculture through innovative research and technology. The company is a leader in crop protection, and ranks third in the high-value commercial seeds market. Sales in 2005 were approximately US$8.1 billion. Syngenta employs more than 19,000 people in over 90 countries.

http://www.syngenta.com/en/index.aspx

About Syngenta: vision and business principles

We believe in delivering better food for a better world through outstanding crop solutions, and we take pride in meeting our commitments to our stakeholders.

Our goal is to be the leading global provider of innovative solutions and brands to growers and the food and feed chain.

Our business principles:

- we are forward looking and we shape the market
- we are bold and deliver innovative solutions
- we focus on external stakeholders and work in partnership
- we grow through challenging and rewarding work
- we strive for outstanding performance and deliver our commitments.

http://www.syngenta.com/en/about_syngenta/index.aspx

2) The Syngenta Foundation

Objectives of the Syngenta Foundation

To work with rural communities in the semi-arid regions of the world to:

- identify challenges
- build on communal efforts and indigenous knowledge
- increase production and productivity of farming and land-use systems
- improve access to knowledge and technologies that are safe, reliable and affordable
- implement locally appropriate solutions
- assess impacts and learn lessons defining good practice.

Goals of the Syngenta Foundation

To improve the livelihoods of poor rural communities through sustainable agriculture, by:

- supporting well targeted projects
- helping to identify and promote good policies
- improving access to research and technology
- making knowledge and information more available
- developing partnerships that increase impact and sustainability.

Criteria for project support

1 Are the purpose and objectives clear and innovative?

2 Are the intended beneficiaries clearly identified and in what way have they been involved in identifying the purpose and objectives of the project?

3 Is there a strong local demand for the project?

4 Who are the partners and have they been engaged in the development of the project?

5 Are the objectives realistic and can progress be assessed?

6 Is there a clear end point or exit strategy?

7 How will the benefits of the project be sustained?

8 Are the resources needed available?

Vision, realism, transparency and partnership will characterise our activities.

http://www.syngentafoundation.org/
about_syngenta_foundation_objectives.htm#Objectives_Syngenta_Foundation

The Syngenta Foundation was a key driver and funder for the IRMA project. The project itself identified five specific objectives. These were product development, dissemination throughout Kenya, assessing the impact of using insect resistant maize, evaluating the issues around adoption of such technology and documentation of the project for consideration and possible roll out across sub-Saharan Africa. More detail on these specific objectives is provided below.[2]

1 Product development – development of maize varieties resistant to the major stem borer species in Kenyan production systems. The project combines conventional and transgenic approaches to produce the new maize varieties. A conventional approach allows the development of new seed varieties by the process of selection from genetic material already present within a species, while a transgenic approach develops seed varieties through insertion of genetic material from different species into a host plant. Product development requires a series of activities, including the development of research infrastructure such as laboratories, greenhouses and quarantine facilities for the crops.
2 Product dissemination – the establishment of procedures to provide insect resistant maize to resource-poor farmers. Effective product dissemination entails, among other things, the acquisition of licenses and agreements to enable the technology to be used in farmers' fields; full application of biosafety and bioethical standards and protocols; agronomic studies of insect resistant maize; and dissemination of insect resistant maize to farmers.
3 Impact assessment – assessment of insect resistant maize varieties in Kenyan agricultural systems, including assessment of demand; and of the acceptability of the technology to farmers.
4 Technology transfer – transfer across Kenya and the development, evaluation, dissemination and monitoring of maize varieties.
5 Project documentation and communication – processes and achievements need to be planned, monitored, and documented for dissemination to other developing countries.

Unlike many donor-funded agricultural research and development projects in Kenya managed by KARI, IRMA is an autonomous project. Its management team is based in Nairobi, at the International Council for Research in Agroforestry. The research and development facilities are on KARI campuses at various sites. The autonomy of the project was meant to serve multiple purposes. It would allow IRMA to develop new initiatives quickly by avoiding the bureaucratic structures of KARI. Its financial business would be independently managed and accounted for (overcoming the allegedly corrupt practices of large public sector agencies in Kenya). Autonomy would also raise the project's profile as a pan-African initiative.

[2] See: http://www.cimmyt.org/ABC/InvestIn-InsectResist/htm/InvestIn-InsectResist.htm accessed 25 July 2006.

Reviewing IRMA grey literature and talking to IRMA staff, there is a lack of clarity as to when the project will deliver on its objectives and come to an end. The period 1999 to 2003 (what has now come to be known as IRMA Phase I) has resulted in the establishment of a framework for achieving the goals. In this period, with an estimated investment of US$6.2 million, the project views its successes as pertaining to a number of areas as outlined below (see Alhassan et al., 2003; Ayele, et al., 2006):

- Research and development: maize varieties effective against four of the five stem borer pests have been identified;

    Considerable research infrastructure was built. At KARI Biotechnology Centre a modern laboratory was developed, along with a state-of-the-art greenhouse built at the cost of around US$130,000. An open field quarantine site and a reference insect collection were constructed.

    There was also significant human resource development. For example, Kenyan scientists were trained in biosafety and greenhouse operations.

    Institutional and organisational capacity building, which contributed to biosafety system development. IRMA's chief scientists are regularly consulted by policy makers on biosafety issues; they also communicate genetic modification (GM) technology issues to stakeholders and to the public.
- Publications: the team produced substantial scientific, socio-economic and progress reports. IRMA's experiences and protocols are carefully documented with a view to sharing them with other projects within and outside Kenya.

However, despite these documented and stated successes, IRMA's biggest challenge to date remains: the target products have yet to be produced and delivered to smallholder farmers.

1.2 IRMA II (2004–2010): delivering products to farmers

At the end of 2003, a review team was set up to assess IRMA's progress and document the lessons learnt (Alhassan et al., 2003). The three-member (and facilitator) team was appointed by the Syngenta Foundation. The lead members, Professors W.S. Alhassan and N. Olembo, were selected for their work in biotechnology across Africa. The team used a combined review methodology and spent 12 days in Kenya – 8 days on visits and interviews and 4 days on writing up their findings. Two feedback sessions were held in Nairobi with CIMMYT, KARI and officials from the Kenya Government. The review methodology involved:

- access to existing documents and literature produced by the programme
- interviews with key staff of both CIMMYT and KARI
- interviews with key stakeholders
- visits made to major sites in Kenya
- observations made during visits.

See details in Alhassan et al. (2003): http://www.syngentafoundation.org/pdf/kenya_irma_project_review_2003.pdf

The team declared that IRMA I's achievements were 'remarkable and excellent' (Appendix 1 to this case study has the executive summary of their report). They noted, however, that there was a delay in product development and delivery – the project timeline had been 'grossly underestimated' (ibid, p. 1) – this was attributed to two factors: the complexity of biotic and abiotic factors such as the understanding of the effect of drought on *Bacillus thuringiensis* (Bt)-maize variety development, and delays in putting biosafety processes in place. The review concluded that it would take 5 more years to develop the target products, and recommended further funding of the project, which led to the birth of IRMA II.

A careful reading of the executive summary of the report suggests the difficulties faced by the consultants in reviewing the project and finding appropriate language to convey their findings. This is most starkly demonstrated by the phrases 'remarkable and excellent' sitting alongside 'grossly underestimated'. While the author of this case study has not had sight of the brief given to the consultants, it can be assumed that they would have had to juggle a number of complex and contradictory considerations. The recommendations suggest that far reaching change was thought necessary together with a quickening of the pace of development of the Bt-maize variety. They provide a list of substantive measures that should be followed to achieve this. But they are also conscious that the Syngenta Foundation is financing the review and therefore paying their fee, with a view to securing the participation of other agencies to move the project forward. As such, there is a need to present the project in a positive light, but to be circumspect in this respect so as not to undermine their individual credibility and professionalism. They also need to be constructive in their recommendations for action in order to justify their fee. These are pertinent issues that underpin all evaluation processes but which are rarely explicitly engaged with for obvious reasons.

On the back of the report, IRMA II was launched in 2004, at a cost of US$6.7 million, to carry out the objectives and activities of IRMA I and deliver products to farmers by 2010.[3] Its core activities are to undertake the project's original objectives (as set out above), particularly ensuring the production of maize seeds. The principal project partners remain the same, but others have joined in, such as the African Agricultural Transfer Foundation which was brought in to help with matters related to intellectual property. However, it is unclear whether IRMA II will end in 2010, on schedule.

IRMA II's progress over 2004/05 showed both high and low points:

- Conventional maize seeds resistant to stem borers were developed and were close to release in 2006. But the new seeds provide damage protection of only up to 40 per cent.

[3] See: http://www.scidev.net/content/news/eng/revision-of-plans-delays-kenyas-gm-maize.cfm accessed 25 July 2006.

- Field trials of Bt-maize (supposed to provide 100 per cent plant protection) began in May 2005, but were halted in August 2005 and the plants destroyed – after the government discovered that the Bt plant was (apparently accidentally) sprayed with a restricted pesticide.[4]
- IRMA II's challenges are still significant; even if Bt-maize seeds were successfully produced there are further hurdles ahead such as testing.

2 The political economy of plant genetic engineering and evaluation

That insect pests, and a range of other constraints such as weeds and plant diseases, affect crops is widely understood in Africa. Such constraints are seen as perpetuating the cycle of food insecurity and poverty on the continent. However, the questions that many Kenyans have been asking, particularly those opposed to the introduction of Bt-maize in their country, are why concentrate on maize, and why target stem borers? Exploring the answers to these and related questions exposes a more complex and charged debate about the project. Moreover, while IRMA was technically located in Kenya and led by KARI, other actors and factors, as discussed below, had key roles in its origin and development.

2.1 IRMA: a public–private partnership

In the late 1990s, as part of its global remit, CIMMYT was looking for multinational private sector donors and research partners in developing countries to develop and deliver insect resistant maize germplasm. It approached Novartis (now Syngenta) as a possible donor. The company accepted the request to support the research which was presented as providing a public good for the poor (De Groote et al., 2004).The leading member of the Board of Trustees of Syngenta Foundation, Klaus Leisinger, made the following statement in response to questions about the motives of Syngenta:

> ... neither Novartis nor Syngenta, which has taken over its seed business, has the slightest economic interest in the project. In Kenya, we are quite intentionally providing support for a public research institute'
>
> (See Appendix 2 to this case study for the whole interview with Klaus Leisinger)[5]

The Syngenta Foundation's interest in the project is likely to be complex, and beyond the analytical reach of this case study. However, it does seem likely to the author that a key interest was the advocacy role that the project could

[4] See: http://www.scidev.net/content/news/eng/kenya-halts-first-field-trials-of-gm-maize.cfm accessed 25 July 2006.

[5] See full interview in: http://www.syngentafoundation.org/diversity_pest_control.htm

present for Syngenta. As Klaus Leisinger says in the final stages of the interview:

> Our ambition is to present an example with IRMA of the way in which a controversial topic can be handled openly and honestly – for the welfare of small-scale farmers and the benefit of the growing population in the sub-Saharan countries.

A further consideration for the Syngenta Foundation is likely to have been strategic. Unlike many African countries, Kenya has relatively developed research infrastructure and showed a keen interest in adopting GM technology (De Groote et al., 2004). Developing Bt-maize in Kenya would thus be more likely to succeed and readily mesh with Kenyan interests. Such strategic benefits would have been perceived as substantial by Syngenta.

IRMA was presented as a blueprint for successful partnerships.[6] It was argued that by drawing on their complementary resources and strengths, the three partners aimed to create products which would otherwise have been difficult to create in Kenya. KARI brought to the partnership its scientific and institutional capabilities for undertaking research to adapt the new technology to the local conditions, and linking research with an extension system to allow subsequent delivery of new seed varieties to farmers. CIMMYT provided the source plant with Bt genes (the bacterium *Bacillus thuringiensis*) effective against stem borers, and expertise in a range of areas including genetic engineering and biosafety. The Syngenta Foundation has been the major funding body, as well as facilitating access to private sector training (see IRMA, 2002; Ayele et al., 2006).

2.2 Debating genetically modified organisms (GMOs)

A repeatedly stated advantage of GM maize is that the technology is embedded in the seed, hence easy to disseminate (De Groote et al., 2004, p. 2). Bt-maize seeds alleviate the need for farmers to buy additional insecticides to control stem borers. The fact that IRMA combines conventional and transgenic approaches also offers farmers a choice of alternative seeds, as senior CIMMYT official Dr David Hoisington noted. According to a senior KARI scientist, the late Dr Ben Odhiambo, the GM route also offers benefits in terms of environmental and human health impacts, from reduced use of pesticides.[7] The seeds, thus, support food security by increasing yield of maize, and reducing yield variability and risk.

Thus, IRMA's development of Bt-maize is based on the premise that GM technology has proved its usefulness. Further experimentation is necessary only to build capacity to more fully exploit the technology. Moreover, they argue that experimentation also makes communication with policy makers

[6] See: http://www.cimmyt.cgiar.org/ABC/InvestIn-InsectResist/pdf/IRMAPartners.pdf

[7] At the time of the interview (September 2003) Dr Hoisington was chairman of CIMMYT's Applied Biotechnology Centre (ABC), while Dr Odhiambo (interviewed in January 2004) was head of KARI's Biotechnology Centre.

and the public real and demonstrable, and thereby raises awareness and overcomes fear about the technology (see Appendix 3 to this case study for the case for GMOs made by De Groote et al. (2004)).

Opposition to IRMA and GMOs in Kenya is not well organised or developed. It is largely composed of local consumer societies, farmers' associations, organic farmers, and academics and focuses upon highlighting the potential risk – concerns over food safety, ethics, and the negative trade impact with countries opposed to GMOs. For John Njoroge, who represents organic farmers, and Samuel Ochieng, who speaks for consumers,[8] the concerns are about the possible side effects of the technology – on smallholder farmers and consumers, and the environment and biodiversity. Njoroge, Ochieng and others have tried to raise their concerns and position these issues for public debate. However, discussion with them revealed that they felt that a powerful public relations machine fuelled by pro-GM groups had stymied their efforts. Their campaign had effectively been marginalised. Njoroge noted that while the majority of the Kenyan scientific community is supportive of the GMOs, people like him are framed as 'dissenting voices'. According to both Njoroge and Ochieng, lack of public awareness is being used to push the technology forward. Both appear to think that if informed more fully, the general public and particularly farmers might become more sceptical of the technology, which would strike a major blow to KARI and its scientists.

In particular, Ochieng blames KARI researchers for the poor state of awareness of GM biotechnology among the farming population:

> ... KARI researchers are trying to keep the farmers away from the public debates about the technology. ... a lot of the funding for the research activities around biotech is directly funded by the biotech industry ... There is very little government funding for research activities in this area in this country. There was a time I specifically talked to someone at KARI, and they told me that if we were going to be very strong to stop these biotech activities, then KARI [biotech centre] would sort of close down. Because ... in our culture we say that the person who pays for the song, is the one for whom the song sings. So I think that the master, the one really in control, makes it very difficult for the other side of view to be heard.
>
> (Ochieng, 2005)

The opposition is also frustrated by the pre-emptive stance taken by the political decision-makers:

> when already the ministers have taken a position, then it really squeezes alternative debate, because it's like, they're the ones in charge, and they've seen that this is a good thing for us.
>
> (Ochieng, 2005)

[8] At the time of the interview (February, 2004), Mr John Njoroge was director of the Kenyan Institute of Organic Farming. The interview with Mr Samuel J. Ochieng (Chief Executive of the Consumer International Network, Nairobi, Kenya) was conducted by the author in June 2005.

While the IRMA public–private partnership arrangement is held as unique, Njoroge sees it as means of containing opposition to the technology:

> ... the multinational [companies] come here and hide themselves behind research institutions. They give donations, financial and technological, but without exposing their presence. ... unless you have somebody who is visible then you cannot lobby against or campaign against them.
>
> (Njoroge, 2004)

Thus the opposition to GMOs has been unsuccessful in finding a strong voice or in opening a public debate around the issue. The political, scientific and foreign economic interests have been able to prevent this issue from reaching a wider audience. However, one issue around which some discussion has coalesced has been whether stem borer damage was significant, and whether stem borers were a priority for poor and smallholder farmers. In a nutshell IRMA, originally initiated as a scientific and technical project to deal with stem borers, has become an arena for debating the broader development of GM technology in Kenya (and in large parts of Africa).

2.3 User involvement and user priority identification

While the rationale for the project was framed in terms of the interests of the poor and smallholder farmers, the level of consultation with farmers and consumers appears minimal. Early discussions around the introduction of Bt-maize to Kenya were confined to the scientific community and focused upon setting up institutions for handling biosafety systems (Siambi et al., 2000). Moreover, the extent of the damage inflicted by stem borers was not fully known, nor whether stem borers were indeed major constraints to maize production. It appears that information about the impact of stem borers, like other constraints on farmers, was derived from patchy farm surveys, which were then used to justify CIMMYT's initiative. The IRMA team, however, consistently stressed that in maize 'the most critical pests are stem borers' (see for example, Mugo et al., 2003). Thus, we have a situation where the level of investigation and efficacy of any results used to justify the project intervention is highly contested and politicised.

As part of the impact assessment objective, the IRMA team conducted a series of studies to assess the maize varieties that farmers grow and their preferences in choosing varieties, and to evaluate farmers' perceptions of constraints to maize production (see for example, Odendo et al., 2002; De Groote et al., 2003). These IRMA studies, conducted on the basis of a Participatory Rural Appraisal approach, revealed some interesting findings.

Firstly, contrary to the team's assumptions, the farmers' order of criteria in selecting seed varieties was in the following order: high yield, early maturity, tolerance to striga (parasitic plants dependent on host root attachment for survival), tolerance to drought and resistance to insect pests of which stem borers are one variety. Other key problems perceived by farmers were soil fertility, lack of financial resources to purchase fertilisers and seeds, and low technical know-how. Thus the studies clearly showed that stem borers were considered less of a priority to the farmers than drought or striga.

Secondly, some 80 per cent of the farmers grow local maize varieties and recycle seeds. But the development of new seed varieties would mean that farmers need to switch to a new practice of purchasing fresh seeds, presumably from seed companies. The distinctive characteristics of maize[9] would require this change, to ensure the quality and productivity of the new varieties.

Thirdly, weevils (a species of beetle) inflict considerable loss to maize in storage, and this undermines the purpose of protecting the crop in the fields, only to lose it in storage. The project, therefore, started to address this problem, carrying out studies which led it to modify its core objective (IRMA, 2001).

2.4 Estimates of losses to stem borers and benefits from Bt-maize

These studies helped the IRMA team come to know the real magnitude of stem borer damage, but only after the launch of the project. This is of vital importance because the rationale for the project was built on a presumed problem around stem borers. Hence, baseline data was key in determining whether the project was well targeted, viable, and ultimately how realistic the scenarios over possible impacts were.

In 2001 the national estimate of crop losses to stem borers stood at 16 per cent (417,000 tons) of total production (2,671,000 tons) – and this estimate was based on studies covering all six major ecological zones, twenty-seven villages, 135 fields, over the short and long rainy seasons of 2000 (De Groote et al., 2003). Estimates of people dependent on maize also varied widely. Repeatedly cited statistics were the annual consumption levels of 79 kg per capita in eastern and southern Africa and 125 kg per capita in Kenya.[10] So, it was not clear how dependent people were on maize or how much was lost.

These problems of assessing impacts from data are also evident in the projected benefits of the IRMA project. When it comes to the benefits from Bt-maize, IRMA's team repeatedly note that full protection against stem borers was valued at about US$80.4 million per year.[11] But this is the best possible scenario. There are at least three major problems with this assumption:

[9] Maize has distinctive characteristics (Morris, 2002, p. 4): it has the ability to open-pollinate. But other major food crops like wheat and rice are self-pollinating; the pollen used to fertilise a given ovary almost always comes from the same plant, resulting in each generation of plants retaining the essential genetic and physiological identities of preceding generations. This has huge implications for farmers' seed selection and exchange. What is regarded as high quality maize seed cannot be guaranteed to retain its qualities for generations. Farmers need to purchase fresh seeds in order to ensure productivity.

[10] See: http://www.cimmyt.org/ABC/InvestIn-InsectResist/htm/InvestIn-InsectResist.htm accessed 25 July 2006.

[11] Valued at US$193/ton (5 years average price per ton at the time) US$80.4 million (estimates vary, based on the annual crop production) – see De Groote et al., 2003.

1 Seed production could prove a constraint as there are not many seed companies interested in the development and delivery of Bt-maize (De Groote et al., 2003, p. 11).

2 Not all farmers are likely to adopt Bt-maize, yet the team still assumed that about 67 per cent of farmers will. Experience shows that successful adoption of an agricultural technology needs to be well received by farmers and extension workers, and it needs to be effective, economical and safe (Ayele, 2005). From impact assessment surveys, it is already known that farmers lack the financial resources to purchase seeds. As a novel product associated with environmental and ethical concerns, adoption rates, particularly in the early years, are likely to be low.

3 Farmers' constraints vary from individual to individual and region to region. Table 1 shows crop losses to the five stem borer species across Kenya's agro-ecological zones. It clearly shows that most crop losses occur in highlands and moist zones, and are due to the *Busseola fusca* species. IRMA's success, therefore, largely depends on producing a seed variety effective against *B. fusca*, and supporting farmers in the most productive areas of the country. Unfortunately, as yet the IRMA team has not found the solution to *B. fusca*.

Table 1 Distribution of total crop losses to stem borer species over different agro-ecological zones (per cent)

	Five main stem borer species					
Agro-ecological zone	*Chilo partellus*	*Busseola fusca*	*Sesamia calamistis*	*Eldana sacharrinna*	*Chilo orichalcilielus*	Total
Highlands	0.0	24.9	1.3	0.0	0.0	26.2
Moist transitional	12.3	31.7	2.7	0.5	0.0	47.2
Moist mid-altitude	5.9	4.4	0.7	0.2	0.0	11.2
Dry mid-altitude and dry transitional	9.8	1.8	1.8	0.0	0.0	13.4
Lowlands tropics	1.4	0.0	0.1	0.0	0.4	1.9
Total	16.5	81.8	0.1	0.0	1.7	100.1

Source: data adapted from De Groote et al., 2003

2.5 Evaluating IRMA's assumptions and objectives

Given the contentious nature of the data and its implications for the entire project, how was IRMA's evidence evaluated? There appear some 'standard' criteria, which were used in a range of studies. Table 2 shows a comparison of assessment results by deGrassi (2003) against that of De Groote et al. (2003; 2004).[12] The criteria used were:

[12] Drs Aaron deGrassi and Hugo De Groote are researchers at the Institute of Development Studies, Sussex, UK and IRMA/CIMMYT, Nairobi, Kenya, respectively.

1 site-specificity: to assess whether new and improved agricultural technologies respond to different farms in different agro-ecological zones
2 demand-led: to ensure that an intervention responds to farmers' diverse and changing priorities
3 poverty-focused: addressing the demands of poor farmers operating under difficult agro-ecological and socio-economic conditions
4 cost-effective: recognising the need for prioritising and choosing the most cost-effective technology among an array of alternatives
5 environmental and intuitional sustainability: to overcome toxicity, soil erosion, and donor fatigue.

Table 2 Evaluating IRMA's Bt-maize: conflicting results

Evaluation criteria	Aaron deGrassi (2003) (Institute of Development Studies, Sussex, UK)	Hugo De Groote et al. (2003; 2004) (IRMA, Nairobi, Kenya)
Site-specificity	Low: crop varieties with traits specific to farmers' agro-ecological and socio-economic conditions have not been developed. IRMA works on 'non-African' borers of interest to multinational companies	High: five stem borer species (across six major agro-ecological zones) have been addressed. Effective Bt genes have been found for all but *B. fusca*
Demand-led	Low: farmers face more pressing constraints such as striga; and ensuring farmers' acceptability of Bt-maize (economic, ethical considerations) and developing and delivering it could prove difficult	High: maize is an important food and cash crop, farmers' perceptions of the stem borers and crop loss to stem borers are high
Poverty-focused	Low: drought, low soil fertility, striga, etc. perpetuate poverty. Bt-maize either fails to reach poor farmers or as poor farmers are not net food buyers they fail to benefit from price falls	High: poor families have higher food expenses; hence substantial impact in poverty reduction could be achieved
Cost-effective	Low: the opportunity cost of millions of dollars spent on this project is high. 'Less generously funded' projects have proved effective	High: Bt genes effective against all five species of stem borers could save up to US$80 million a year, against marginal costs
Environmental and institutional sustainability	Low: concerns (such as risk of resistance) remain about environmental sustainability of Bt-maize. Project is external donor dependent	High: environmental and human health impacts from reduced use of pesticides; the project is well funded

The two key studies used similar criteria, but came up with quite different interpretations (Table 2). From Table 2 and Appendix 3 we can see that De Groote et al. (2004) conclude that objections to Bt-maize are based on 'myths'. In contrast, deGrassi's (2003) conclusion was that IRMA's Bt-maize showed low site-specificity and demand, poor cost-effectiveness, and poor institutional sustainability.

From the data and analysis above, it is apparent that the IRMA team – that is De Groote et al. – respond by rebuffing the claims of others. It is a reactive form of evaluation. In the case above they produced original scientific evidence directly to oppose the criticisms labelled against them by deGrassi (though he is by no means the only critic).

3 Conclusion

There has been, in recent years, an increasing realisation that substantial gains in food production cannot be achieved without science, technology and innovation policy (UN Millennium Project, 2005). In this context, IRMA and similar projects are likely to support efforts towards improving food security in Africa.

IRMA was set up as an innovative partnership model. Drawing on the complementary resources and strengths of its core partners, it is developing products which otherwise would have been difficult to create in Kenya. It actively works on linking research with development and delivery of products. IRMA has been aware of, and committed to, addressing barriers such as the weaknesses of the private sector in delivering products to farms. It also assists the Kenyan biosafety review programme.

However, IRMA's project initiation was relatively weak in involving farmers and extension workers at the outset in the shaping and implementation of the project. Consequently, the project started off with poor understanding of the socio-economic circumstances of the farmers, their preferences for technologies, and the specific agro-ecological constraints they face. IRMA's project timeline has been underestimated too. While a single project cannot be expected to address all the problems that farmers face, it becomes apparent that those with economic and political power (as well as those with scientific knowledge) primarily decided on the choice and implementation of IRMA.

Acknowledgement

This case study is based on research conducted in Kenya over the period 2003 to 2005 funded by the UK Economic and Social Research Council (ESRC) Science in Society Programme (Award Reference Nos: RES-151-25-0002 and RES-160-25-006). The author gratefully acknowledges this support. The views expressed in the case study do not necessarily reflect those of the ESRC or the Programme.

Appendices

Appendix 1: Insect resistant maize for Africa project review report

Appendix 2: An interview with Klaus Leisinger of the Syngenta Foundation

Appendix 3: Debunking the myths of GM crops for Africa: the case of Bt-maize in Kenya

Appendix 4: Evaluation of GM maize in Africa

Appendix 5: Glossary

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Appendix 1

Insect resistant maize for Africa project review report

The review of IRMA Phase I. http://www.syngentafoundation.org/pdf/kenya_irma_project_review_2003.pdf

Nairobi, Kenya, 2–14 February 2003.

1 Executive summary

The initial phase of five years in the partnership between CIMMYT, KARI and Syngenta Foundation in the IRMA project will expire by the end of 2003. In order to bring forward the strategy for the next phase Syngenta Foundation has proposed to carry out a strategic review of progress made and lessons learnt in order to establish a detailed business plan which shall be the basis for contact with other donors who might be participating.

Achievements of the IRMA I have been remarkable and excellent work has been done by a highly motivated team.

The target product is yet to be delivered which means that the timeline has been grossly underestimated. This was due firstly to the complexity of the biotic and abiotic factors influencing maize development in addition to stem borer damage. Secondly, the biosafety regulatory process although in place, has contributed to the delays due to slow acquaintance with formalities and understanding of the function of the different national committees.

The review team recommends a second phase IRMA under the following provisions:

Closer collaboration should be intensified between KARI, farmers and extension which should lead to the launching of a product obtained through conventional breeding by 2005 and Bt-maize by 2008 to meet the farmers' expectation and to avoid disillusion.

KARI should nominate a counterpart to the CIMMYT Kenya IRMA coordinator:

- A key person should be identified by KARI to follow up regulatory processes in order to avoid delays.
- More of the remaining fundamental work should be performed in KARI under the scientific leadership of CIMMYT.
- In order to meet the challenging time schedule more collaborative activities should be undertaken with institutions such as ICIPE [International Center for Insect Research and Ecology] pursuing similar research goals.
- The marketability of Bt-maize locally and regionally should be examined. Product identification by seed companies and the farmer will present new challenges.
- The Intellectual Property and Biosafety issues as well as delivery systems have to be considered and closely monitored.
- Issues related to liability and farmers' ability to recycle seeds must receive attention.
- A detailed business plan must be presented by mid May 2003 to Syngenta Foundation.

Appendix 2

An interview with Klaus Leisinger of the Syngenta Foundation

http://www.syngentafoundation.org/diversity_pest_control.htm

IRMA breaks new ground in Kenya

Interview with Klaus M. Leisinger, member of Board of Trustees of the Syngenta Foundation for Sustainable Agriculture, on methodological diversity in pest control.

Dr Leisinger, does the research project on Insect Resistant Maize for Africa (IRMA) mean that the agribusiness is transferring biotechnological field research, which has been banned in Europe, to the Third World?

> Leisinger: 'No. It is not agribusiness that is promoting the IRMA project, but the International Center for the Improvement of Maize and Wheat (CIMMYT), an international research organisation associated with the World Bank, and the Kenyan Agricultural Research Institute (KARI)'.

So the accusation leveled by development organisations that the experiments in Kenya are evidence of unscrupulous power hunger on the part of agricultural corporations is wrong?

> Leisinger: 'Yes, it's completely wrong. To begin with, IRMA is concerned with developing insect-resistant maize ...'
>
> ... using agrobiotechnology ...
>
> Leisinger: '... using every method that is known – biological pest control, traditional breeding methods, and also genetic technology'.

And second?

> Leisinger: 'Second, neither Novartis nor Syngenta, which has taken over its seed business, has the slightest economic interest in the project. In Kenya, we are quite intentionally providing support for a public research institute'.

Why?

> Leisinger: 'Because the research at KARI is competent, has practical relevance, and directly benefits poor farmers. In addition, however, to help prevent biotechnology research from being carried out only by private companies, which are only able to make investments when there are profits to be earned'.

And there aren't any to be earned in Kenya?

> Leisinger: 'The market is very small and the farmers are usually penniless. There is practically no profit that could be made'.

It's hard to believe that your Foundation's commitments are completely without ulterior motives.

> Leisinger: 'There aren't any'.

Let's suppose the Kenyan scientists are successful and manage to breed a reliably insect-resistant variety of maize that also produces good crops. Who would the patents belong to?

> Leisinger: 'It's a hypothetical question, because it anticipates a lot of things we don't know about yet. In any case, our view is that the rights would belong to the institution making the discovery'.

Meaning KARI?

> Leisinger: 'Yes. Patent issues also need to be clarified in the course of the project. It's new territory for Kenya as well'.

How much money are you allocating to IRMA and how long will the research work last?

> Leisinger: 'Kenya is the first and probably the most important station for the IRMA project, which includes seven sub-Saharan countries. For the whole project, we are intending to spend US$6 million during the next five years'.

Is that enough time?

> Leisinger: 'We'll have to see. We will certainly not put anybody under time pressure'.

Is it difficult to find farmers willing to take part in the experiments?

> Leisinger: 'It will take a while yet. At the moment the researchers have only got as far as measuring the crop losses caused by the stem borer precisely. But it is true, the project leaders already have difficulties explaining to the village elder why it's not him but his neighbours who have been selected for the project'.

What are the criteria used?

> Leisinger: 'The farmers have to be able to read and write, or have someone in the family who can, so that they can keep records of their experience. Also they have to be in direct contact with their district's agricultural extension service. Still, as I have said, Kenyan Bt-maize will only start growing on the farmers' land a few years from now – if at all'.

What do you mean by that?

> Leisinger: 'That the results of the research project must not be anticipated. IRMA is an open-ended project'.

Are you just wanting to investigate how much the yield increases when new maize varieties are used, or are you also using ecological criteria?

> Leisinger: 'Of course we are using ecological criteria. It's important to note once again that what IRMA is aiming for is not the introduction of Bt-maize, but the breeding of insect-resistant maize varieties, using every method that might be appropriate. In the field of biotechnology research, the same cautious method of proceeding is being used as in the industrial countries. Even in Kenya researchers are obliged to proceed with all possible caution'.

Have you looked for farmers willing to form a control group and only use beneficial insects like the parasitoid against the stem borer?

> Leisinger: 'No, because we already know that it works in specific conditions. The so-called push–pull method also has its merits in selected

> locations. We want to compare the advantages and disadvantages of the various approaches. Because we are convinced that there is not going to be just one single patent remedy for the stem borer problem'.

Are you in touch with the project's critics, for example with researchers at the International Center for Insect Research and Ecology (ICIPE) in Nairobi?

> Leisinger: 'Yes, the scientists at KARI and CIMMYT maintain a lively exchange of views with the ICIPE'.

With no communications problems?

> Leisinger: 'The goals at IRMA are well known, and the ICIPE knows that we appreciate biological methods, although we do not want to restrict ourselves to them. In insect protection, the goal is more important than the path by which it is reached'.

Assuming that future new varieties of maize live up to what people expect of them, will it not automatically lead to a reduction in species diversity? The farmers will then only plant genetically manipulated Bt-maize and neglect their own breeding varieties.

> Leisinger: 'No. In exactly the same way as in Europe and the United States, farmers in Africa are people with a will of their own. Studies have shown that many of them want to stay with tried and tested methods. Also, genetic technology is only supplementing the existing seed banks available at KARI. There will be no standardised Kenyan Bt-maize. In a country that is so geographically varied that would hardly be possible. The characteristics of the new varieties will be cross-bred with the normal seed in the traditional fashion'.

From time immemorial, farmers have always kept back part of their harvest to use it for the next sowing. This does not seem to be possible any more with genetically altered seed. The industry even holds patents for procedures preventing even just a single additional use that would allow individual hybrid varieties.

> Leisinger: 'The 'terminator technology' you are talking about – which by the way has so far not gone beyond the laboratory stage – is something I oppose as a technology for subsistence farmers. It would lead to new forms of dependency for these people – and their life is hard enough as it is already'.

It seems that the Kenyans are less afraid of health reactions, such as allergies, caused by GM foods than Europeans are.

> Leisinger: 'Yes, so far the issue hasn't arisen. It may be that a well-fed society has more worries about that sort of thing than people who are well aware that their food supply is already no longer secure'.

How do you deal with the enthusiasm shown by the small-scale farmers who are wanting to use Bt-maize inside the next six months?

> Leisinger: 'The pressure is actually greater than expected. The project's directors have to make it clear to the farmers that they will have to wait. In any case, scientific quality and biological safety take priority over fast results in the field'.

With this kind of pressure, isn't there a danger that the research will be done in a hurry and that people will declare themselves satisfied with half-finished studies so that the results can be put into action quickly?

> Leisinger: 'That would be the worst possible thing that could happen. Our involvement can only be justified if exactly the same care is taken during the research as it would be in Europe or anywhere else'.

How can you make sure that will happen? You are involved in a country that has the reputation of being among the most corrupt in Africa, if not the whole world.

> Leisinger: 'I have no wish to pass any sort of judgement on Kenya in this connection. I lived there for many years and I love the country and its people. However, we are aware of the dangers and are keeping strict control of the financial resources'.

And scientifically?

> Leisinger: 'We regularly present a public account of the progress of the research. Our ambition is to present an example with IRMA of the way in which a controversial topic can be handled openly and honestly – for the welfare of small-scale farmers and the benefit of the growing population in the sub-Saharan countries'.

The interview was conducted by Jürg Bürgi, a freelance journalist from Basel, Switzerland.

Appendix 3

Debunking the myths of GM crops for Africa: the case of Bt-maize in Kenya

De Groote, H., Mugo, S., Bergvinson, D. and Odhiambo, B. (2004) 'Debunking the myths of GM crops for Africa: the case of Bt-maize in Kenya', Paper Presented at the Annual Meetings of the American Agricultural Economics Association, August 4, Denver, Colorado. http://www.syngentafoundation.org/insect_resistant_maize.htm

Debunking the Myths of GM Crops for Africa: the Case of Bt Maize in Kenya

Hugo De Groote, Stephen Mugo, David Bergvinson, and Ben Odhiambo

Extended Abstract of a Presentation at the Annual Meetings of the American Agricultural Economics Association (AAEA), Denver, Colorado, August 4 2004

BACKGROUND

GM crops have been highly successful in developed countries, increasing yields and profits without negative health or environmental effects. However, the technology has generally not been well received in Europe, where environmentalists and green activists are worried about irreversible environmental damage. Moreover, European agriculture has a consistent overproduction problem, so yield enhancing technologies are not their first priority; the powerful farmers' organizations would rather protect their markets from external competition. Expected benefits to the European consumer are also small. Therefore, Europe has accepted the precautionary principle, which imposes very stringent regulations and requirements of risk assessment on GM crops, basically banning them for the time being. In 2004, Europe approved the importation of the first GM maize food, but use of GM maize seed is generally not allowed.

African countries are caught in between: should they embrace the technology to help feed their hungry people, or rather protect them from potential dangers? Potential advantages of the technology include: increased yield (for the only continent that has benefited little from the Green Revolution), increased food security (for the only region in the world where the percentage of malnourished children is expected to rise during the next 20 years), and a technology easy to disseminate (for a region where extension services have collapsed and liberalization is lagging).

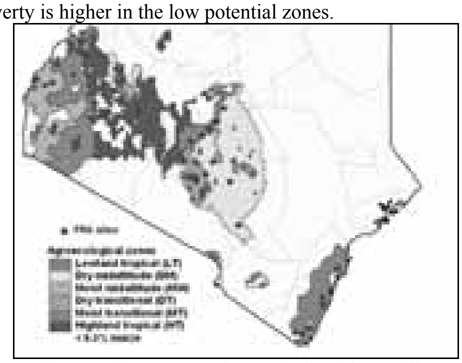
Despite these potential benefits, deployment of GM crops in Africa remains highly controversial. Among the arguments against them are: GM crops would not respond to small farmers' priorities, their traits would not reply to a particular demand, and seed would be expensive. GM technology would only be beneficial to the agro-business, who can protect their interests through Intellectual Property Rights (IPR) and terminator genes, and make farmers dependent on new varieties while they loose biodiversity of their old ones. Further, GM crops could pose serious risks to the environment through the development of resistance in the target insects, gene flow into weeds and local varieties, and from the disruption of non-target organisms. Moreover, African countries might not be sufficiently equipped with the appropriate bio-safety regulations to make an informed choice. Finally, it is argued that poor people, if given a choice, would not necessarily opt for GM crops but might prefer other solutions.

We argue that African farmers and consumers have the right to choose their own technologies, based on the best available knowledge. African scientists need to develop and test GM crops on the alternative precautionary principle: poor farmers and consumers risk being denied a chance to improve their livelihood based on an academic debate in which they cannot participate. On this principle, the Insect Resistant Maize for Africa (IRMA) project was launched in 1999, using both conventional breeding and biotechnology, and combining the best available science, bio-physical as well as social. After five years of research in the first phase, it can be shown how most, but not all, concerns against Bt maize can be answered.

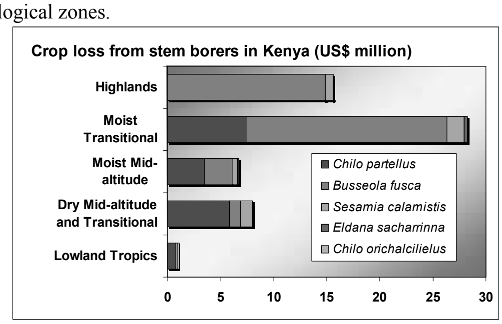
RESULTS

Demand for Bt maize

Demand for Bt maize is likely to be high. Maize is the major food crop in Kenya but, after progress in the 1960s and 1970s, maize yields and production have stagnated while production per capita has decreased. While more maize is grown in the high potential zones, the level of poverty is higher in the low potential zones.



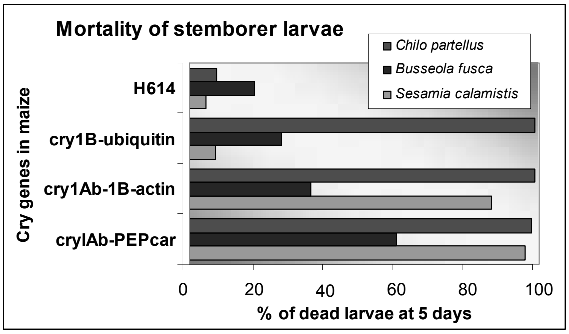
During participatory rural appraisals with 43 villages in all maize agroecological zones, more than 900 farmers explained which varieties they grow and why, and expressed the constraints and pest problems they face. Most farmers grow local varieties, except for the high potential zones. The two major criteria for variety selection are early maturity and yield, with three other important traits: tolerance to drought, field pests and storage pests. The three major constraints to maize production were cash constraints, lack of technical know-how and extension, and problems with maize seed: high cost, poor quality and low availability. Pest problems are usually found in the top six constraints. The two most important pest problems farmers encounter are stem borers and weevils, which rank in the top three in all agro-ecological zones.



Yield losses due to stem borers were calculated based on farmers' estimates from a survey of 1400 farmers, and resulted in a first estimate of 12.9%. These losses were higher in the low-potential zones (15–21%) than in the high-potential zones (10–12%). Next, yield losses were measured in 150 farmers' fields using a simple experiment comparing protected and unprotected maize, leading to an estimated loss of 13.5%, totaling 0.4 million tons annually, valued at US$ 80 million.

Supply of Bt maize technology

Supplying the Bt technology for Kenyan maize production does not pose major technological problems. IRMA, working within the regulatory system, introduced several samples of maize leaves with different Bt genes (one per plant) for bio-assays. Effective Bt genes were found against all major stem borer species, except for one, Busseola fusca, which dominates in the higher altitudes and is economically more important. In bio-assays of multiple genes per plant, higher levels of efficacy were found. These events will now be tested in the recently approved biosafety greenhouse, followed by trials in an open quarantine facility. Moreover, a review of relevant Intellectual Property Rights, including a Freedom to Operate review, concluded that there are no patents filed in Kenya that would restrict the use of Bt genes in maize. Finally, local seed companies have shown great interest in adopting the technology, as long as the costs are reasonable.



Economic Analysis

The estimated demand and supply were combined in an economic surplus model, which calculated a modest profitability with the currently available Bt genes. The project would be highly profitable if a gene or combination of genes can be found against B. fusca. More than two thirds of the benefits would go to the consumer through a reduction in prices.

The Environment

Demand and supply need to find one another through markets, within the regulatory framework. Biosafety guidelines were established and Institutional and National Biosafety Committees set up to implement these. These committees have, over the years, become experienced and efficient in dealing with bio-safety applications, partially due to the experience and interaction with IRMA. An analysis of the seed sector found that liberalization has increased the number of companies and varieties dramatically, but overall markets are still dominated by one company and a limited number of varieties, especially in the highlands. Moreover, the amount of improved maize seed sold has not increased over the years.

The PRAs also showed that farmers often recycle seed, including hybrids, and that they mark selected plants for this purpose. A study of the credit sector showed that formal agricultural credit has basically collapsed, and has been replaced by small, informal finance groups. Farmers who have access to this type of credit use half of it for agriculture, which allows them to double their use of improved maize seed. Regular discussions with farmers, consumers and institutions during annual stakeholders meetings, group discussions and other fora, reveal that farmers are generally very enthusiastic about Bt maize, while scientists, consumers and the general audience are cautiously optimistic.

During a survey in Nairobi, few consumers objected to the use of GM crops for food, although they have concerns about risks for environment and for biodiversity. Interestingly, upon learning that the Bt gene is dominant (and can therefore be recycled) farmers requested that the project also consider transformation of their local varieties.

Farm surveys showed that most areas have enough alternative hosts that form natural refugia, and prevent the build-up of resistance against the toxins. No relatives of maize exist in Africa, so the gene cannot cross into weeds. Farm surveys and PRAs also indicate that biodiversity does not decrease with agricultural intensification. Although the number of local varieties does decrease with intensification, the total number of varieties does not. In the high-potential areas, farmers typically use more varieties than in the low-potential areas, so that their biodiversity indices are higher.

CONCLUSIONS

The results of the different studies clearly show how most objections to Bt maize are based on myths and can easily be debunked. First, it is indispensable to work with Bt maize and introduce it in an experimental setting so that farmers, consumers and policy makers can make informed decisions. The first results, moreover, indicate that Bt maize responds to an important constraint and that farmers are very interested. Consumers are likely to benefit too, and they do not express strong objections. The poorer farmers in the low-potential areas will benefit relatively more, since they have relatively higher losses, and poor consumers will benefit relatively more since they spend more of their income on maize. Bt maize is likely to be commercialized by local companies, since there are no restrictive IPRs involved, and so extra costs will be low. Because the Bt genes are dominant, farmers will not become dependent on the seed industry since they can recycle their seed with the genes. Their recycling methods, moreover, are likely to select for the Bt gene and, over time, incorporate the gene into local varieties.

However, local varieties are likely to become contaminated, and this process could be irreversible. IRMA has taken samples of all local varieties in the different zones to deposit in the National Genebank. Further, natural refugia might be insufficient in certain areas. This could to be countered by pyramiding several Bt genes in appropriate varieties, or mixing seed with sufficient amounts of non-Bt maize. The study of the effects of Bt maize on non-target organisms has not yet been initiated, but identification of these organisms has started and comparative studies will start immediately with the field trials.

Further reading

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Please contact us:

Stephen Mugo, IRMA co-coordinator (s.mugo@cgiar.org), Hugo De Groote, (h.degroote @cgiar.org), CIMMYT, P.O. Box 25171 Nairobi, Kenya, tel. 254-20-524600, fax 254-20-524601

Benjamin Odhiambo, IRMA co-coordinator (kari@biotech.or.ke, biotech @skyweb.co.ke), KARI, Nairobi, Kenya

Appendix 4

Evaluation of GM maize in Africa

Genetically modified crops and sustainable poverty alleviation in sub-Saharan Africa: an assessment of current evidence, by Aaron deGrassi, *Third World Network – Africa*, June 2003.

Extracts[1] from the Executive Summary

This paper goes beyond the debates about hypothetical potential benefits and/or risks of genetically modified crops for small farmers in sub-Saharan Africa. I identify five widely accepted criteria for evaluating conventional crop breeding, and apply these to three heavily publicised genetically modified crops either currently grown or nearing release: stem borer resistant Bt-maize, weevil resistant Bt cotton, and virus resistant sweet potato. The five criteria include: demand-led, site-specific, poverty-focused, cost-effective, and environmentally and institutionally sustainable.

The criteria

Simply because technologies exist is not sufficient reason to utilise them – criteria are needed to select which technologies are best to develop and disseminate. Crop breeding has come to recognise that different farmers in different areas have different constraints, so agricultural research will have to generate site-specific varieties. To ensure that research programs respond to farmers' diverse, changing priorities, research must be led by the demands of poor farmers. Further, they recognise that these constraints encompass not only technical measures, such as yield, or pests, but socio-economic ones such as marketing, or labor requirements. Increasingly, researchers are focusing their attention on poor farmers facing difficult agro-ecologial and socio-economic conditions. Gone are the days when new technologies were thought desirable simply by virtue of being new or 'modern'; there is now a recognised need to prioritise and choose the most cost-effective technologies among the many at our disposal. Environmental sustainability encompasses not just second generation affects of the Green Revolution (such as pesticide affects on ecology and human health), but also basic problems such as soil fertility. Donor fatigue has illustrated the need for institutional sustainability.

Maize

The Syngenta Foundation is supporting work at KARI with CIMMYT (the International Maize and Wheat Improvement Center) to develop Bt-maize that is resistant to the stem borer through the Insect Resistance Management

[1]The report also deals with sweet potatoes and cotton, but the course team have edited this discussion out, although occasional mention is made of these cases in the summary sections.

in Africa (IRMA) project. Several varieties have been developed by CIMMYT in Mexico, and are awaiting bio-safety clearance to begin testing in Kenya.

Like the sweet-potato case, the deficiencies of the Kenyan RE system have impeded a demand-led approach. The Syngenta Foundation – a merger incorporating Novartis – has a poor record of supporting client-driven public agricultural research institutes, as illustrated by the Cinzana research station in Mali. The extent of damage by stem borers was repeatedly overestimated based on ad hoc guesses. No rigorous assessments were done before the project was started of the extent of damage by stem borers, nor of whether farmers felt they were a significant problem. When the project did survey 30 villages throughout the country, none identified stem borers as the most pressing constraint upon maize production. As with sweet potatoes, project surveys found that many farmers were already using their own resistant varieties.

Scientists have transformed several maize varieties with different Bt strains – developed initially by Novartis and CIMMYT – able to protect against 3 types of stem borers.

However, they have yet to engineer protection against the most important stem borer in Kenya, which affects 80 per cent of the country's maize crop. Rural surveys have identified potential suitable local varieties to transform, but due to biosafety procedures, none have been engineered yet. Farmers prioritise numerous different characteristics of maize, and to be acceptable, numerous different appropriate varieties will have to be identified and successfully transformed.

Maize is one of the most important crops in Africa, and is a basic staple for much of southern and eastern Africa, where stem borers predominate. However, stem borers are a relatively insignificant contributing factor to poverty in these areas. Of greater importance are other agronomic constraints – such as droughts, low soil fertility, and the weed Striga – as well as other socio-economic and political constraints – such as corruption, HIV/AIDS, poor transport, unequal land tenure, and political repression.

The cost effectiveness of the project is still based on ballpark projections. In contrast, other less generously funded projects have used a range of techniques and already proved capable of protecting against stem borers in farmers fields. As early as two decades ago, conventional crop breeders had identified and were working to improve borer-resistant varieties. Farmers have long used their own techniques, such as disposing of crop residue, changing the time and type of crop planted, or adding soil, pepper, or ash into leaf whorls.

Biological control methods – supported by the Dutch government – have been used to control the Asian stem-borer by introducing a wasp that is its natural enemy from Asia. The International Center for Insect Protection and Ecology (ICIPE) coordinated this project and the Asian wasp has now established itself in Kenya, Uganda, Tanzania, Mozambique, and several other countries, and is rapidly expanding. ICIPE has also developed economically viable 'push-pull' methods of intercropping using grasses that repel borers out of maize fields and pull them towards farm edges, and that have the added benefits of restoring soil fertility, reducing Striga, and providing livestock fodder. The methods – which have shown to reduce borers to negligible levels – have been tested in farmers' fields and are already being adopted.

There are serious concerns regarding the environmental sustainability of Bt-maize, given the likelihood of evolved pest resistance. The IRMA project is attempting gene stacking, as well as using conventionally developed resistance. Refuges may exist by default, but could disappear with widespread cross-pollination with Bt varieties. Another possibility is that the composition of stem borers may shift, so that African types (to which Bt-maize is still susceptible) become more prevalent, as already observed in some areas. The institutional sustainability of the project is very similar to the sweet potato project, with complete reliance on company funding, and the possibility of a locked-in focus on genetic engineering of certain traits.

Summary

To summarise, virus-resistant sweet potatoes are also not greatly demand driven, site specific, poverty focused, cost effective, or institutionally sustainable. The environmental sustainability of modified sweet potatoes is ambiguous. Bt cotton scores low on criteria of demand drive, site specificity, and institutional sustainability. It shows ambiguous results in poverty focus, and cost effectiveness. Environmental sustainability is currently moderate, but could potentially be moderate to strong. For Bt-maize, the analysis shows low demand drive, cost-effectiveness, and institutional sustainability. It is too early too detect unambiguous site specificity or poverty focus. Environmental sustainability is currently low to moderate, but could potentially be raised.

There has been a great deal of excitement over these new engineered crops despite their low suitability. The maximum gains from genetic modification are small, much lower than with either conventional breeding or agroecology-based techniques. The heavy publicity may be due to the politicised international debates about genetically engineered crops. In particular, biotechnology firms have been eager to use philanthropic African projects for public relations purposes. Such public legitimacy may be needed by companies in their attempts to reduce trade restrictions, biosaftey controls, and monopoly regulations.

Appendix 5

Glossary

http://www.fao.org/biotech/index_glossary.asp, and http://www.oecd.org/dataoecd/11/22/35492491.pdf?contentId=35492492 both accessed 23 February 2007.

Abiotic (factors)

Non-living factors or components of an environment, such as soil conditions, drought, and temperature.

Biotic (factors)

Living components of an environment, such as plants, animals and fungi.

Genetic modification (or genetic engineering)

Using recombinant DNA techniques and related methods to move one or several genes from one organism to another, to rearrange one or several genes within a cell, or to alter gene-controlled processes. Transforming a DNA segment from an organism and inserting it into the DNA of another organism to modify, amplify, transform and express genetic information. The two organisms can be totally unrelated.

Transgenic

The term describes an organism modified by genetic engineering to contain one or more new genes from another organism. In plants this is often done to increase resistance to disease and pests, or to increase productivity.

Bacillus thuringiensis (abbreviation: Bt)

A bacterium that produces a toxin against certain insects, particularly Coloeoptera and Lepidoptera; a major means of insecticide for organic farming. Some of the toxin genes are important for transgenic approaches to crop protection.