John Templeton Foundation

Grant #15652

Can GM crops help to feed the world?

REPORT

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Contents

Summary
World population is forecast to grow from 7 billion to 9 billion by 2050, one in eight people are already hungry (870 million) and food production must increase by 70–100 per cent during that time. No single solution will solve this problem but the new genetic technologies of plant breeding promise to help increase agricultural production and save people from hunger in a sustainable manner, particularly in African nations where the need is greatest.

The aim is to produce a model for dialogue and communication in African nations – Ghana, Nigeria, Tanzania and Uganda. These countries have been selected on their willingness to engage in the adoption of new genetic technologies used in plant breeding (including genetic modification, GM, when required), to address food security and poverty alleviation, and because of their diverse regional climatic and soil differences.

Three main activities will be described:
Activity 1 produced scholarly publications, linked to a dedicated website, which synthesised information and views from global opinion leaders about the potential benefits, concerns, applications and consequences of new genetic technologies for farming in Africa.

Activity 2 provided a professional development Fellowship on the new genetics of plant breeding for 160 media professionals – journalists and editors from radio, television, newspapers and journals. The programme offered technical training combined with field-visits, mentoring and support, and long-term networking.

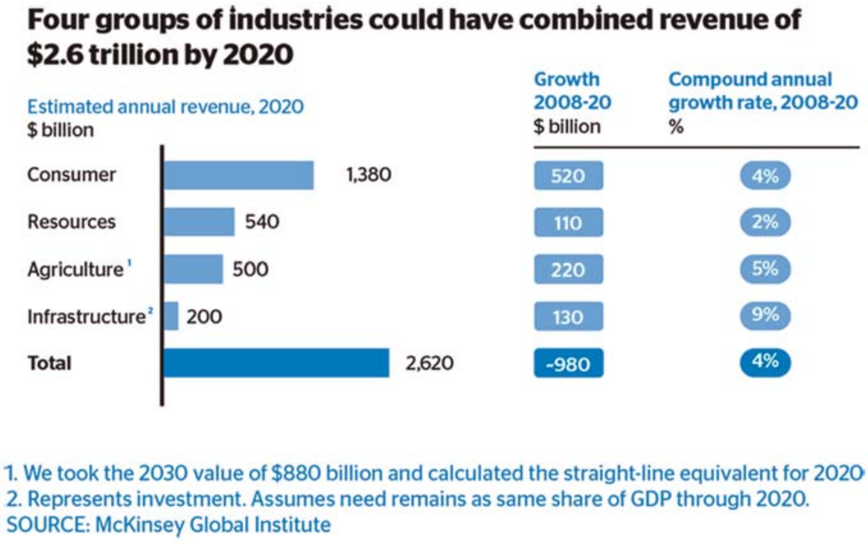
Activity 3 consisted of three scoping studies among smallholder farmers which focused on extension services and how to strengthen them through a model innovation farm in Uganda and Ghana; understanding how knowledge transfer of new plant varieties occurs among rural communities in Uganda; and how a novel digital learning platform could enhance crop productivity in Tanzania.

Parallel and complimentary studies were funded by the Foundation to study the barriers to progress through the socio-economic, socio-political and cultural implications of introducing new plant breeding technologies for smallholder farmers.

Introduction
At the outset of this project the stated aim of the United Nation's Millennium Development Goal (MDG) was to halve the proportion of the world's population that suffers from hunger or chronic undernourishment by 2015. However, the United Nations Food and Agriculture Organization estimated that the figure has fallen by only 17 per cent since 1990 to nearly 870 million people of the 7.1 billion people in the world, or one in eight, in 2010–2012 (FAO 2012). Moreover, almost all the hungry people, 852 million, live in developing countries, representing 15 per cent of the population of developing counties. A much smaller proportion of undernourished people, 16 million, live in more developed countries.

Regionally, changes have occurred over the past two decades with the number of undernourished people in Asia and the Pacific decreasing from 739 million to 563 million (24 per cent), largely due to socio-economic progress in many countries in the region. Latin America and the Caribbean also made progress with the prevalence of undernourishment dipping to 8.3 per cent. But the number of hungry in Africa grew from 175 million to 239 million, with nearly 20 million added in the last few years. In Sub-Saharan Africa (SSA) nearly one in four remain hungry and the modest progress

Figure 1 Estimated growth of major industries in Africa



achieved in recent years up to 2007 was reversed with hunger rising 2 per cent per year since then. Thus, the difficulties in meeting the MDGs have increased the pressure to explore all possible solutions to improve food production and overcome undernourishment including the technological advances in plant breeding. By 2020 agriculture is estimated to be one of the main four groups of industries with the highest compound annual growth rate (Figure 1).

As we said in our original proposal 'no single silver bullet will solve the problems of world hunger, but the new genetic technologies of plant breeding, and GM crops in particular, will help to save people from hunger and encourage them to develop an enterprise culture, particularly in African nations where the need is greatest'. Globally, the growth of the area planted with GM crops has continued to increase to a record 175.2 million hectares of biotech crops in 2013, an annual growth rate of 3 per cent. The year 2013 was the 18th year of commercialisation and 12 of which showed double-digit growth rates. A record number of 18 million farmers grew GM crops, for the second year running developing countries grew more than industrial countries, and in Africa seven countries conducted field trails (Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria and Uganda) (ISAAA Brief 46-2013). During the course of this project, the upward trajectory of GM crop adoption in the Americas, China and India has been sustained, but in Africa and Europe uptake has remained weak.

While Africa remains the only continent where poverty and hunger continue to increase, and average cereal yields over the past 50 years show little improvement, its economic growth is set to reach 5.2 per cent this year according to the World Bank's New Africa's Pulse. This performance has been boosted by rising investment in natural resources and infrastructure and a strong household spending, notably in resource-rich countries. Even non-resource-rich countries, particularly Ethiopia and Rwanda, have experienced solid economic growth of around seven per cent. These advances have so far failed to translate into job creation and the broad-based development needed to reduce high poverty and rising inequality rates.

The strongest growth on the continent is expected in West Africa with an anticipated increase to 6.9 per cent this year, and East Africa which is expecting to experience robust growth increasing from 6 per cent last year to 6.4 per cent in 2014. Growth will benefit from increased consumer spending (e.g. Kenya), higher consumption and investment in natural gas (Tanzania), and a rise in activity in construction, transport, telecommunications, as well as exploration and construction in the burgeoning oil industry (Uganda). In addition, demographic studies reveal that by 2040, Africa will have a larger working-age population than China or India. Already today, returns on investment are higher in Africa than in other emerging markets making it a key continent for long-term planning (www.mckinsey.com/mgi).

Given this context and the potential for enormous beneficial impact from the new genetic technologies through conventional and biotechnological plant breeding, this project was designed to address the challenges of food security in Sub-Saharan Africa and the prospects that smallholder farmers could benefit from the advances in genetics as they relate to plant breeding. So far, most African nations have been reticent about these technologies influenced by European concerns about GM food as unsafe, GM crops as damaging the environment, and GM products as being unmarketable in Europe with the result that GM crops are grown mainly in South Africa together with GM cotton in Burkina Faso. We have therefore used three major activities to address these challenges and to elucidate the opportunities for policy makers, politicians, media and farmers' organisations alike (Box 1). Biographies of the team can be found at Appendix 1.1 (Appendices in Volume 2).

The project will be referred to in the text that follows as B4FA.

Box 1 Biosciences for Farming in Africa (www.B4FA.org)

Rationale: World population is forecast to grow from 7 billion to 9 billion by 2050, one in eight are already hungry (870 million) and food production must increase by 70–100 per cent during that time. No single solution will solve this problem but the new genetic technologies of plant breeding developed during the last few years promise to help increase agricultural production and save people from hunger in a sustainable manner, particularly in African nations where the need is greatest. Just by adopting existing and available improved planting material and agronomic practices, agricultural production in Africa could double or treble. Furthermore, genomics, marker-assisted screening, phenotype analysis, and computer modeling have greatly accelerated the breeding process.

The latest advances can help by rapidly incorporating or developing traits for higher yields, resistance to pests, disease, drought and soil salinisation, reduced energy and pesticide use and soil damage, enhanced nutritional quality, and increased efficiency of nutrient uptake and water use. They also greatly reduce the time and costs taken to improve research-neglected local crop varieties and so-called 'orphan' crops in emerging economies, and to domesticate new crops from semi-wild plants, making them practically and economically feasible.

The problems and challenges now lie in the implementation of these impressive scientific advances where they are desperately needed, currently and for the future. And this is the very issue that has not specifically received adequate attention or financial support so far.

Activities: The aim is to produce a model for dialogue and communication in African nations – Ghana, Nigeria, Tanzania and Uganda. These countries have been selected on their willingness to engage in the adoption of new genetic technologies used in plant breeding (including genetic modification, GM, when required), to address food security and poverty alleviation, and because of their diverse regional climatic and soil differences. Success here could serve as a model for wider application.

Activity 1 – Overall Benefit and Promise of Genetics. Production of a scholarly publication, linked to a dedicated website, which synthesises information and views from global opinion leaders about the potential benefits, concerns, applications and consequences of new genetic technologies for farming in Africa; audiences will particularly be policy makers, regulators, and governments, but also media, teaching and research institutions, farmers' organisations and the general public,

Activity 2 – Effective Communication of Genetics. A professional development Fellowship on the new genetics of plant breeding for media professionals. Journalists and editors from radio, television, newspapers and journals will be enrolled, by competitive application, in a Fellowship programme that will offer technical training combined with field-visits, mentoring and support, and long-term networking amongst the Fellows, and between them and the research community of their country

Activity 3 – Strengthening and Enabling Implementation. Scoping studies of how to strengthen extension services, or their alternatives, that deal with an enterprise culture through application of the new technologies of plant breeding genetics (e.g. hybrid breeding, marker-assisted selection, transgenic breeding) as well as other socio-economic studies. These services can provide a crucial link between the knowledge base in institutions that hold the intellectual know-how, and small-scale farmers, but they are by no means the only channels of knowledge transfer.

Activity 1 (see Appendix A)

A Publications

Professor Sir Brian Heap, Project Leader;
Dr David Bennett, Project Co-Leader.

1 Introduction

Sir John Templeton's interest in the science of genetics and its potential to improve life for humanity applied to those who were undernourished and living in poverty. His son, Dr Jack Templeton, concerned to build up the John Templeton Foundation's commitment to genetics, raised the question – Can GM crops help to feed the world? His concern sustained his father's legacy as it related to the need to address global poverty, to anticipate food security for the predicted increase in the number of people living on this planet by 2050, and the application of the best brains and entrepreneurs alike, whether in laboratories, farms, businesses or partnerships.

We commissioned *Insights* as a key part of a grant awarded by the Templeton Foundation to examine the implementation of biosciences for farming in Africa (www.B4FA.org). The plan was to collect a series of eclectic and personal essays written in the style of other Templeton publications in being sharply focused and informative for decision-takers. They were not intended to advocate a position but to offer from personal experience an authoritative and independent brief.

Insights as a model was to be followed by *Viewpoints* recently compiled originally for the website and then for publication in paper copy (in progress). In both cases the objective was to inform political, academic and farming leaders, support evidence-based policy-making, and encourage balanced debates in schools, colleges, churches, villages and the media.

2 Methodology

Insight essays were commissioned from international and national leaders with a particular emphasis on Africans and those with first-hand knowledge of African countries. Individuals were selected by a Panel of Experts on the basis that 'we believe you have really important things to say about the future of biotechnology in African countries and how it could change the lives of people and smallholder farmers in particular. Your personal experience has so much relevance to food security, development and the acceptability of new technologies in Africa'. Authors were invited to write a 1 000-word personal viewpoint in an easily accessible style with a few key references.

3 Results

3.1 *Insights – Africa's future...can biosciences contribute?*

The first volume published in 2013 by Banson (Cambridge) consisted of 18 essays (Appendix A.1.2) from leading experts, half of whom came from Africa (Appendix A.1.3). Selected out-quotes follow.

Biosciences in Africa's economic transformation – Calestous Juma (Kenya and USA)

Africa's economic transformation is starting in the new age of biology;
It will not be possible to promote prosperity in Africa without significant focus on agricultural transformation.

The right to food in a changing world – Phil Bloomer (UK)

One key solution to this threat of worsening hunger in Africa and other continents is to increase investment in poor farmers, especially women;

The inappropriate agribusiness model must be distinguished from the potential biotechnologies to help accelerate the breeding of enhanced crop varieties for the poor.

Seeds: hope for smallholder farmers – Joe de Vries (Kenya)

... there is still nothing equal to the thrill of seeing a smallholder farmer receiving a new batch of improved seed Africa's demands on the new seed would be very different from those that worked wonders in Latin America or Asia;
It is one thing to have one bag of seed of a new crop variety... it is quite another to deliver that seed to thousands and eventually to millions of farmers living in isolated villages.

Can the supply of seed meet the demand? – Dannie Romney, Roger Day, Daniel Karanja, N. Louwars (Kenya)

Reaping the benefits of purchased seeds requires inputs such as fertilisers and agrochemicals;
A Green Revolution in Africa needs multiple demand-side and supply-side constraints to be addressed simultaneously.

The Biosciences eastern and central Africa Hub – Segenet Kelemu (Kenya)

The challenge of food security in sub-Saharan Africa is formidable, the timeframe for action is tight and the investment required is substantial. But the potential gains for human development are immense;
A highly skilled, healthy and well-paid workforce is critical in making Africa productive and globally competitive.

Training for the future of food security – Eric Yirenkyi Danquah (Ghana)

The need for a critical mass of scientists trained in plant breeding with conventional and molecular expertise is urgent;
The financial obligations are enormous but the potential benefits to present and future generations far outweigh the investment.

Biofortified sorghum: lessons for biotechnology – Florence Wambugu (Kenya)

A compelling vision helped African institutions overcome the perception that they would play the role of junior partners;
... support from multiple sources is more sustainable than relying on a single funder.

Achieving water efficiency with maize – Denis T. Kyetere, Sylvester O. Oikeh and Grace Wachoro (Kenya)

Both conventional and molecular breeding have resulted in positive developments.

Where will the water come from? – Nick Moon (Kenya)

... we must develop water management to exploit the value of new seeds from modern genetics;
... we have lowered the barriers to entry for the very poorest farmers.

South Africa: an early adopter of GM crops – Jennifer A. Thompson (South Africa)

Scientists had to give evidence of having been trained in the correct safety standard;
Farmers are sufficiently sophisticated to be willing to test the latest technologies.

Biotechnology and small-scale farmers: an industry viewpoint – Julian Little (UK)

The amount of arable land available for agriculture worldwide is declining GM should not be ignored as a tool for ensuring greater food security and reliability of agricultural supply.

Private sector R&D, supply chains and the small farmer – Marco Ferroni (Switzerland)

Productivity growth requires the involvement of the private sector at all stages of the 'farm-to-fork' supply chain;

(Plant) breeding in Africa is intrinsically difficult because of the diversity in production patterns and the large number of different crops and agro-ecological conditions.

SABIMA: an initiative for safe and high-quality GM crops – Walter S. Alhassan (Ghana)

An underlying factor for the slow growth of GM crops in some continents remains scepticism over their safety to humans and the environment;

The adherence to best stewardship practices enjoins all individuals ... to practise good stewardship.

Preparing youth for high-tech agriculture – Margaret Karembu (Kenya)

Appropriate value chains with clearly defined service providers at each stage of the chain would also ensure that farmers do not become victims of their own success, with increased production failing to reach the market;

There is need for a fundamental change in the mindsets of African youth.

Risks to biodiversity – real or imaginary? – Ghillean T. Prance (UK)

The new focus of agriculture is sustainable intensification ... a strategy in which GM crops can play their part;

One of the greatest potentials of GM crops in the future is to enable the use of marginal land, especially in such places as the arid regions of Africa.

Hazards and benefits of GM crops: a case study – David Baulcombe (UK)

... transgenes are effective in virus resistance because they reinforce a natural defence system against viruses;

With good crop management there is no reason why virus resistance ... should not become a durable and widely used technology.

Do patents hold up progress in food security? – Sean Butler (UK)

Patents are part of the wider field of 'intellectual property', a branch of law that recognises works of intellectual effort, and grants limited ownership;

... the patent system needs to operate efficiently...both the precise rules under which patents are granted and rights exercised, and the effectiveness of the rule of law to give those rights teeth.

Genetically Modified Crops – a moral imperative? – Jürgen Mittelstrass (Germany)

Nature is always creative nature (natura naturans) *or created nature* (natura naturata). *The first is nature we cannot live without; the other is nature that we increasingly appropriate.*

3.2 *Viewpoints*

A second volume based on a series of essays published on the B4FA website (B4FA.org) will soon be published as a paperback. The titles are listed below:

Golden Rice; a long-running story at the watershed of the GM debate – Adrian Dubock (Switzerland)

Changing lives with Victoria seeds through wealth creation, a personal journey – Josephine Okot (Uganda)

Changing the lives of smallholder farmers, a personal journey – Paul Seward (Kenya)

Why I changed my mind – Michael Ssali (Uganda)

Tackling coffee wilt by new genetic selection techniques – Africano Kangire (Uganda)
GM crop benefits: how long before Africa sees its share of the gains? – Graham Brookes (UK)
African Orphan Crops Consortium, a NEPAD-led initiative – Diran Makinde (Burkina Faso).
Knowledge transfer and the role of farmers – Mariechel Navarro (Philippines)
Better seeds, better yields – Tinashe Chiurugwi and Sean Butler (UK)
Public attitudes towards agricultural biotechnology – Philipp Aerni (Switzerland)
New plant breeding technologies – Joachim Schiemann (Germany)
Agricultural delivery systems: some options for East Africa – Johanna Nesseth Tuttle (USA)
From aid to trade – David Bennett (UK)
Will trade barriers prevent the adoption of genetically modified crops in East Africa? – John Komen and David Wafula (Netherlands)
Can a growing world feed itself without GM crops? – Brian Heap (UK)

3.3 Distribution

To achieve the purpose of an up-to-date book about genetics and the advances in plant breeding that reached a broad audience we therefore adopted a distribution policy that reached primarily African countries but also wider afield. The pattern of distribution and how this was achieved is given below.

Of 5 500 copies printed, 4 995 were distributed in 81 countries (Appendix A.1.4) including 157 sales with the revenues reimbursed to the consortium through deducting the relevant amounts from other charges. Of copies distributed, 2 291 (46 per cent) were consigned to UK members of the team for onward distribution at conferences, trainings, and special events.

Table 1 Summary of distribution of copies of *Insights* by region

Target countries (Ghana, Nigeria, Uganda and Tanzania)	1 968
Europe and Scandinavia	1 266
Consortium[1]	615
Africa (other than target countries)	554
North America	540
South America	24
Asia	28
Total	**4 995**

[1] Allocations to UK team members for distribution at multiple outlets.

Launches. Book launches were held in 2013 in each of the target countries corresponding with courses for journalists described later under Activity 2. These included sequential events at Accra, Ghana; Abuja, Nigeria (March 2013); Kampala, Uganda; and Arusha, Tanzania (September 2013). Invitees included politicians, policy makers, scientists, media, farmers' organisations, educationalists, NGOs and members of the general public. Numbers attending ranged from 70–100 and coverage was extensive not least from journalists attending the courses.

Books were distributed through multiple networks and at other special events which included the EuropaBio network of major biotechnology companies and national associations, the European Academies Science Advisory Council's (EASAC) joint meeting with the African Technology Policy Studies (ATPS) at the Africa Union in Addis Ababa (December 2012), the World Food Prize at Des Moines, Iowa (October 2012), FARA Science Week Accra Ghana (July 2013), the American Association for the Advancement of Science (AAAS), Chicago, Illinois (February 2014), and the House of Lords Africa Celebratory Luncheon organised by B4FA (April 2014). The EASAC/ATPS conference also saw the launch of the document – Regulation of Agricultural GM Technology in Africa by the Academy of Science of South Africa, a document to which members of the B4FA team contributed as referees and advisers.

Audio versions of all the essays are available for free downloading as it was clear from discussion with our media consultants, Julia Vitullo-Martin and Sharon Schmickle, and B4FA Media Fellows that radio was a preferred channel of communication in our target countries as well as in other parts of Africa. Recordings produced in English with an Africa-speaking voice accessible on the website are at http://b4fa.org/resources/.

Feedback. Among the feedback received there were messages from Ambassadors and High Commissioners in London (Appendix A.1.5), experts in Africa and Media Fellows in target countries.

The High Commissioner of Malawi spoke of the book providing 'new insight on diverse issues on regulation and ethics as far as scientific research in breeding African staple crops is concerned. It will, indeed, help to inspire and inform leaders, decision makers and communicators as well as encourage balanced debate at all levels of society. We look forward to working with you closely on issues of bioscience for farming in Africa'.

The High Commissioner for the Republic of Cameroon wrote that 'the said book provides very important information on Agriculture in Africa and the important role which biosciences can play in contributing to sustainable food production. *Insights* also contributes to the on-going debates within and outside Africa about the challenges posed by the role of science and technology in genetically – modified high-yielding crops'.

Cabinet Secretary of the Ministry of Education, Science and Technology in Nairobi, Kenya replied 'I want to thank you for the efforts you have made to collect, and consolidate the essays; the information is no doubt beneficial to the smallholder farmers and consumers of their products'.

Professor Ahmed Al-Hassan (Deputy Minister of Agriculture, Ghana) reported that he always has a few copies on his desk to refer to and give or lend to people. Similarly, Professor Turner Isoun, former Minister of Science and Technology, Nigeria, offered compliments on the collection of essays and recalled that he had found only one error, which related to an inaccuracy describing an indigenous bean variety. Professor Walter Alhassan of Ghana (member, B4FA Advisory Group) has also spoken of the value of keeping a copy to hand for reference purposes.

Further material developed for communication purposes included B4FA Leaflets (2 324 distributed) and an Africa Infographic (500 copies) for use at the meetings to which were invited to participate – the World Food Prize, Des Moines and the AAAS Chicago 2014 annual conference – and for our House of Lords Celebratory luncheon (Appendix A.1.6).

A special version of *Viewpoints* was published in April 2014 for the House of Lords luncheon which was attended by about 150 invitees. A total of 150 copies were produced and all copies were taken by participants.

Sir Eldryd Parry, formerly Professor of Medicine and Dean at Ilorin, Nigeria, and Kumasi, Ghana wrote 'what a splendid goal you have and, if the essays and their messages in *Viewpoints* can be translated into action which has effects, it will be different for many who struggle today'.

Insights and *Viewpoints* on the web are available on line both on http://www.b4fa.org and http://www.ourplanet.com/insights-2014/. A planned volume containing 15 *Viewpoints* essays is currently in active preparation and will be available before the end of the grant period.

As each new essay is loaded to http://www.ourplanet.com/insights-2014/ e-mails are sent to a mailing list of 12 000 people. On average, the site has received 14 000 readers/visitors per month, mainly from the USA and Europe.

4. Discussion

Strengths

The readiness of African leaders and others to participate in this exercise of compiling accessible pieces on topics relevant to the question – Can GM crops help to feed Africa? A particular strength has been the willingness to write in a way that informs a wide constituency from smallholder farmers' leaders through to policy makers and decision-takers. Availability of what in many cases transpired to be unique literature for the four target African countries has meant that readers could readily get up to speed on highly pertinent subjects about food security, people's right to nutritious food and the role of promising technologies based on the new genetics. Authors were asked to present their arguments in a balanced and objective manner without becoming overly protective of their position, and this they have very largely achieved. All essays are available on the website and feedback has been wholly positive with no interventions from anti-GM activists.

Weaknesses

Contributors from a wider range of African countries would have been an advantage particularly from West Africa together with a greater number of female authors. The choice reflected the aim to include internationally recognised leaders, but it was also influenced by the size of the pool of well qualified individuals who were willing to spend time writing for us among the many other pressures on their time. Distribution was targeted to individuals and specific institutions but postal distribution was expensive and in several cases unreliable reflecting the difficulty of communication in Africa through normal channels.

Opportunities

Our original application acknowledged the unique brand developed by the John Templeton Foundation in print and electronic version, namely, the Big Questions Essay Series. The brand has a wide appeal and provided an excellent opportunity to reach a broad audience. Distribution reached the intended audience of informed public, college staff and students, policy makers, government ministers, extension service, farmers' leaders, NGOs, international agencies, industry and potential donors. As proposed, environmental, nutritional, economic and social benefits and consequences of GM crop in African countries were addressed as well as entrepreneurship and future advances in plant breeding technologies. As proposed originally, approximately 50 per cent of the authorship was African with titles of essays along the lines outlined.

Threats

The essays were different from many other publications so the risk of duplication was limited. The authors were asked to provide a balanced account rather than advocate a specific GM position for plant breeding so the attention of anti-GM activists was not attracted. This did not neutralise the presentation of the case for GM crops but it was done in the context of improvements in plant breeding for African countries by conventional means or by GM where needed. The major threat came from the difficulty and expense of distribution, and ensuring that publications reached their beneficiaries. Availability of the publications on the web helped to circumvent the problem.

B B4FA.org website (Appendix A.1.7)

1 Name and affiliation

Dr Claudia Canales-Holzeis, B4FA Research Associate;
Erik Childerhouse, B4FA Information Technology;
Molly Hurley-Depret, B4FA Director of Communications;
Michael-Andre Joda, Web designer.

2 Introduction

Biosciences for Farming in Africa (B4FA)’s own dedicated website – www.B4FA.org – was established in order to serve as a portal for accurate and accessible information about plant genetics and biosciences, including written explanations, visual graphics, news and videos. The website serves as a central resource with a clear focus on African crops. It allows visitors to better understand and explore the challenges that African smallholder farmers face and how plant science and the new genetics are attempting to address these challenges to improve food security and, potentially, farmers’ income and wellbeing.

In addition to explaining the science that underpins plant genetics and plant breeding (conventional and biotechnological), the B4FA website also shares relevant news and features about this topic since few other sites covered plant genetics news in Africa. The news produced by B4FA Media Fellows (see below) in Ghana, Nigeria, Tanzania and Uganda is a very important element for our site, forming some 90 per cent of B4FA *Week in Review*, a newsletter developed by B4FA in Autumn 2012 to showcase the Media Fellows’ work and other relevant news. It is sent each Tuesday to over 1 000 recipients.

In order to communicate relevant news and bring attention to its website, B4FA has also established a very active social media presence on Twitter since Autumn 2012 and a YouTube channel.

B4FA also announces news in relation to its activities. Major events recorded on the website are the invitation to attend and participate in the annual World Food Prize event at Des Moines, Iowa, October 2013, the annual American Association for the Advancement of Science (AAAS) in Chicago, February 2014, and a celebratory event at the House of Lords for 150 guests hosted and introduced

Figure 2 The B4FA website – www.b4fa.org

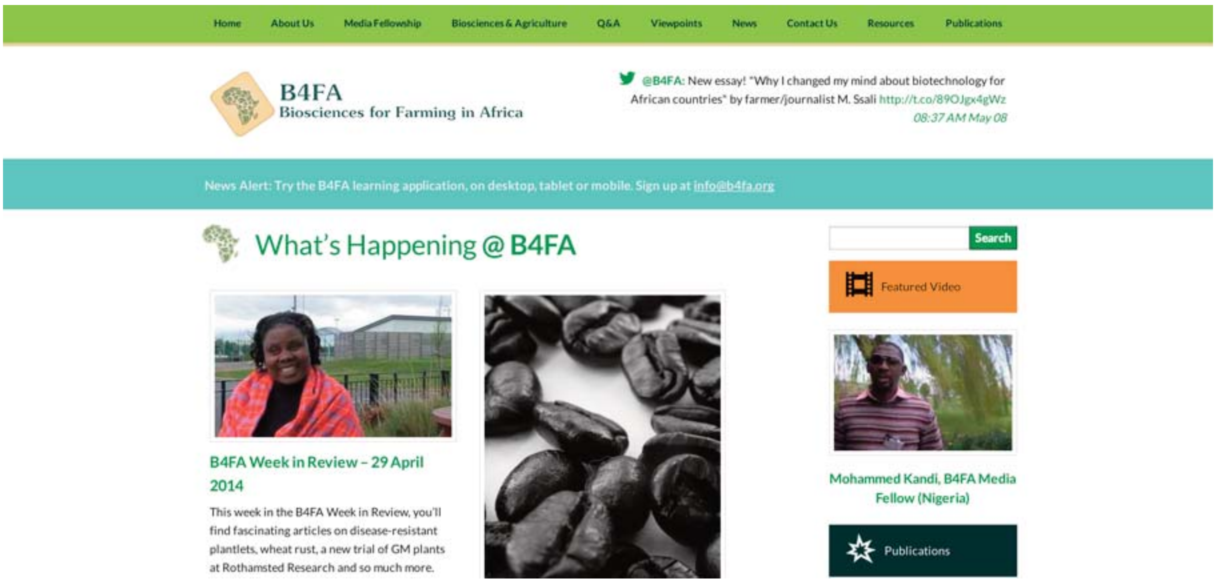


Figure 3 The B4FA website – top locations

by Lord Cameron of Dillington at which the main speakers were Lord Boateng of Camden (formerly from Ghana), Sir Brian Heap (Project Leader) and Dr Bernie Jones (Director of Media Programme). At each event several B4FA Media Fellows took an active part. These events have provided opportunities to produce video interviews of leading scientists and politicians which have been placed on the B4FA website.

The intended audiences of the B4FA website vary from policymakers and scientists to journalists seeking accurate information, students learning about plant genetics and the wider public. Though it is challenging to determine the precise audience that visits the website, based on an analysis of search terms, it is clear that people seeking basic information about plant genetics are visiting it. The top locations of audiences indicated above are the USA and Europe.

Moreover, based on the recipients of the B4FA *Week in Review*, we are also reaching an audience of specialists focusing on Africa who wish to be kept abreast of plant genetics news. Approximately 12 per cent of the list is B4FA Media Fellows, staff members and funders, while the other 88 per cent of the list is made up of experts, whether in academia, research, policymaking or farmer leaders, and members of the wider public.

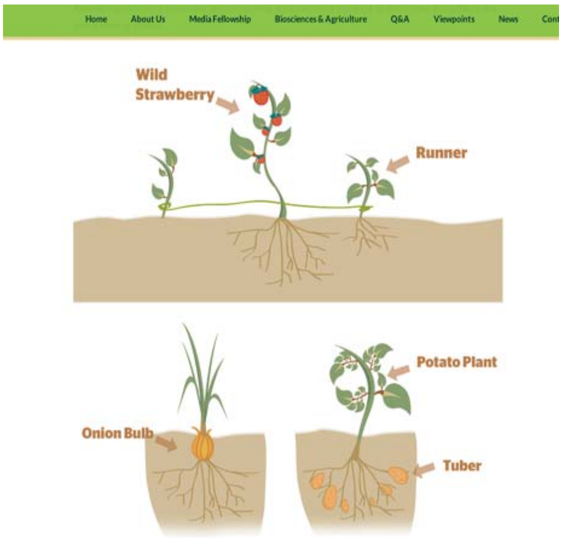
3 Methodologies

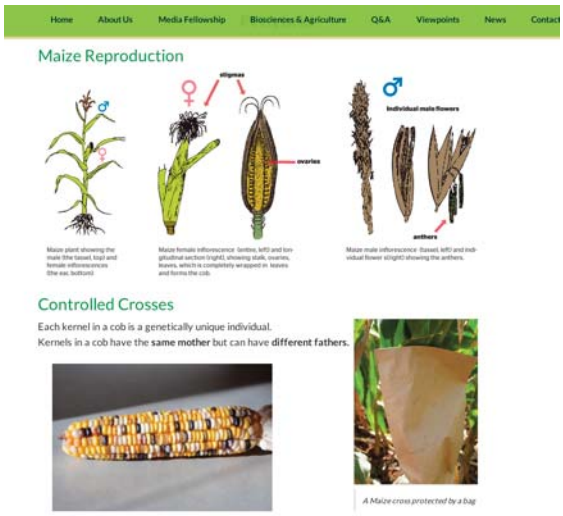
The B4FA website was built by Erik Childerhouse and Michael-Andre Joda in collaboration with Dr Claudia Canales-Holzeis. This collaboration included the development of a wide variety of graphics to illustrate plant genetics (see below). Molly Hurley-Depret joined the project in Autumn 2012 and developed the website's ambitious focus on news and social media.

Website development and information technology was led by Erik Childerhouse with Michael-Andre Joda while Dr Claudia Canales developed the scientific information and collaborated with Mr Joda to produce the many graphics on plant breeding on the site. She was also responsible for new pages approval. Molly Hurley-Depret managed the site in terms of developing the *Week in Review*, videos and other news content.

Week in Review was first developed as an internal team newsletter in September 2012 by Molly Hurley-Depret based on her previous experience with media communication. It was agreed that a weekly newsletter would be useful to others, particularly B4FA's network in Africa. The first edition of the B4FA *Week in Review* was published on the B4FA website in October 2012.

Figure 4 The B4FA website – providing information





The platform was developed for the use of B4FA's growing network of Media Fellows in African countries. The process consisted of B4FA Media Fellows sending their weekly articles for inclusion in the B4FA *Week in Review* alongside articles shared by Professor Chris Leaver and other relevant articles found through such sources as Google News, SciDev.net, Crop Biotech Update and the Genetic Literacy Project. Professor Leaver was responsible for the scientific review of each newsletter to ensure that accurate information was being shared.

Social media B4FA became active on Twitter in Autumn 2012. From past experience, Molly Hurley-Depret as Director of Communications recommended that Twitter would be a good format for building awareness of the project and its various outputs.

B4FA utilises social media, particularly Twitter, for several reasons:

1 to spread awareness of the importance of plant genetics for Africa and in particular of the scientific work being done in this area;
2 to contribute fact-based information about plant breeding, including the latest advances in biotechnology and genetic modification;
3 to promote B4FA *Week in Review* and *Insights*/*Viewpoints* articles;
4 to promote B4FA *Week in Review* articles prepared by B4FA Media Fellows;
5 to build online contacts with relevant people and international and national organisations.

In terms of methodology, the Twitter account was reviewed on at least four days per week. This was aided by the use of Hootsuite, a software that allows users to monitor their Twitter feed as well as key words, re-tweets, sent tweets and scheduled tweets. Hootsuite is a time-saving measure as one can schedule tweets throughout the course of the week to have regularly updated content (e.g. links to articles published by B4FA Media Fellows). In this case, the Twitter feed key words (genetics, biotechnology, etc.) are the only elements that need to be monitored on a regular basis. This monitoring and re-tweeting of others would be completed in one or two 20-minute sessions on Hootsuite per day.

The statistics of our Twitter account were monitored through a low-cost ($5 per month) software called Retweet rank. In this way we kept track of all tweets sent by @B4FA, as well as re-tweets by

Figure 5 The B4FA website – providing information

others. It produced Excel tables of all the information allowing for an analysis of activity and measurement of success.

Videos In Spring 2013, video became an additional component of the B4FA website. While in East and West Africa in March/April, there were opportunities to interview scientific experts as well as B4FA Media Fellows. In May 2013, the visit of the Templeton Associated Project Leaders and B4FA Media Fellows to Cambridge offered a further opportunity. In October 2013, science and policy experts were interviewed at the World Food Prize in Des Moines, Iowa, and in February 2014, more experts were interviewed at AAAS in Chicago.

Most journalists and project leaders attending the meeting of the Associated Project Leaders and B4FA Media Fellows (April 2014) participated in brief video interviews. The project leaders discussed their results whilst the B4FA Media Fellows discussed their experience of B4FA training and how it has helped them professionally.

The viewpoints of the B4FA Media Fellows are being published on the B4FA website and will also be edited into a brief overview by Molly Hurley-Depret.

4 Results (see Appendix A.1.7)

Visits. The graph below from Google Analytics showed that the B4FA.org website has had strong, steady growth since going online in the summer of 2012, particularly in January/February 2013.

In this time 52 387 people have visited the website. On average they visit 2.22 pages per session (140 003 in total) and remained on the website for two minutes. The average bounce rate (those leaving the website almost immediately) was 68.84 per cent. This is partly attributable to the 83.1 per cent of new visitors who came to the site, with 16.9 per cent returning visitors. The graph shows that the B4FA websites's performance has been at its best recently in Winter/ Spring 2014, indicating that awareness of B4FA has grown and it has become an established site with useful information.

Changes between 2012–2013 and 2013–2014 (Appendix A.1.7).

A comparison between 2012–2013 and 2013–2014 reveals that there has been a good increase in page views in 2013–2014 of over 130 per cent. The unique page views increased by nearly 200 per cent. The average time spent on the page has been variable in both years with a slight decrease perhaps attributable to the large increase in visitors and page views. The bounce rate has also increased, but this is likely for the same reason as the decrease in time spent on pages.

Figure 6 The B4FA website – a growing audience

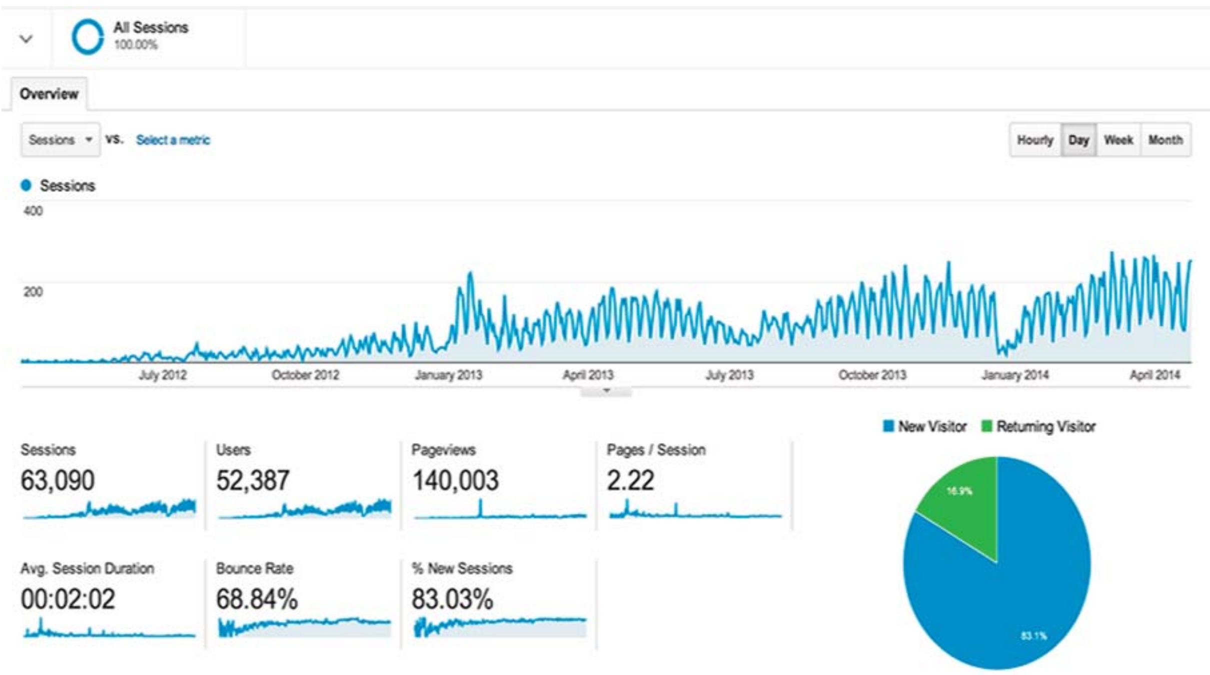


Figure 7 The B4FA website – visitors

	Country / Territory	Sessions	% Sessions
1.	United States	23,554	35.61%
2.	United Kingdom	10,478	15.84%
3.	India	2,816	4.26%
4.	Philippines	2,732	4.13%
5.	Canada	2,681	4.05%
6.	Australia	2,398	3.63%
7.	(not set)	2,058	3.11%
8.	Uganda	1,733	2.62%
9.	Nigeria	1,539	2.33%
10.	Ghana	1,479	2.24%

Most visited sections. 'Biosciences and agriculture', the scientific section, is the clear leader as it is intended to be. The explanatory pages received 56.9 per cent of total site traffic.

Following from this, the homepage attracted 14.68 per cent of page views, followed by the Media Fellowship Programme (3.94 per cent), the B4FA team members (3.81 per cent), videos (1.24 per cent), B4FA publications (0.95 per cent), news (0.95 per cent) and the contact page (0.88 per cent).

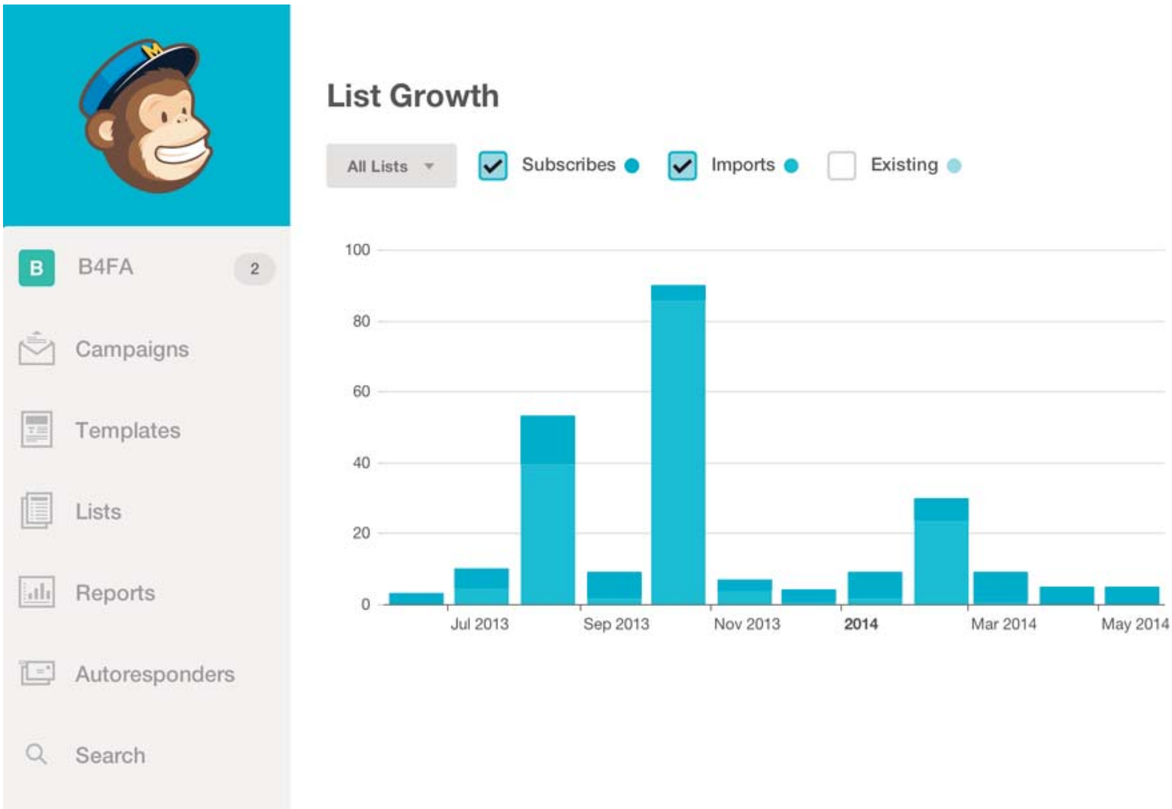
Most visited pages. The most visited pages include the homepage which had a far lower bounce rate than the average for 2012–2014, indicating that users decided to continue visiting the site. Other top pages included the scientific content that explains genetic variation and sexual reproduction, how plants reproduce sexually and asexually, what a chromosome is, the 'About' page, and the Media Fellowship Programme. Interestingly, the Media Fellowship Programme also had a very low bounce rate (35.7 per cent), indicating visitors' interest.

National locations of visitors. Regarding the locations of B4FA's website visitors, it is clear that developing countries, and particularly African countries (Uganda, Ghana and Nigeria), have had significant numbers of visitors to the site. These three African countries made up 7.36 per cent of total site visits from 2012–2014. Kenya (1.83 per cent), Tanzania (1.78 per cent) and South Africa (1.19 per cent) made up smaller percentages of site visits. In total, just over 20 per cent of the website's visitors were based in developing countries in Africa and Asia.

B4FA *Week in Review* gained in popularity over the course of 18 months and grew from an initial circulation of c. 200 individuals to 1 077 as of May 2014. The best indication of the success of the newsletter is its 'open rate'. The open rate is the per centage of subscribers who actually open the e-mail and view the newsletter, not only receive it. This percentage varies between 20 and 30 per cent each week. The best open rate occurred with our first newsletter sent via 'Mailchimp' in January 2013 (39.9 per cent opened). Moreover, the B4FA website access rate often peaks on Tuesdays and Wednesdays. The B4FA *Week in Review* circulation coincides with these peaks.

As more people joined the newsletter's mailing list, our overall open rate decreased to around 22–23 per cent each week. As can be seen in the accompanying graph, our average open rate is still well above the industry average for the Education category.

Figure 8 List growth



The *Week in Review* mailing list has continued to increase throughout the project. This is probably partly through awareness building through Twitter and the B4FA website and related to events B4FA team members have attended, such as the World Food Prize and AAAS conferences which enabled us to add at least 400 people to the list with their permission, mainly those who visited our booths.

Social media It took time for B4FA to become known on Twitter and to develop a good number of followers, but there are now over 500 followers (May 2014). While this number may seem small, when one reviews the followers themselves, they are highly relevant to plant genetics. Many people with a large number of followers also have a number of ‘spam’ followers, which we do not have.

Our followers include people such as Dr Julie Borlaug (IFPRI), Professor Calestous Juma (Harvard) and a wide array of scientists, African agriculture and development specialists and African journalists. We have been re-tweeted numerous times by Dr Juma and Ms Borlaug has ‘favorited’ our tweets, a positive indication.

In terms of statistics about Twitter over the past 18 months, we currently have 506 followers and we follow 851 people/organisations.

In our *Retweet* Rank dashboard (Figure 7), we were re-tweeted 1 021 times since the beginning of @B4FA on Twitter. In addition to re-tweets (in which others shared our content), we were also mentioned 396 times. We have sent a total of 1 648 tweets, on average 4–5 per day. The total number of times that @B4FA was re-tweeted or mentioned almost equals the number of tweets that we have sent which is a positive indication.

Figure 9 *Retweet* Rank dashboard

In another type of measurement, our ‘Klout’ score which measures a social media account’s level of interaction with others, not only re-tweets and follows, and varies between 42 and 46.9 which is a strong score.

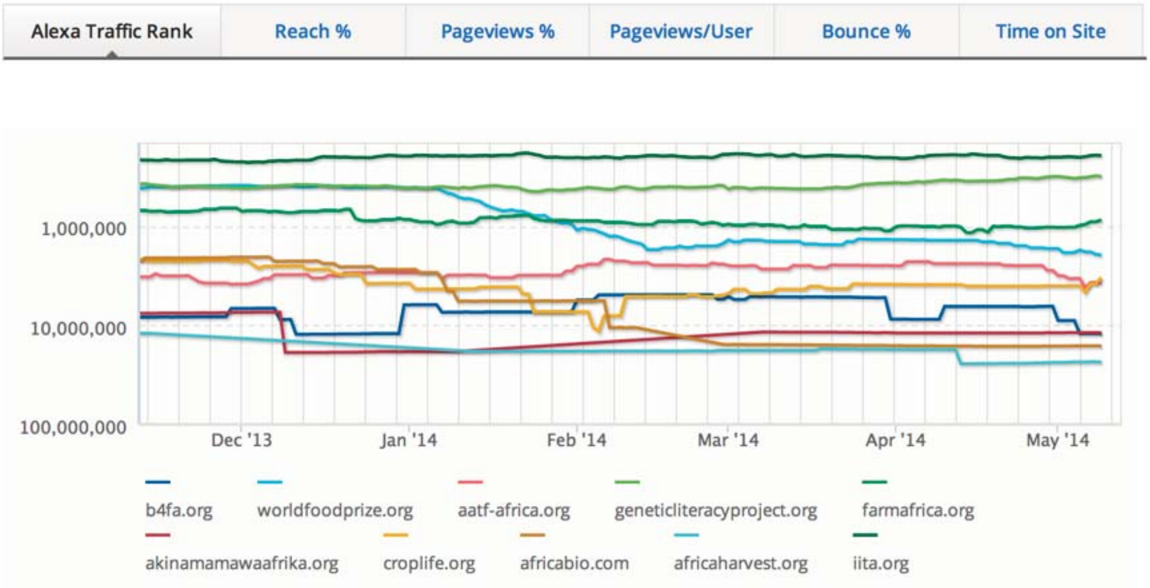
5 Discussion

Strengths

The B4FA website’s communication activities have clearly built a strong following over the past two years. In particular, the independent scientific content of B4FA.org continues to attract visitors and serves as a useful and accurate resource on conventional, hybrid and genetic modification in plant breeding. The number of visits to the website in general clearly indicates its usefulness.

As a point of comparison, we compared the B4FA website with a number of other web sites, including web sites dealing with Africa, genetics and agriculture, industry web sites and others such as the World Food Prize and Farm Africa charity. Figure 10 reveals that while several of these organisations are much higher than B4FA.org (such as IITA, Farm Africa and the World Food Prize), B4FA.org is comparable or above other Africa-focused NGO web sites (chart via http://alexa.com).

Figure 10 The B4FA website – traffic ranking



Traffic Metrics — Rank in Country: United States

Site	Global Rank		Rank in Country (US)	Global Reach %		Global Pageviews %	
iita.org	200,007	▲-1284	-	0.00083%	▲7.00%	0.0000178%	▼-1.75%
geneticliteracyproject.org	316,831	▲-84740	78,257	0.00059%	▲30.00%	0.0000077%	▲40.00%
farmafrica.org	886,435		-	0.00017%		0.0000027%	
worldfoodprize.org	2,040,594		-	0.00006%		0.000001%	
aatf-africa.org	3,711,183		-	0.000029%		0.00000041%	
croplife.org	4,071,422		-	0.000023%		0.00000045%	
akinamamawaafrika.org	11,858,469		-	0.000004%		0.0000002%	
b4fa.org	12,067,457		-	0.000005%		0.00000009%	
africabio.com	16,107,452		-	0.000004%		0.00000004%	
africaharvest.org	23,314,477		-	0.0000003%		0.000000003%	

The news content of the B4FA website has been very useful to scientific experts, journalists and the wider public interested in Africa and plant genetics/agriculture. We have received numerous e-mails complimenting the content of the B4FA *Week in Review*.

Loved the interview with Mark Lynas.
Powerful! Judy
Judy Chambers, IFPRI, Washington DC

Dear Sir Heap and Dr Bennett,
This is to thank you most sincerely for sharing with us the newsletter.

Kindly keep us posted.
Regards,
Burton.
Prof Burton Mwanila, Vice Chancellor,
The Nelson Mandela African Institute of Science and Technology

Thanks this is good information!
Regards
Roshan
Dr Roshan Abdallah, Chief Research Scientist at the Tropical Pesticides Research Institute, Tanzania

Hi, I wish to thank you so much for the regular updates on information from the B4FA activities and particularly the ever-increasing volume of news coming out due to active participation of B4FA Media fellows – thanks to B4FA Project's support.
Peter Wamboga-Mugirya,
Director of Communication and Partnerships at the Science Foundation for Livelihoods and Development (SCIFODE)

Many thanks for adding my name to your circular. I have looked through it with interest and made a note of the web address. There are great potential synergies with the Journal World Agriculture and its website. I wonder if you might have ideas on how these might develop?
Robert Cook,
Assistant Editor
World Agriculture

Dear Sir Brian
We recently met with Camilla Beech and colleagues at Oxitec, Oxford. You may already know of the fine work they are doing with their solutions for disease control using genetically engineered insects. Camilla expressed an interest in connecting with you and learning more about the B4FA. Would it be possible to add Oxitec to the distribution of your Week in Review?
Jennifer Wilson,
USDA (London)

Hi there,
Just to ask if the new banana varieties are available for sale and how can one get them. I am in Kenya Meru county where bananas are doing well though seriously affected by nematodes.
Charles Munyi Mwaniki

To Sir Brian and Dr David,
My name is Benta and I am a member Kenya Professional Association of Women in Agriculture and Environment – Kisumu County.I read a lot of your articles on the above subject as I am a subscriber and at the same time have interest in this kind of farming, however I realize you are only in Tanzania and Uganda, please may I know if you have offices in Kenya so that I visit them.
Thank you.
Benta

An amazing, enriching and rewarding year it has been!!
Thank you B4FA Team for the great work.
I look forward to continuing with the same next year and beyond.
Enjoy the festive season.
Best regards
PASCHAL

The number of re-tweets and mentions of @B4FA on Twitter reflect that our impact reaches well beyond our 500 followers. On high re-tweet days, our reach can be 5 000–10 000+.

Weaknesses
Overall, the weaknesses of the B4FA.org website are few; however, Search Engine Optimisation for non-scientific pages could be improved which would bring more visitors to these pages, such as the *Insights*/*Viewpoints* essays, news items and videos.

Our number of Twitter followers (500) and newsletter subscribers (1 077) are good but still reflect room for improvement.

Opportunities
In terms of opportunities, B4FA.org has a bright future ahead of it should it continue. The newsletter and Twitter account will continue to grow as long as we continue to provide high-quality content.

Another possibility would be to include more B4FA Media Fellows in producing news items for the website. Several fellows expressed an interest in continuing to provide copy because they often have stories that cannot be published for one reason or another (e.g., lack of space/airtime). Integrating their work into the website would give the site fresh and exclusive content from African journalists who understand plant genetics.

Threats
There are few threats to B4FA.org. Despite publishing a good deal of content on controversial issues such as genetic modification, B4FA has successfully avoided the unwelcome attention of anti-science/anti-GM NGOs, particularly those based in Europe. While we are followed on Twitter by some of these organisations, our name has never been ‘smeared’. This is likely to be because of the quality of B4FA’s scientific focus and independence from corporate influence.

6 Conclusions
B4FA.org has been a success and will continue to be in the future as long as fresh content is being published and the site’s scientific content is being shared regularly. It has been a rewarding endeavour, and the website’s increase in visits and page views over the past year reveals that if the website continues, further growth should be expected.

7 Recommendations for future work/study
B4FA.org should do the following:

- publish and promote the upcoming *Viewpoints* book, alongside the previous essays from *Insights*;
- continue to produce the *Week in Review*;
- continue to tweet and follow relevant people in order to build up to 1 000–2 000 followers in the next one or two years;
- integrate additional work from the B4FA Media Fellows in the website;

- improve search engine optimisation for some of the website's pages;
- add new videos to the website and YouTube.

Activity 2 (Appendix A.2.1)

B4FA media programme

Dr Bernie Jones, Director of Media Programme, B4FA

1 Introduction

The idea in the originally accepted proposal to the John Templeton Foundation (#15652) was to produce a model for engagement, enhanced understanding and informed dialogue on the breakthrough potential of GM and the new genetics of plant breeding for food security and economic and social development in Ghana and Tanzania. Those countries were chosen on the basis of their good governance, low corruption levels and willingness to engage in the adoption of new genetics technologies to address food security, as well as diverse regional climatic and soil differences.

Specifically the second activity of the project aimed to deliver a course on GM crops and new genetics for plant breeding for journalists and editors from those two countries, from both print and broadcast. These courses were intended to lead to the media in those countries being better informed, which in turn was hypothesised to elevate the debate in each country and inform the wider population about the facts of GM crops.

The longer-term outcomes of the initiative were to make a difference in the understanding of the new genetics of plant breeding in Africa, in particular by having built a base of young and professional people, from the media, students, decision-makers and regulators, as well as farmers and extension officers who had received and understood high quality information about how the new genetics of plant breeding fits strategies to improve food security, rural poverty alleviation, economic development and greater social and environmental sustainability.

2 Research

The initial stages of the media activity were to carry out further detailed on-the-ground research in the shape of several scoping visits and analyses:

i analysis of the media universe in Ghana and Tanzania;

ii scoping visits to better understand the situation on the ground in Ghana and Tanzania;

iii scoping visit to Nairobi, Kenya where many of the pan-African stakeholder organisations are based.

The analysis of the media establishment was performed by two experienced US-based journalists, trainers and media consultants – New York-based Julia Vitullo-Martin and Minneapolis-based Sharon Schmickle. The scoping visits were carried out by members of the project team.

Media research was carried out by a mixture of internet analysis and a large number of telephone interviews, consolidated by face-to-face meetings during the scoping visits. The detailed findings have already been reported to the John Templeton Foundation, but can be summarised as:

a journalism in both countries is operating under considerable limitations, is concentrated in urban areas, and as a result, agricultural coverage has been thin;

b radio has the greatest reach of all media arms, and due to rural coverage and language is the main channel to reach farmers. Cutting edge news about agriculture in general and agricultural biotechnology in particular is principally carried in print journalism however;

c much agricultural coverage represents single-source reporting based on official statements and press conferences. Analysis, if present at all, typically comes from academics or other experts outside journalism. However, journalism training is having an impact, prompting occasional deeply reported stories;

d Government influence continues to be felt – government-owned publications in Tanzania have the most resources and, therefore, the greatest ability to cover issues widely. In Ghana, conversely, the state-owned heritage of the media still pervades and weakens coverage overall;

e sophisticated science coverage is rare, and often weak. The best coverage of biotech and GM is by outsiders (EU, South African and US journalists). GM foes have exerted strong influence on the coverage of agricultural biotechnology, and they continue to organise against it. The active opposition includes religious leaders;

f it is often challenging for reporters to persuade their editors or producers to carry a piece on science or agriculture – business and politics (and sport and entertainment) continue to dominate prominent coverage in print and broadcast media.

Similarly, the media scoping visits have already been reported to the Foundation in detail, but findings from all three can be summarised as:

a the idea of the media training is a novel one, and interesting to both media and scientists;

b Ghana is a receptive environment, owing to a conducive legislative environment and enough local champions of the technologies;

c Tanzania is a challenging environment, due to both a difficult legislative and political environment as well as a strong local network of (anti) activist organisations;

d our initiative comes across as very GM-focused, when clearly other genetic crop innovations (F1 hybrid seed) have wider and more immediate impact and are equally poorly understood;

e there is a wealth of local research activity in Africa (on both GM and conventional crop improvement technologies) for the project to tap into, though research facilities in Tanzania are particularly challenged;

f there is a lack of funding in local research programmes for communication of their activities, and consequently the local research establishments and scientists rarely get to discuss their work with journalists.

3 Modifications to the programme

Firstly, it bears re-stating at this stage what was clear to many project staff from the very inception of the activities, and what emerged very clearly from research and scoping activity – namely the unique and innovative nature of the proposed media engagement under this project. Usually interaction between research and the media – especially in Africa – is very short term, poorly funded and poorly explained, and in the African context is often not present at all, or has been added as an afterthought. This situation created a very positive reaction to our initiative from the very beginning, and genuine excitement amongst both the media and research communities to be involved and benefit from it.

The opportunity for four major changes for our initiative arose from the findings of the research phase: *Firstly,* to spell out much more clearly that the scope of the project –new genetic technologies for plant breeding – encompassed many 'conventional' techniques in addition to genetic modification, and also to focus more attention to these other technologies as being of more immediate relevance to much of African agriculture. It was from this insight that the project brand 'Biosciences for Farming in Africa – B4FA' was developed, and this name has served us extremely well in stimulating across-the-board interest as well as averting suspicion.

Secondly, the technical knowledge and understanding of journalists and editors in Africa was low, as a result of streaming in the education system and a lack of focus on science reporting as a skill in Africa. Therefore for maximum and sustained impact of our efforts, the workshops needed to be adjusted to start from some of the fundamental aspects of the science, as well as a basic introduction to science journalism as a distinct discipline.

Thirdly, there was an opportunity to increase the geographical range of the activity. Whilst the argument for choosing Tanzania and Ghana still held (though the regulatory framework in Tanzania made any research in and adoption of genetic modification almost impossible in the short to medium term), both journalists and scientists kept referring us to biotechnology research being carried out in Uganda. This was so broad and so far progressed that it became clear that Uganda would be a productive third country to include in the media activity. Uganda's proximity to Tanzania also made it sensible to make budget efficiencies by combining travel to the two counties. This in turn suggested a model for including a fourth country in West Africa, to combine with activities in Ghana, and the population and economic importance of Nigeria, as well as the biotech research being carried out there, led us to include Nigeria as our fourth target country for the activity.

Fourthly, the lack of long term engagements between researchers and the media, combined with the lower level of technical knowledge among many of the journalists and the enthusiasm among them for continuing professional development and qualifications, suggested that significantly improved outcomes could be achieved by engaging over the long term. Rather than planning single workshop interactions with groups of journalists and editors, we redesigned the initiative into a set of longer term media fellowships in each country, which would commence with a training and dialogue workshop, but then involve continued contact, networking and follow-up opportunities with researchers and institutes, opportunities to attend international meetings, and further 'consolidation' training.

4 Methodology

We planned to run three rounds of the six-month fellowships in each of the four focus countries, to the following timetable:

April 2012	Advertisement of Media Fellowships
June 2012	Interviews of applicants
Sept/Oct 2012	Training workshops for 1st round Fellowships
Oct 2012 – Feb 2013	Follow-up period for 1st round Fellowships
December 2012	2nd round Fellowships advertised
Jan/Feb 2013	Interview of applicants
Mar/April 2013	Consolidation training for 1st round Fellows
Mar/April 2013	Training workshops for 2nd round Fellowships
Apr – Aug 2013	Follow-up period for 2nd round Fellowships
June 2013	3rd round Fellowships advertised
July/Aug 2013	Interview of applicants
Sept/Oct 2013	Consolidation training for 2nd round Fellows
Sept/Oct 2013	Training workshops for 3rd round Fellowships
Oct 2013 – Feb 2014	Follow-up period for 3rd round Fellowships
Mar/April 2014	Consolidation training for 3rd round Fellows

Using the repetition over three rounds of four media fellowships in each country enabled a highly modular design, so that we could reuse elements and easily apply learning from one iteration to the next.

The fellowships were first advertised in May and June 2012 on our website, as well as to our contacts from scoping visits and media research, key journalism networks in-country and to contacts in each main national media house. Journalists applying for the fellowship programmes were asked to supply examples of existing work as well indicating their experience and interest in covering agricultural biotechnology. We received applications from and interviewed 43 (Ghana), 54 (Nigeria), 24[1] (Uganda) and 54 (Tanzania) journalists.

The interview process itself served to uncover some key issues for the design of the training courses and fellowships:

a journalists typically had had no science exposure since the age of 12 and most had no relationship or contact with scientists;

b journalists in Uganda and Tanzania were often farmers themselves, or had families who still lived in villages and farmed;

c given the importance of agriculture in each of the four countries, most journalists had a reasonable understanding of the main issues facing farmers in their country, even if most did not cover those issues in their work;

d there was little understanding (other than in Uganda) of genetics, biotechnology or genetic modification, beyond scare stories spread by activists. These included widespread belief that biotech or GM crops caused infertility, had to be repurchased every year, were 'foreign' and resulting in produce that looked different;

e there was little understanding of the difference between conventional breeding technology (hybrid seed) and transgenic crops, or indeed understanding of the plant breeding at all.

Between 20 and 22 journalists were selected from each country to participate in the first round of training. The reason we picked a higher number (double) of participants than originally imagined was because we anticipated that some of the fellows would not be strongly engaged with the issues covered, might not understand them, or might be unable to persuade their editors or producers to carry the pieces they produced. We chose the numbers with a potential fall-out rate of 50 per cent in mind.

The initial training/dialogue workshops with which each of the media fellowship programmes began were programmed with the following broad content:

basic plant breeding and agricultural practice;
science journalism;
principles of genetics;
practical experiment;
'entertaining' practical science discussion;
non-GM breeding techniques (hybrids, tissue culture, mutagenesis, gene banks);
genetic modification;
local crop science/breeding case studies;
field trip to research institute(s);
journalism practice session and mentoring;
regulatory environment for biotechnology;
commercial considerations (seed companies, breeders' rights, distribution etc.);

[1] Since science journalism in Uganda was more established than in other countries, we directly invited a representative cross-section of journalists with science and agricultural reporting credentials. They were still interviewed to the same criteria as those from other countries, however.

local keynote speakers.

For each of the substantive training session, a detailed content outline was prepared which experts and trainers were asked to follow in preparing their own presentations, and presentation content was reviewed and amended by the course leader to ensure that the different modules combined together well and were at an appropriate level of detail and complexity. Up to six local case study presenters were asked to attend for the entirety of each workshop to ensure time to network with the journalists outside the formal training environment. The brief for the case-study presenters was to present their material as accessibly as possible, at a level that would be appropriate for high-school children, to ensure that the content was easy for the media fellows to understand.

To maintain a lively and participatory atmosphere in the training workshops, content and engagement methods were varied as much as possible between sessions. Hence practical journalism writing and discussion exercises were interleaved with formal presentations, and practical experiments and learning games were devised and inserted at appropriate points into the technical presentations. One additional innovation was prompted by the unavoidable late withdrawal of one of our international technical experts. Rather than recruiting a new speaker at the last minute, we decided to deal with each of the technical issues to be covered in that presentation through a mock broadcast interview by media fellows of the international national experts present.

After the four-day training workshop the plan in each focus country was to maintain a network of the fellows, continue to offer them mentoring and support for writing and broadcasting on new genetic technologies, offer them regular opportunity for facilitated visits to local research institutes, occasional opportunities for international travel to research institutes or conferences, and to consolidate their learning with a refresher training for one day before the next round of fellowship training workshops.

Fellows were requested to join a facebook discussion group for their country, and to send B4FA project staff copies or references to any piece they wrote or broadcast that was relevant to new genetic technologies for farming in Africa and derived from material they had learned from the project.

5 Results and feedback

5.1 First round of workshops

A total of 80 fellows attended the four first round training workshops in our focus countries. These fellows represented a mixture of print, online, radio and television (though print dominated) and also represented a cross-section of media roles, from freelancers though reporters, desk chiefs, sub-editors, editors and bureau chiefs.

The principal technical training sessions were covered by a combination of senior international and national experts (from regulators, the media, academia and NGOs):

Plant breeding and agriculture	Prof Wayne Powell, University of Aberystwyth (UK); Dr Tina Barsby, National Institute for Agricultural Botany (UK)
Science journalism	Mr Alex Abutu, AfricaSTI and scidev.net (NG); Mr Diran Onifade, World Federation of Science Journalists (NG); Mr Peter Wamboga, SciFoDe (UG), Mr Patrick Luganda, Farmers Media (UG); Mr Simon Berege, Tumaini University (TZ); Mr Joseph Kithama (TZ)
Principles of genetics	Prof Erik Danquah, University of Ghana at Legon (GH); Dr Charles Amadi, National Root Crop Research Institute (NG);

Figure 11 The Media Fellows certificate

	Dr Tina Barsby, national Institute for Agricultural Botany (UK)
Genetic modification	Prof Jim Dunwell, University of Reading (UK);
	Prof Chris Leaver, University of Oxford (UK)
Journalism mentoring	Ms Julia Vitullo-Martin (US); Ms Sharon Schmickle (US)
Regulatory environment	Mr Eric Okoree, Ministry of Environment, Science and Technology (GH); Dr Christian Fatokun, International Institute for Tropical Agriculture (NG); Dr Theresa Sengooba, Program for Biosafety Systems (UG); Dr Grace Chipungahelo, Mikocheni Agricultural Research Institute (TZ)
Commercial considerations	Mr Daniel Otunge, African Agricultural technology Foundation (KE)

Each media fellow was asked to work on two journalistic pieces during the four day workshop, for which mentoring and feedback, which were then judged for their quality and content, and for the best of which small cash prizes were awarded. Certificates were awarded to media fellows at the end of each training workshop.

A feedback form was circulated to all workshops participants – trainers, media fellows, scientists and mentors – to assess the quality and value of each workshop (and components of the training) as well to indicate productive possible changes to training workshops and engagements in future rounds of the programme. The principal items of feedback are summarised as follows:

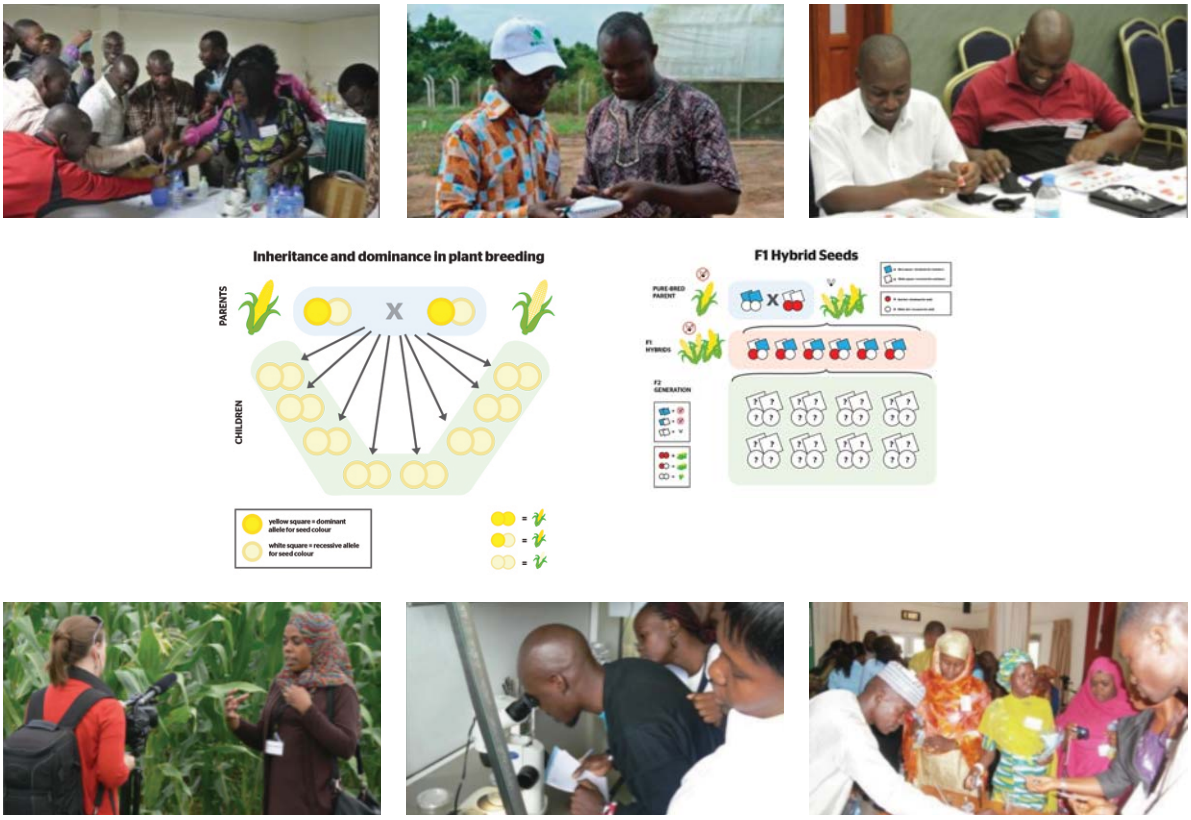
a journalists gave the training and programme consistently high ratings, and few had had any exposure of this type to genetics and agricultural biotechnology reporting before;

b few journalists had had any opportunity to visit research institutes or laboratories before, or speak with local experts on the issues;

c few local researchers had ever had the opportunity to meet or discuss their work with members of the media, so the training courses enabled barriers and mistrust to be broken down between the scientific and media community;

d fewer than 10 per cent of journalists had ever carried out a practical scientific experiment themselves before – the DNA extraction experiment was consistently rated as one of the best aspects of the training workshops;

Figure 12 B4FA media workshops



- e in general, the practical aspects of the training workshops were rated most highly and were felt to be most valuable by participants (experiment, simulations/games, field trips and journalism exercises). The genetics simulations and games that had been designed specifically for the workshops were invaluable as learning aids as well as encouraging networking and discussion between the journalist and scientist participants. We were able to observe peer-to-peer mentoring developing during these practical sessions (see below for workshops in progress);
- f few of the journalist participants had a good understanding at the start of the workshop of genetics or any modern approaches to plant breeding or agriculture. From the quality of their questions and participation in discussions, as well as the journalism exercises they carried out, we could observe their level of understanding and belief in the science and technology growing through the workshop, with some participants even able to crack 'genetic jokes' after several days. Even those journalists (mainly Ugandan) who had covered the area previously, few had an understanding of the science underlying the technical approaches that were being taken;
- g F1 hybrid seeds and (commercial) tissue culture were the agricultural biotechnologies of most immediate potential in the countries, though all four countries were carrying out GM research at various levels of advancedness. None of the technologies were well appreciated in any of the countries and they were usually confused with each other and subject to misinformation;
- h several journalists who were either farmers themselves or came from rural backgrounds were able to tell stories about 'folk knowledge' experiences of their families, and relate these and explain them through the genetics and breeding information that they were learning.

Some key quotes from our feedback:

> *'I have been a maize breeder for 25 years, and this is the first time I have ever had the chance to speak to a journalist about my work';*

'This course was an eye opener […] we were getting contradictory information that GM causes cancer and diabetes but now I have better understanding on the topic and its relevance to my country to improve our economy';

'It has transformed me into a more critical journalist'.

As a result of the feedback, progressive changes were made to the content of the training workshops and the fellowship programme overall, for the East African component of the first round of fellowships, and for all the second-round workshops. The principal changes were:

a to reduce the number of technical sessions and the complexity of the content, and in particular begin with a simplified 'history of agriculture and plant breeding' session;
b to make all fellowships run until the end of the project rather than ending after six months;
c rather than just offer a one day refresher training, to invite the 10 best fellows in each round to participate in the whole of the next round's training workshop as alumni mentors;
d to increase the number of field trips during the training workshops;
e to make the application process for subsequent rounds online, via the B4FA website;
f to add a specific session on F1 hybrid seeds and the difference between them and GM;
g to add interactive discussion sessions on journalistic concepts and controversial ideas;
h the introduction of a participatory audience feedback system to allow regular collection of feedback throughout the workshop rather than all at the end, and also to introduce a degree of interactivity into the training sessions;
i the introduction of a session on biotechnology and ethics.

5.2 Second round of workshops

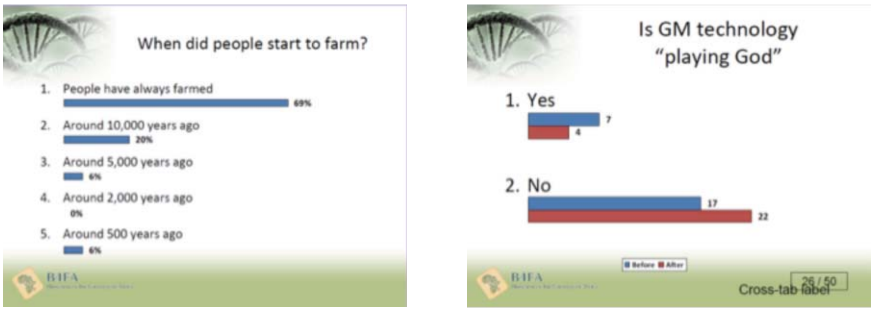
The second round online application process resulted in 32, 50, 33, and 24 applications respectively from Ghana, Nigeria, Uganda and Tanzania. In many cases, word of mouth had made journalists enthusiastic to participate in B4FA, and we received applications from some very senior and very high profile journalists (for example two of the main daily presenters on Ugandan television, and the winner of Ghana's journalist of the year award). Between 20 and 22 fellows were selected from each country of whom a total of 80 attended the second round training workshops, accompanied in each country by the 10 best fellows of the first round programme, as measured by the quantity and quality of their reporting. Again, the fellows had been chosen for a good representation of print, broadcast, online and agency staff, although the second round contained slightly more broadcast journalists than the first, and more senior-level staff in most countries. Each workshop contained at least two field trips, an additional game (on marker assisted breeding), and five or six local case study presentations. The principal technical training sessions were again covered by a combination of senior international and national experts:

History of breeding and agriculture	Dr Bernie Jones, B4FA (UK);
Science journalism	Mr Alex Abutu, AfricaSTI and scidev.net (NG); Mr Diran Onifade, World Federation of Science Journalists (NG); Mr Peter Wamboga, SciFoDe (UG), Mr Patrick Luganda, Farmers Media (UG); Mr Joachim Buwembo (UG)
Principles of genetics	Prof Erik Danquah, University of Ghana at Legon (GH); Dr Moses Adebayo, LAUTECH and IITA (NG); Prof Chris Leaver, University of Oxford (UK); Dr Paul Kusolwa, Sokoine University of Agriculture (TZ)
F1 hybrids	Dr Claudia Canales-Holzeis, University of Oxford and B4FA (UK)

Genetic modification	Prof Jim Dunwell, University of Reading (UK); Prof Chris Leaver, University of Oxford (UK)
Journalism mentoring	Ms Julia Vitullo-Martin (US); Ms Sharon Schmickle (US)
European Regulatory System	Dr Guy van den Eede, European Commission (Be)
Ethics and Biotechnology	Prof Sir Brian Heap, University of Cambridge and B4FA (UK)
Regulatory environment	Prof Josephine Nketsia-Tabiri, National Biosafety Committee (GH); Dr Rufus Ebegba, National Biosafety Authority (NG); Dr Arthur Makara, SciFoDe (UG); Dr Roshan Abdallah, Tanzania Pesticide Research Centre (TZ)
Commercial considerations	Mr Daniel Otunge, African Agricultural technology Foundation (KE)

This format was very successful – the greater focus on practical aspects (field trips and interactive games and discussions) gave us an opportunity to focus on the issues that were locally important. The interactive system also played a very powerful role when integrated into presentations, to gauge levels of understanding and belief before discussions of facts, and therefore to personalise delivery. For example, use of the system established that the majority of journalists thought that farming had always been a way of life for human beings, and that the staple crops currently grown in Africa were indigenous to that continent, when in fact many (maize, cassava, banana etc) were introduced relatively recently. The system also gave us an opportunity to 'test' understanding of key issues before and after presentations, as well as at the end of the workshop.

Figure 13 Testing understanding issues



The progress that the first round fellows had made in the preceding six months was evident in the mentoring role they were able to play in the workshops, but even they benefited from the opportunity to hear all the technical presentations and explanations for a second time.

5.3 Further journalist mentoring

Having taken 160 journalists in our four focus countries through the training and follow-up activities, and with over 500 articles already submitted to us as having been produced as outputs of the programme, we decided there would be little value in recruiting a further 80 journalists in a third round of the media fellowships, and that most of the able and biotechnology-enthusiastic journalists had probably already been engaged with. However, discussions with the mentors and evidence from the pieces that were being submitted to us indicated that there was a need to engage further with the fellows on improving their science journalism skills. Therefore the third round of workshops were redesigned to be media masterclasses in each country, for the top 10–12 fellows as measured by productivity and quality of content. These masterclasses would serve to engage with fellows in a group and individually to improve their science reporting skills as well as rehearsing the science and genetics underlying their reporting. The masterclasses were programmed as follows:

discussion of experience of reporting on agricultural biotechnology
deconstruction and analysis of Fellows' pieces;
journalism ethics;
recap of science, genetics and definitions;
effective use of social media;
writing for international publication;
field trip.

During the 21 months in which journalists were enrolled in the media fellowships (September 2012–May 2014) they went on field trips to 50 research institutions and commercial and experimental facilities. These field trips were popular, and since numbers were limited there was competition to be eligible to attend them. The importance of the field trips was two fold – typically, the media houses for which the fellows worked had little or no funds available for travel outside the city where they were located (usually the capital) making coverage of research or contact with farmers trialling new technologies difficult; furthermore, there was often limited awareness of the existence of venues for visits, and even when journalists knew of institutes, it was difficult for them to be invited without the B4FA name behind them.

In addition to the national field trips, the media fellows were offered international opportunities to visit institutes and to attend conferences:

- Science Academies conference on GM and biotechnology, Nairobi, Kenya (April 2013);
- Visit to EuropaBio industry body in Brussels and to GM farmers in Spain (March–May 2013);
- Visit to research institutes and science media organisations in UK (May 2013);
- Attendance of FARA General Assembly and African Agricultural Science Week, Accra, Ghana (July 2013);
- Visits to research institutes in Uganda (Aug–Nov 2013);
- Attendance of World Food Prize conference and CropLife International global media tour, Des Moines, Iowa (Oct 2013);
- Attendance of African Science Academies Conference on Biotechnology in Africa, Addis Ababa, Ethiopia (Nov 2013);
- Attendance of American Association for the Advancement of Science meeting, Chicago, Illinois (Feb 2014);
- B4FA concluding training workshop and visit programme, Cambridge and London, UK (April 2014);
- Attendance of AATF workshop on transgenic research in West Africa and field trips, Accra, Ghana (April 2014).

5.4 Achievements

The B4FA media fellowship programmes have proved an overwhelming success, in terms of both outputs and outcomes, and we believe that the activities are well on the way to achieving the lasting impacts that were imagined in the drafting of the original project. But there have been some further, very powerful, additional outputs and outcomes (Table 2).

Annex 1 provides a representative sample of 100 of the more than 1 000 journalistic print and broadcast pieces submitted to us by our B4FA Media Fellows.

Table 2 Summary of distribution of copies of *Insights* by region

Output/Outcome/Impact	Achieved
Four journalism workshops run (two in Ghana and two in Tanzania)	13 journalism workshops held (three each Ghana, Nigeria, Uganda and Tanzania, and one in UK)
32 journalistic pieces from the workshop participants (8 per workshop)	More than 1 000 journalistic pieces reported to us
20 journalists and 20 editors will be better informed about GM crops and their potential; 36 participants have a better understanding of GM crops, and 20 are more amenable to the idea of their use in Africa.	160 journalists (including over 20 editors, subeditors or bureau chiefs) better informed; and at least 60 are more amenable to GM usage in Africa
Within five years, 100 media professionals, 1 000 students, 100 policymakers, 10 000 farmers and 100 extension service centres have gained experience on GM crops	160 media professionals (from media fellowships), 450 policymakers (from distribution of *Insights*)
Within 10 years 100 media professionals will have an appreciation for GM crops, evidenced by […] 400 articles in local, national and African media outlets	More than 1 000 articles already published/broadcast by 160 journalists
Within 10 years, 10 000 farmers and extension workers reached with information about new genetic technologies, and having increased understanding.	Circulation figures of print media and listener/viewer figures of broadcast outlets of the 160 media fellows already exceed 17 million (see Appendix A.2.1).

Additional outcomes are that many of the best media fellows have, through the experience and contacts they gained from the B4FA project, become effective advocates for regulatory liberalisation and broad adoption of modern genetic technologies for crop improvement in Africa, and are regularly challenging their government decision-makers to act decisively on the issues. Biotechnology regulation has become a hot topic in all four of our focus countries over the three-year span of the project, and our media fellows have been at the centre of the debate, often presenting the best informed and most accurate coverage of the issues. But the media fellows also report to us that as a direct result of their increased focus on reporting more on agricultural biotechnology issues, their decision-makers and Ministers are becoming more vocal about the issue.

> *'our [Nigerian] Minister for Agriculture Akinwumi Adesina is an agric scientist, yet since being appointed in 2010 he said nothing about biotech and GM. Only since our increased coverage began in late 2012, as a result of B4FA, does Adesina now speak about the issue and advocate action'.*

Many media fellows report that, as a result of their interest and efforts, their publications take agricultural science stories more seriously now, and are willing to devote more prominent space to their coverage. Several fellows have established agric science 'beats' for themselves, and have become the go-to people in their organisations for stories on biotechnology and modern farming.

We have also successfully broken down barriers between the national agricultural research communities and the media in our focus countries. The two groups now regularly meet and share information, and the media fellows regularly speak with their scientific contacts to enhance their coverage.

Those journalists who were also farmers have started to take their farming more seriously and see it as important, and in many cases are now testing and using the results of modern plant breeding technology themselves in their farms – mainly F1 hybrid seed and tissue cultured planting material, but they are enthusiastic to trial GM for themselves as soon as it become legally available. More encouragingly, several journalists who were not farmers initially have been motivated to begin to farm alongside their media activity and/or to explore entrepreneurial opportunities in agricultural biotechnology.

We have published all the presentations given at the training workshops on the public presentation-sharing site slideshare.net, where they have already achieved more than 6 000 views and downloads globally.

To consolidate our masterclasses and fellows agricultural genetic science journalism skills, we have produced a B4FA Journalism Guidelines publication which is available from our website in pdf form.

We have anecdotal feedback that at least one pan-African biotech NGO has completely revised the way in which they engage with the media as a result of seeing the effectiveness of the B4FA model of engagement, which they have now adapted to their own use.

Researchers and NGOs internationally and in Africa are recognising the quality of our programme and journalists, and make requests of us to recommend our journalists to them to cover events and stories, or to participate in visits, workshops and field trips.

At least eight of our media fellows have won national journalism awards as a result of coverage they have produced under the B4FA programme, and two have won international awards.

Eager that the African media 'movement' created by B4FA should not decline after the end of the main phase of the project, our best media fellows are inaugurating a Network of African Agriculture Journalists, to enable them to continue to network and support each other, to advocate for the importance of covering agricultural biotechnology in Africa, to encourage more journalists to focus on the area, and in time to seek to raise support to facilitate more of this coverage.

6 Conclusion

The project team were enthusiastic about the model of engagement in Africa proposed for B4FA, and there was almost universal enthusiasm for the idea in Africa in our research and scoping phase. That enthusiasm and confidence has been borne out, and the model that B4FA sought to test in our target countries in Sub-Saharan Africa has been validated.

Engaging with journalists in Africa to seek to improve coverage and understanding of a technical and controversial area can be most successfully achieved by engaging with those journalists for the long term, training them in the fundamental concepts of the subject matter so that they are able to critically evaluate and consider arguments and issues that they are reporting on, establishing an ethical framework for the interaction (emphasising journalistic ethics and, e.g. not paying for stories), helping them establish their own networks and breaking down barriers with local experts, and providing ongoing opportunities for training or experience of the subject matter to be covered.

Many of our journalists came to the programme with only awareness of the activist-generated misinformation. But honest presentation of scientific facts and techniques, as well as opening doors for discussions and questions with domestic and international experts, soon changed their impressions and beliefs. Since the journalists know themselves what challenges their farmers and their populations face, they have become far stronger advocates of the technology than the B4FA team members, who always sought to present a balanced and honest picture of the capability and suitability of all the different technological options. This is a further strength of the very honest and unbiased approach adopted by the B4FA project: journalists are good at spotting when they have been 'sold a line'.

We were apprehensive about engaging with one of our fellows. He used to produce the fiercest critical articles about GM in his country. He told us that he would go to USAID events, and then deliberately write a story from the opposite angle to show that he 'had not been bought by them'. Now his coverage of modern agricultural biotechnology, from hybrids and tissue culture to GM, is among the best and most positive in the country, as a result of unbiased learning and being able to make up his own mind.

Strengths
The model adopted by B4FA for training, engagement, networking and follow-up has been uniquely powerful in driving media coverage of new genetic technologies for farming in Africa. The timing of the project was also perfect, since the introduction of new technologies, and GM in particular, has become a big regulatory and political issue in each of the four countries during the period of the project (encouraged, in some cases, by the actions of media fellows trained by the project). Informed and nuanced reporting of the issues and the facts during this time has been critical in all countries as the only way to counteract the misinformation that continues to come from the activist community, and to educate and support the policymakers in their decision-making process.

Weaknesses
Though we did have reasonable participation in the programme from editors and producers, the reason why agricultural science stories are not covered more still lies with them. Therefore it would have been good to try to engage more directly with busy editors to both inform them better about the subject matter and convince them of its importance for their audiences.

While we were able to network scientists and journalists, and help make the journalists better communicators of the science, it was a missed opportunity that we did not have more resource (and the remit) to enable us to deliver training to the scientists to make them better communicators of their work to wider audiences.

Opportunities
There are opportunities to engage, using a similar training and dialogue model, with extension agencies in some countries[2] to improve their understanding and appreciation of the new genetic technologies and their promise for transforming agricultural productivity. Additionally, the same model could be applied for decision-makers and NGOs.

[2] Though not, for example, in Tanzania where many extension workers are qualified agricultural scientists and the extension services themselves are carrying out some of the research and breeding activity.

There is an opportunity to work with schools of journalism in Sub-Saharan Africa to improve (or indeed to create) appreciation and skills of science journalism, especially focussing on key nationally important sector such as agriculture.

We found some excellent research being carried out in local research institutes that was virtually unknown nationally and internationally, owing to a lack of capacity in communications and outreach. Significant benefits could arise from working with these institutes to improve their national and international visibility.

Threats
European and US-sponsored activism continues to be a threat to uptake of agricultural biotechnology in Africa, and even to reporting on it. Our media fellows found themselves constantly having to defend themselves and their stories from allegations and inaccuracies fostered by this misinformation. Since the activists have sophisticated communications and PR capabilities, there continues to be the risk that they drown out the voice of the researchers and derail the debate.

Box 2 Summary observations on B4FA media training
By independent journalists Sharon Schmickle (Minnesota, USA) and Julia Vitullo-Martin (Manhattan, New York, USA).

Genetics is not a regular beat in most newsrooms, even those in developed countries. So it was boldly ambitious to focus a media training programme on crop genetics, especially in Africa where farmers have yet to adopt genetically improved hybrids or even Green Revolution technologies made available since the middle of the 20th century. It also was crucially important in Africa at a time when the population is skyrocketing while crop yields remain stubbornly low.

In late 2011 and early 2012, we conducted initial research in Ghana and Tanzania for purposes of analysing the media establishment. We found no sophisticated reporting of crop genetics – and, for that matter, very little serious coverage of agriculture. Yet, interviews with editors and reporters revealed a keen understanding of the importance of agriculture and a deep frustration with the lack of media capacity to cover the subject in any depth. Thus, we concluded that conditions on the ground were right for this highly specialised training programme, and we recommended that it proceed.

That eagerness on the part of African journalists (many of whom are farmers and nearly all of whom have rural roots) became one factor in the ultimate success of the media training programme. In each round of the training sessions, we judged stories the journalists were required to submit. The first round was discouraging. The quality of most of the stories was so low that it was difficult to find any articles that were worthy even of discussion and analysis in the seminars, much less of the awards the programme had promised. What kept us going was the drive and intellectual curiosity the African journalists demonstrated during the sessions. They were engaged in these subjects, and they repeatedly expressed a desire to grow in the quality and the volume of their coverage. They took the training sessions seriously, markedly improving their pieces as we drilled down substantively, exploring possible leads, structure, arguments, controversies, and technical issues.

Language is also a key factor – it emerges that one reason for local suspicions and negativity about new genetic technologies is that there simply is not the vocabulary in local African language to describe it, and so either people need to make up their own definitions, or as is often the case an early unfortunate description (which may or may not have been influenced by activism) becomes the accepted term, and is almost impossible to move beyond. For example, in Luganda (one of the main local languages in Uganda) the term for a hybrid seed is 'improved seed', whereas for a GM seed is 'fake [or manufactured] seed'. Lack of a standard lexicon also makes it hard for journalists working in the local languages, especially those working in farmers' radio, to discuss new technologies in a nuanced and informed manner.

5 Recommendations

- The network of B4FA media fellows should continue to be supported and encouraged to continue their coverage. Other organisations are aware of their skill and expertise and area already requesting recommendations for journalists with whom to interact, or suggestions for those that they should invite to participate in other events. However, the occasional ability to invite a cohort of them to key international conferences or field trips would still be valuable to their coverage, and their profile within their organisations.

In retrospect, that weak initial coverage was an important benchmark for the media training programme. In subsequent training sessions we observed a steady growth in the quality of the stories submitted for review. The improvement was uneven although all the journalists eventually demonstrated some understanding of and interest in the fundamentals of crop genetics. Best of all, a few of the journalists had grown to a very sophisticated level, delivering consistently high-quality and deeply thoughtful coverage of issues that previously had been ignored by their media houses.

The upshot is that the media training programme has effectively seeded newsrooms across four African countries with well-informed journalists who are eager to report up-to-date developments in crop genetics and also to hold their public officials accountable for any failures to support farmers and local agricultural research. They also form an effective front-line guard against misinformation about crop genetics.

Recommendations:

Discussions of journalistic practices, norms and strategies should be woven more thoroughly into every aspect of the training. Journalists who rarely spoke during science lectures came alive when we turned to analyses of the journalistic challenges posed by the applied science. When the final master class session focused on journalism as it related to coverage of crop genetics, journalists in every country told us that was the most useful session in the overall training programme.

Structured follow-through will be important if the training is to have a long-term impact on coverage of crop genetics. Like journalists everywhere, our African colleagues are under tremendous pressure to meet the demands of daily and weekly journalism. It will be all too easy for them to gradually lose the motivation to focus on crop genetics. Ongoing strategies could include more start-up support for the proposed African Agricultural Journalists Network and also support for more linkage between the trained journalists and local universities. Several of our trainees expressed an interest in serving as adjunct faculty if more courses in agricultural communication were offered.

- A number of opportunities were highlighted for applying a similar model to different audiences, such as extension agents, regulators and NGOs, to further shift the quality of debate and knowledge in the countries concerned.

- The African media as a whole could be encouraged to lend greater weight to science journalism, especially in scientific fields like crop genetics which are critical for the economic and social future of the continent. An example could be a greater engagement with schools of journalism to introduce modules on science (or agricultural science) journalism.

- Even without this groundwork, local science stakeholders – such as national academies of science – could be encouraged to promote science journalism and technical training/awareness for members of the media in their countries.

- African scientists are still poorly supported in terms of resources and skills for science communication. Science communication training courses for agricultural scientists would therefore be a further channel to improve public perception and understanding of agricultural genetics.

- African research institutes are still poor at publicising their work or even making public their work. Very few have their own websites which are populated with up-to-date information, making it hard – if not impossible – for national and international audiences (and potential collaborators) to find out what they are doing. PR engagement with research institutes who are willing would go some way to addressing this issue, and improving their international visibility and therefore interest in their work, and offers of collaboration and assistance.

The value of the project's model for training and interacting with the media has proven uniquely powerful in its impact and visibility. It could be readily replicated in other Sub-Saharan countries.

Activity 3 (see also Appendix A)

Scoping studies

The purpose of this activity was to produce a scoping study on how to strengthen the understanding among small-scale farmers and extension services of the new genetic technologies of plant breeding in African nations. The study, after discussion with the Advisory Group, was set up in three parts to build on collaborations with the National Institute of Agricultural Botany (NIAB) at Cambridge (Activity 3.1); the University of Reading, the Department for International Development (DFID) and the Economic and Social Research Council (ESRC)(Activity 3.2; and the work of the Cambridge Malaysian Education and Development Trust's (CMEDT) work with the Malaysian Commonwealth Study Centre (MCSC) at Cambridge (Activity 3.3).

Activity 3.1 examined how innovation farms could be used to display and compare a range of plant breeding technologies including GM crops where appropriate. Activity 3.2 was designed to discover from the farming community in our target countries in Africa how farmers gained access to new knowledge. Activity 3.3 also carried out work in the field to see how a new tablet technology could assist the rural community in adapting to new technologies.

Activity 3.1 Strengthening and enabling implementation – a scoping study (with the National Institute of Agricultural Botany, NIAB, Cambridge, UK; see also Appendix A)

This project assessed how showcasing genetic innovations in crop breeding could raise farmer awareness and adoption rates of improved varieties in three African countries, and examined the use of the model developed in the UK at the National Institute of Agricultural Botany Innovation Farm, Huntingdon Road, Cambridge, CB3 0LE.

Study team and responsibilities

- Dr Sean Butler, Head of NIAB International: Team leader, oversight of all stages of the study, co-author;
- Dr Tinashe Chiurugwi, Research Associate, NIAB: Lead researcher, involved at all stages of the study, co-author;
- Dr Tina Barsby, CEO and Director of NIAB; involved during the inception phase and final analysis;
- Dr Lydia Smith, Director, NIAB Innovation Farm: involved during the inception phase, follow-on visits, and final analysis;
- B4FA Team: involved in reviewing all projects plans and activities.

Summary

1 Introduction

Food and nutrition security is a major challenge facing the world's governments, especially in developing countries. Improved and sustainable crop productivity is necessary to address this challenge, and this relies on using species/varieties which are adapted to the growing environment and whose product is suitable for the intended end use (The Montpellier Panel, 2013; Van Mele *et al.*, 2011). Considerable effort is put into breeding improved varieties in many Sub-Saharan African countries, and around the world, better in terms of yield, nutritional content and tolerance to production limitations such as drought, disease, pests, etc. At the same time, challenges still remain in transferring knowledge about these advances to the wider agricultural sector and supplying actual seed for farmers to grow (AGRA, 2013; Ragasa *et al.*, 2013a, 2013b; Tripp and Mensah-Bonsu, 2013; Van Mele *et al.*, 2011). As a result most smallholder farmers lack information about the range of species and varieties suitable for their requirements, and still grow a narrow selection of old, inferior varieties (Agri-experience, 2012).

To help address these issues, the National Institute of Agricultural Botany (NIAB) recently completed a one year Scoping Study as part of the Templeton Foundation-funded Biosciences for Farming in Africa initiative (B4FA; www.B4FA.org), the Strengthening and Enabling Implementation Activity. Under the this activity, B4FA explored how to strengthen alternatives to traditional extension services, which can provide a crucial link between the knowledge-base in research institutions or seed companies and smallscale farmers. This channel of knowledge transfer becomes increasingly important for the adoption of GM crops and for the provision of agronomy advice.

2 NIAB

The National Institute of Agricultural Botany (NIAB, Cambridge, UK; www.niab.com) has a long history and distinguished reputation in supporting the development of improved crop varieties, and transferring advances in plant science knowledge into practical agriculture.

NIAB is ideally placed to ensure that advances in plant breeding actually reach the farmer, through core activities in seed testing, crop analysis and variety evaluation, and through the Institute's unparalleled role in pre-breeding, applied genetic research and knowledge transfer. NIAB also has a proven ability to deliver first class, well-managed projects. With a wealth of UK and international experience, our access to up-to-date knowledge, industrial partners and government contacts in this area is unrivalled.

In the UK, NIAB Innovation Farm (www.innovationfarm.co.uk) was created and developed by Dr Lydia Smith and Dr Tina Barsby as a unique knowledge transfer and exchange hub linking scientific research and agricultural practice through themed exhibitions; links to NIAB core farmer interactions; small-scale focused projects; targeted assistance for small industrial companies; training (including practical participatory events); conferences, and many other types of strategic and industry-led events. Recently, due to its independent, even-handed status, it has also become an important venue and base for strategic groups and committees to meet and to launch national programmes and engage in discussions towards future initiatives. It is able to broker connections between farmers, the general public, large, medium and small enterprises, policy makers, and researchers to improve the inception and application of plant genetic innovations aimed at improving production and utilisation of plant-based materials. The facility helps address drivers and constraints to innovation application, including policy, legislation, market, and economic factors, bringing together diverse stakeholders around key challenges in the industry (Appendix A.3.1.1).

3 The scoping study

The main objective of the Scoping Study was to find out whether the NIAB Innovation Farm concept can be applied in Kenya, Uganda and Ghana to help improve the awareness by smallholder farmers of new genetics in agriculture, and more specifically the adoption of improved varieties. We also sought to identify potential partners to work with in developing proposals for setting up NIAB Innovation Farm in these countries. NIAB Innovation Farm UK was of course designed and developed specifically for the UK context, so in carrying out the study we were considering its essential aspects – such as impartiality, demonstration of technology, farmer-facing orientation, and research-industry-farmer links – rather than all of it, to avoid falling into the trap of taking 'best practice' in one country and attempting to deliver it in another.

The project began with desk studies but was based largely on interviews with representatives of the key organisations involved in producing and disseminating improved plant varieties to farmers (government agencies, non-governmental organisations, universities, plant breeders, seed companies, farmers, farmer institutions, etc.) to understand their activities and the market forces linking them together, and to explore whether there are any comparable innovation platforms already in place. We found a number of gaps in the seed systems, including lack of farmer education about improved varieties and their use, inadequate capacity to carry out trials and surveillance necessary for variety registration and seed certification, and inefficient foundation seed production systems.

We therefore proposed a three-pronged approach aimed at (1) better dissemination of variety information to farmers and other stakeholders, (2) more systematic variety performance evaluation and demonstration, and (3) improved variety registration and seed certification processes. This would all be in the context of the interaction between business and farmers, between researchers and farmers, and between policy makers and the agricultural sector. There was a willingness to address these issues, and there were several governmental and non-governmental initiatives that showcased and promoted plant varieties to farmers in Ghana, Uganda and Kenya. However, most of the initiatives (which mostly revolved around demonstration plots, field days, media campaigns and printed promotional material) were in need of better resourcing and coordination to improve message accuracy, coverage, and impact on development and adoption of varieties. This could be achieved within the framework of a NIAB Innovation Farm in Ghana and Uganda, and by working with existing facilities in Kenya.

4 Follow-on activities

Since completing the scoping study, we have started to identify, approach, and engage with potential donors to launch NIAB Innovation Farm Africa in Ghana and Uganda.

The NIAB Innovation Farm Africa framework could be optimised for variety evaluation and registration, seed certification, and dissemination of know-how to farmers and other stakeholders. We are working with various sponsors and partners to explore these opportunities in the three project countries and other parts of Africa.

5 Approach and methodology

The study was conducted in a number of phases (all carried out in consultation/discussion with the B4FA project team), some activities were replicated for each of the three countries as shown in the timeline in Table 3:

Table 3 Project timeline

Milestones	Timeline
Inception phase	November 2012–January 2013
Data collection and analysis (allowing 4 weeks for preparation, 5 weeks in-country and 2 weeks for analysis and write-up per country)	Uganda: January–March 2013 Ghana: April–June 2013 Kenya: July–September 2013
Follow-on field visits (with Dr Lydia Smith, Director of the NIAB Innovation Farm)	Ghana: 29 September–5 October 2013 Kenya: 5–11 October 2013 Uganda: 11–18 October 2013
Final analysis and report	October 2013–April 2014

Inception phase: desk review of background and context, identification of emerging issues and questions (from documents listed in the Bibliography list, Appendix A.3.1.7); preliminary interviews with stakeholders (including the B4FA project team) in the UK; and design of study framework and data gathering approach.

Data gathering and analysis: gathering and review of relevant documents and information (see References & Bibliography lists), interviews in-country (during a comprehensive five-week field study); data analysis and drafting of country-specific models of how NIAB Innovation Farm could be relevant; and findings review and verification with key informants in-country (during a follow-on 5-day field study).

6 Final analysis and report:
Approaching the study this way, we were able to:

a set out the primary features of NIAB Innovation Farm that could be relevant to each of Uganda, Ghana and Kenya. This analysis formed part of a presentation that was used as a conversation aid during the field visits (Appendix A.3.1.1);

b identify the key players in the three countries' crop-based industries and meet with key staff at specific institutions using a checklist (Appendices A.3.1.2, A.3.1.3);

c review existing services that seek to bridge the gap between Research and Application in the three countries, and how the NIAB Innovation Farm concept could supplement them;

d develop models for setting up NIAB Innovation Farm in each country. The models were discussed with all interviewees during the field visits.

Sampling procedure
Maximum variation (non-random purposive) sampling was used to come up with the initial list of diverse interviewees (a group of 'key informants' covering a wide range of perspectives), based on a desk study and advice from the B4FA team and members of the UK All Party Parliamentary Group on Agriculture and Food for Development.

The snowball sampling technique, following referrals from the initial interviewees, was used to expand the sample. At all times, the qualities, reliability and competency of potential candidates was kept in mind, as was the potential bias that could be introduced from the trial and error process involved in setting up successful meetings in the three study countries. Informant reliability was assessed based on the primary researcher's experience of African seed systems and employing cross-checking and validation methods (e.g. triangulation) when information, ideas or concepts appeared incoherent or implausible. Informal interviews with ground staff and the follow-on trip to each study country also helped clear some lingering inconsistencies.

In total some 55 people were interviewed in Ghana, 57 in Uganda and 66 in Kenya (see Appendix A.3.1.4). These numbers were determined by the amount of people required to gather a broad range of perspectives and to optimise representativeness (internal validity) of the study, since the informants were chosen using non-probability methods. Key staff ranging from 1–15 per organisation were interviewed during the field visits.

Data gathering
Key players of the crop-based industry in the three countries (Appendix A.3.1.3) were identified and interviewed. The interviews sought to ascertain their roles in linking research and on-farm practice, solicit their views on the scoping study and what role they would expect to have in a relationship between their organisation and NIAB Innovation Farm in their country. A selected sample of organisations, identified through a desk study, was judged to be more appropriate than a random sample because the study sought to gather particular views of people with diverse characteristics, knowledge and experience in relation to technology transfer in the study countries. While using interviews was costly, time consuming, and restrictive on sample size (like most qualitative studies), it

allowed gathering of detailed information, flexibility with questions, and interpretation of cultural significance of the information.

The semi-structured interviews (Appendix A.3.1.2) were supported by direct observation of facilities (e.g. research, demonstration, seed processing and seed marketing facilities) and informal interviews with ground staff and service users of these facilities (e.g. farmers, merchants, journalists, researchers). In situations where the key contact preferred to have more than one member of staff in a meeting, the interviews took the form of a focus groups discussion, with specific questions answered by informants judged to have the most relevant knowledge and experience. Questions posed during the interviews were structured so as to reduce the chances of informant bias.

7 Results

Agriculture is the mainstay of the economies of Ghana, Uganda and Kenya; it contributes employment for an estimated >70 per cent of the population and >25 per cent of annual GDP. The staple crops in the three countries can be grouped into cereals (maize, rice, sorghum, wheat and millet), roots, tubers and bananas (cassava, yam, cocoyam/arrow root, sweet potato, Irish potato, banana, and plantain), and pulses (cowpea, pigeon pea, chickpea and green grams/mung bean). Among these, the key carbohydrate sources are: plantain, cassava and maize in Uganda; cassava, yam and maize in Ghana; and maize and wheat in Kenya (FAO, 2011, 2013). While self-sufficient in most staples, the three study countries import key products like maize, rice, wheat, vegetables, and sugar.

Given that in all three countries most (>70 per cent) of the agriculture is practised by smallholder farmers (working on less than 5 hectares of land, employing traditional production methods/inputs and family labour) there is a shortage of farm workers with basic skills or knowledge to support commercial agriculture (GOG, 2013a; GOK, 2010a, 2010c; GOU, 2010). Additionally, the use and availability of bought-in agricultural inputs is very limited (e.g. inorganic fertiliser use is estimated at only about 5–10 per cent in Uganda and Ghana) and most farmers are not well-trained in the application of these inputs (GOG, 2013a).

While improved varieties are available for almost all major crops in Uganda, Ghana and Kenya, there are problems with seed supply to farmers: most farmers (>70 per cent) use seed from the informal sector—uncertified seed that is saved on-farm, exchanged among farmers, or bought from local markets. Among those that use certified seed of improved/registered varieties, only a small percentage (<10 per cent) purchase it from approved sources, the rest obtain it through the various input support programmes operated by relief NGOs and national governments. In Uganda and Ghana, these programmes have the unfortunate effect of distorting and crippling the seed industry for most crops. In all three countries, the formal seed sector can only provide for a fraction (<30 per cent in Ghana and Kenya) of the national seed requirements for most staple crops, so as a result farmers are likely to be using seed of sub-standard quality in terms of purity and germination.

7.1 *Plant breeding profiles.* In Uganda, investigative crop science research is mainly carried out by the National Agricultural Research Organisation (NARO), CGIAR institutes, Universities and seed companies although the majority of seed company research in this category is carried out outside Uganda). Research within seed companies is mainly managed by retired researchers, and it is still to produce new varieties. The main NARO Institutes are the National Crops Resources Research Institute (NaCRRI), with units at Kawanda, Namulonge and Kituza; the National Semi-Arid Resources Research Institute (NaSSARI) in Serere and the National Agricultural Research Laboratories (NARL) at Kawanda.

Investigative staple crops research in Ghana is mainly carried out by the Council for Scientific and Industrial Research (CSIR) Institutes: Crop Research Institute (CRI), Forestry Research Institute of Ghana (FRIG), Oil Palm Research Institute (OPRI), Plant Genetic Resources Research Institute (PGRI), and Savannah Agricultural Research Institute (SARI). Some work is also carried out at Cocoa Research Institute of Ghana (CRIG), the Biotechnology and Nuclear Agricultural Research Institute (BNARI), and Universities.

In Kenya, plant breeding for staple crops is mainly carried out by the Kenya Agricultural Research Institute (KARI), with some work going on in breeding programmes run by multinational seed companies, a few local seed companies, CGIAR Centres, NGOs and Universities. Other State institutions carry out commodity-specific research, e.g. The Tea Research Foundation Kenya (TRFK), Kenya Forestry Research Institute (KEFRI) and the Kenya Sugar Research Foundation (KESREF). At the time of this study, KARI, together with some of the research institutes mentioned above were in the process of being transformed into Kenya Agricultural and Livestock Research Organisation (KALRO) in line with the Kenya Agricultural and Livestock Research Act, 2013.

Most breeding programmes in Uganda and Ghana are funded publicly or by NGOs at national research institutes/universities, or through international programmes such as those run by the CGIAR; with a few nascent breeding programmes in the emerging private seed industry. On the other hand, the private sector plays an equally (if not more) significant role in breeding most of Kenya's staples. In all three countries, breeding targets are centred on combining improved farmer yield with other agronomic traits such as disease/drought/cold tolerance, maturity, nutritional content and post-harvest quality.

7.2 *Formal seed systems.* All the study countries have plant and varieties regulations: plant varieties of most staple crops have to be registered with the national authorities – National Seed Certification Service (NSCS) in Uganda, Kenya Plant Health Inspectorate Services (KEPHIS) in Kenya, and Ghana Seed Inspection Division (GSID) in Ghana – before certified seed can be produced and marketed. Kenya is a member of UPOV (the international body for protecting plant variety rights), and both Uganda and Ghana are in the process of joining. Once varieties are released, variety maintenance and production of breeders' and foundation seed are handled by the breeders (except foundation seed production which is the responsibility of the Grains and Legumes Development Board (GLDB) in Ghana) while certified seed production is carried out by the individual seed companies (both publicly and privately owned), NGOs, community-based organisations and government-run applied research and training centres.

While KEPHIS in Kenya is well-respected in the field, it has been known to be too restrictive in managing National Performance Trials (NPTs), which are carried out pursuant to variety release regulations, and to lack capacity to meet fully the demand for their services within the industry. On the other hand, NSCS and GSID are known to lack adequate capacity (manpower, infrastructure and funding) to carry out surveillance, certification and quality control activities necessary for their roles.

When the multiplying or commercialising agent is not the breeder of a variety, the breeders are paid royalties for all varieties in Kenya and for hybrids in Uganda. For non-hybrid varieties in Uganda and all varieties in Ghana, breeders recover their costs through sale of breeders'/foundation seed (directly or through public or private agents, e.g. GLDB in Ghana).

In all three countries seed companies sell seed to input support schemes run by the government or NGOs or to farmers directly and through agro-dealers operating conventional shops or stalls in major markets. While the seed companies and agro-dealer shops are well organised in Kenya (with more than 90 registered seed companies in 2013), and to a lesser extent in Uganda (about 25 registered seed companies in 2013), in Ghana they are few, small and new (<15 registered seed companies in 2013). The same statistics are reflected in the level of interaction between researchers and seed companies, and the number of registered varieties and state of variety registration and seed certification procedures: unlike the other two countries, Ghana is yet to legislate for Plant Breeders Rights and does not have a seed testing laboratory that operates to International standards (e.g. International Seed Testing Association (ISTA) or Organisation for Economic Co-operation and Development (OECD) schemes in Kenya and Uganda).

The main impediments to development of the seed systems in all the study countries are: under-resourced variety maintenance and breeder seed production schemes; lack of suitably isolated land and experienced growers for seed production; uncertainty over quality and origin of seed supplied informally or through input support schemes; insufficient marketing and promotion of improved varieties; and insufficient credit facilities for seed producers, agro-dealers and farmers (Ragasa *et al.*, 2013a, 2013b; Agri-experience, 2012). These are discussed further in Appendices A.3.1.5 a, b, c).

7.3 *Technology transfer profiles.* Several initiatives are in place to link farmers with research outputs to facilitate knowledge and technology transfer in Ghana, Uganda and Kenya, with government and non-governmental support. The initiatives mostly revolve around annual agricultural and trade shows, demonstration plots, field days, open days, media campaigns and printed promotional material. A number of them share some aspects with NIAB Innovation Farm. While some of them are very effective, they are often erratically arranged and their coverage is limited and narrow, depending on project focus areas/crops and availability of funds; and they need to be better resourced and coordinated to improve message accuracy, coverage and impact. The initiatives in each country are discussed in Appendices A.3.1.5 a, b, c, while only the main ones are discussed here.

7.4 *Seed companies, research institutes and agriculture ministries.* Seed companies, research institutes and agriculture ministries have a key role in plant variety-related technology transfer for most food crops in Ghana, Uganda and Kenya. However, in Ghana and Uganda, their roles and responsibilities are not clearly defined and their efforts poorly coordinated because seed companies are relatively new and are still reliant on the publicly funded research and extension services for breeding and marketing. In all three countries, seed companies promote their seed through various means including on-station and on-farm demonstrations, field days, agricultural/trade shows, media campaigns, and printed promotional material. The promotional campaigns are organised independently or in collaboration with other stakeholders in the seed systems. In Kenya the seed companies have more say on how the collaborative campaigns are operated, compared to the other two countries.

National research institutes have outreach programmes which facilitate dissemination of their research outputs through field days and demonstrations, open days, etc. in association with seed companies, universities, NGOs, international research organisations, farmer groups, and public extension services. These outreach programmes are more regularly offered in Kenya than in Uganda and Ghana (KARI actually has its own seed company which commercialises some of the products that private seed companies have no interest in) – in Ghana, for example, the last open day at the Crop Research Institute (the main plant breeding institution) was held in 2011.

While research institutes depend on seed companies to disseminate their varieties in all three countries, for most of those crops that private seed companies choose not to commercialise (e.g., vegetatively propagated plants – banana, cassava, sweet potato; forage crops and self-pollinated plants – millet, sorghum, beans, etc.), they rely on the agriculture ministries, NGOs, and farmer groups for distribution (they usually charge a small fee for their material). The national research institutes also act as the conduits for delivery of varieties from international research organisations like the CGIAR, although other international organisations like the African Agricultural Technology Foundation (AATF) are now trying to license out their varieties to seed companies directly.

Formal links between farmers and research/extension services have been attempted in all three countries. For example, the (so-called) Research-Extension-Farmer Linkage Committees (RELCs) programme was set up in 1994 in Ghana to provide an interface between the research and extension service providers, and a bridge between researchers, extension experts; farmers and agribusiness. While the roles are clearly spelt out in documentation that established these arrangements, it was not possible to assess their efficacy and, since most of the linkages are donor-funded, it was also unclear how they would continue once their funding stopped. In all three countries research institutions play a leading role in the research/extension services, but this limits their inclusivity: e.g. in Ghana, farmer representatives said there was minimal farmer participation in the RELCs.

The agriculture ministries in all three countries have a number of extension initiatives tasked with bringing agricultural innovation to farmers. These are controlled centrally from the ministries (or head offices in the capital if they are specific donor projects, e.g. the National Agricultural Advisory Service – NAADS in Uganda) with decentralised structures which follow local government systems.

The extension services have several problems in all three countries, although they are more pronounced in Uganda and Ghana than in Kenya. These include very low staff-to-farmer ratios, poor quality of information in terms of accuracy and reliability, low coverage rates, and ineffective methods of dissemination (e.g. top-down group extension, which rarely changes farmer behaviour).

The extension services in all three countries have projects looking into e-extension (using mobile phone messages and various methods over the internet and portable computers), although Kenya has the best functioning variety information systems among them: KEPHIS operates an SMS advisory service to help farmers with variety choices (farmers text in with their location and request, and they get a text back with variety recommendations), and similar information is available from the KEPHIS website.

7.5 *Farmer training centres.* The agriculture ministries of all three countries have farmer training centres throughout the farming regions to carry out adaptive trials, demonstrate and multiply plant varieties, disseminate new technologies, and train farmers. This role is carried out by Agricultural Training Centres (ATC) in Kenya, Farmer Training Centres (FTC) in Ghana and Zonal Agricultural Research and Development Institutes (ZARDI) in Uganda. The roles of these organisations are sometimes supplemented by the research institutes through their main centres or sub-stations. In all the countries, the aim is to bring research results closer to farmers and test/demonstrate them in the relevant agro-ecological conditions.

To extend their reach, farmer training centres also carry out outreach visits to the farming communities and allow farmers or farmer groups to arrange site visits or training sessions. These are usually designed to tie in with the year-round demonstrations that the centres maintain so as to train and inform farmers on various aspects of farming including agribusiness, agronomy, animal husbandry and post-harvest handling/processing.

The farmer training centres are also used by other organisations with technologies or products they want to disseminate to farmers, including companies that sell seeds, agro-chemicals, glasshouses, irrigation equipment, etc., as well as universities, research institutes, NGOs, farmer groups, and agro-product processors. In Kenya this multi-stakeholder approach is being formalised and has a wide coverage (one each of the 47 counties), the stakeholders have their own committees which coordinate their activities and organise annual field days at the training centres. In Ghana and Uganda the relationships between centres and other service providers are developed *ad hoc*, and the stakeholders do not have formal relationships among themselves.

Although in principle valuable, farmer training centres in all three countries (in common with other technology transfer initiatives) are heavily under-resourced and are unable to perform most of the functions listed above well enough to improve farmer adoption of improved varieties. In all three countries, the centres also lack a standardised/coordinated approach to operations or systematic structuring of reports on their activities in a manner that is accessible to farmers or the general public. These limitations are more pronounced in Uganda and Ghana than in Kenya.

7.6 *Agricultural shows.* In each of the three countries there are annual agricultural and trade shows held to allow knowledge exchange and technology transfer in the industry. Smaller versions of the shows are held in different regions of the countries throughout the year, culminating in a big national event. Agricultural innovations and technologies (including plant varieties, agro-chemicals, tools/equipment, etc.) are presented and sometimes available for sale at the shows. Some people questioned the usefulness of these shows for effective technology transfer, dismissing them as mere funfairs because of the non-agricultural activities included in the programmes. This opinion was mainly held by technical experts; farmer representatives appeared to value the shows, and they regularly attend whenever they can.

The national agricultural shows are organised by different types of organisations in the three study countries: the Uganda National Farmers' Federation in Uganda; the Ministry of Food and Agriculture in Ghana, and the Agricultural Society of Kenya in Kenya.

7.7 *NGO and other development partners.* In all three countries various development initiatives run by farmer organisations and local/international NGOs are involved in agricultural technology transfer, including dissemination of improved plant varieties. Most of these initiatives (depending on the programme) use demonstration/trial plots and also deal with issues related to improving agricultural productivity, in addition to showcasing and distributing improved varieties. They include correct use of inputs, agronomy and disease/pest control training and advice, post-harvest handling, processing and marketing of produce.

Most programmes deal with specific communities or crops and rarely cover a significant part of the farming communities (dealing with tens of thousands of farmers in countries with tens of millions of farmers). There is need to improve on the best of these initiatives, to achieve greater impact and sustainability through expanding their remits (geographical and range of crops) and better coordinating them to improve accessibility by farmers and other key stakeholders in the sector. Another alternative, as suggested by many participants in this study, is to have other initiatives which are structured to cater for those farmers excluded from the current set up.

7.8 *Perceptions about NIAB Innovation Farm.* While some aspects of the demonstration and outreach initiatives described above are clearly similar to the NIAB Innovation Farm in the UK, they are invariably erratically arranged and their coverage is limited and narrow, depending on the preferences of the persons in charge, project focus areas/crops, and availability/targeting of funding. There was general agreement from respondents that these initiatives could be improved by drawing on NIAB's skills – launching NIAB Innovation Farm in Uganda and Ghana and helping improve existing facilities in Kenya. These findings are explored further below.

7.8.1 Kenya

In Kenya, the NIAB Innovation Farm concept was generally well received as a new way of doing things but most respondents suggested that it would be better for NIAB to work with existing organisations and structures than set up a new institution, unless it was to have a radically different approach. Such an approach would, however, mean that the institution would be too different from NIAB Innovation Farm and therefore not fulfil the objectives of this study.

The farmer training institutions, Agricultural Training Centres (ATCs), run by the Agriculture Ministry in 27 of Kenya's 47 counties (there will be one in each county by 2015) resemble the certain farmer-facing aspects of the NIAB Innovation Farm. All of the institutions hold an agricultural and trade show (field day) annually. Exhibitors at these events include financial institutions, agro-chemical companies, universities, research institutes, agro-chemical companies and seed companies; and they have committees which organises the fairs at each ATC. For example at one site, Wambugu ATC in Nyeri County, they had 88 exhibitors at their 2013 field day, which was attended by 18 000 people over a two-day period. Exhibitors pay for a spot and the events are publicised through various types of media, including SMS; the Wambugu ATC had 11 000 farmers on its database and could target its SMS messages according to farmer interests/enterprise. The ATCs also hold open days (at least once weekly) when anyone is welcome to visit and ask questions.

Many respondents said that a NIAB Innovation Farm Kenya as envisaged would be neither novel nor necessary. What should be done, they suggested, is to help the ATCs and the various other outreach activities (agricultural shows; demonstrations by seed companies, NGOs, the Ministry, NARS, etc.; Farmer Field Schools; field days organised by farmer-based organisations; etc.) to upscale and be more effective. It was clear from the field study that what is lacking in the ATCs and other initiatives is a standardised/coordinated approach to operations and systematic packaging of reports on their activities in a manner that is accessible to farmers and the general public.

Proposed action: The findings indicate at this stage that launching NIAB Innovation Farm Kenya will not be appropriate. NIAB could have a role in supporting the Kenyan technology transfer systems, but would have to fit in with the current 'innovation' craze in Kenya: there is widespread realisation that a lot of innovations have been generated and remain inaccessible to farmers or other end-users because they were never relevant in the first place, or were not packaged well (i.e. they are gathering dust on shelves, or they only make sense in the researchers' minds). There are a lot of initiatives targeted at providing practical agricultural training to farmers and these are working well for horticultural and other cash crops. The current drive is to take this approach to the marginalised farmers: peri-urban farmers, the youth, and (more importantly in most respondents' opinion) farmers who produce staple crops for the local market; farmers working with the sort of crops that multinational seed companies are not interested in.

7.8.2 Uganda and Ghana

When the possibility of launching the NIAB Innovation Farm in Uganda/Ghana was raised with participants who were already providing certain aspects of the concept, general feedback was positive. Most participants had clear ideas of how they would participate in the project to complement their current activities (see Appendix A.3.1.5 a, b).

In both Uganda and Ghana, the interviewees were in general agreement that the NIAB Innovation Farms could add to the existing mix of technology transfer and knowledge exchange systems by providing a facility initially for independently showcasing new plant varieties to improve impact on on-farm practice.

In both countries, it was encouraging to note that the technical drivers behind agricultural policy in government agencies (e.g. the departments responsible for crops and extension services in the ministries of agriculture, national research institutes, and seed certification services providers) were very clear on how they saw the facility fitting in with and enhancing their activities. The concept of having a NIAB Innovation Farm in both Uganda and Ghana was also supported by virtually all independent organisations currently involved in delivery of innovation and they expressed willingness to contribute to its launch and participate in its operation. For example, representatives of the CGIAR Centres/Programmes (e.g. IITA and Harvest Plus), Alliance for a Green Revolution in Africa (AGRA) and the African Agricultural Technology Foundation (AATF), prominent sponsors of plant breeding in Uganda and Ghana, all said their dissemination activities would benefit immensely from working with the NIAB Innovation Farm in these countries.

As a result of our consultations and research, we have developed operational models of NIAB Innovation Farm Uganda and NIAB Innovation Farm Ghana which adapt the NIAB Innovation Farm UK concept to suit local circumstances. Specific details for each country are discussed in Appendix A.3.1.5 a, b, c.

We have identified: appropriate hosts and partners, facilities, potential innovations for exhibition, possible management setup, and ways of reaching the target audience, and explored ways for funding and long term sustainability.

We have also identified aspects that are not provided by NIAB Innovation Farm UK, suggested by respondents as necessary to make the project more relevant and effective. These aspects are centred on helping researchers, seed companies and seed certification staff in the design, establishment and enforcement of seed certification standards, methods and procedures; and improving communication of complex agricultural science information. For example, NIAB Innovation Farm Uganda could host post-certification control plots for certified seed which, at the moment, are not planted out regularly due to lack of resources. It would be an ideal partner in this exercise as a neutral and independent player, and including farmers would be a welcome addition; turning the process into one of both verification and showcasing, improving awareness and accountability all round. In NIAB Innovation Farm Ghana the additional aspects would include adopting a value chain approach to exhibitions and events, production of quality planting material for OPV, self-pollinated and vegetatively propagated crops which do not require large isolation distances during seed production and training services for the Ghana Seed Inspection Division.

8 Proposal for NIAB Innovation Farm Uganda and NIAB Innovation Farm Ghana (Appendices A.3.1.5.a, b)

Themes

The themes to be addressed by NIAB Innovation Farms Uganda/Ghana (drawing on the work done by NIAB Innovation Farm in the UK) were developed through consultation in-country having in mind what would be required to facilitate the dissemination and adoption of GM crops once appropriate regulatory were in place. They would fall under the broad headings of:

a Health and nutrition – improve, maintain and harness the nutritional and health properties of crops
b Sustainable resources – extend the area under sustainable land and water management
c Climate change – predict and respond to the evolving threat from pests, diseases and extreme weather
d Food security – improve food supply and reduce poverty and hunger by raising smallholder farmer productivity.

These themes were described as globally applicable and widely acceptable and it was noted that other organisations had similar goals in mind, namely, the African Union, CGIAR Consortium and Forum for Agricultural Research in Africa (FARA). The subject emphasis, target crops and innovations demonstrated for each theme would be appropriate to suit local circumstances.

The general feeling was that, to start with, NIAB Innovation Farms Uganda/Ghana should focus on a few staple crops (up to 10), covering the main food and cash crops (see Appendix A.3.1.5 a, b for details of potential exhibitions).

Communication role

The communication strategy should suit local circumstances making use of existing channels of information dissemination and looking into developing new ones together with other development partners. These would include: mobile phone communication, audiovisual material, and written material or other visuals.

Organisation

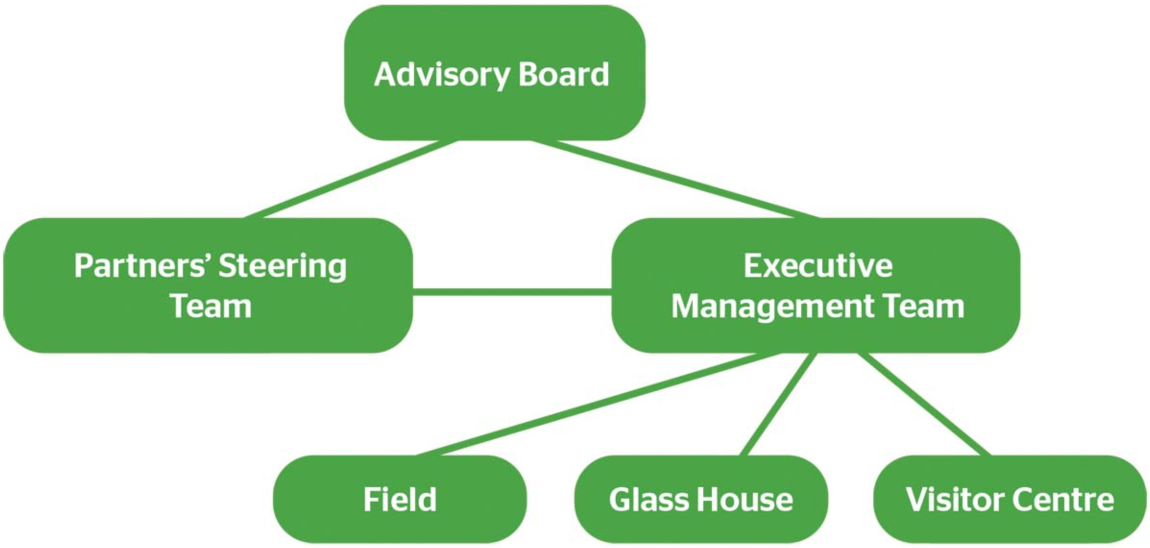
Two new NGOs – NIAB Innovation Farm Uganda and NIAB Innovation Farm Ghana – would be established and registered with the relevant authorities. The management of the NGOs would consist of an Advisory Board, a Partners' Steering Committee, and an Executive Management Team (Figure 14).

The Advisory Board would be made up of representatives from national agricultural research systems, agriculture ministries (crop services and extension services), processors, agricultural NGOs, seed companies, farmer based organisations, NIAB, and regional/international bodies. Public bodies would be included to secure sustainability for the new NGOs, and to guard against buy-out from these key participants in a highly politicised sector. The Advisory Board would be chosen to include strategic partners who can identify synergistic development programmes, or additional funds (e.g. partners who have a budget for promoting improved varieties could end up spending it on NIAB Innovation Farms Uganda/Ghana activities), thus ensuring sustainability.

The Partners' Steering Team would include a subset of organisations represented in the Advisory Board, and other stakeholders, who would have a closer, hands-on involvement in setting the direction of NIAB Innovation Farms in Uganda/Ghana, working as an 'operations sub-committee' of the Advisory Board. As key partners, farmers, researchers and extension experts would have a leading role in the Partners' Steering Team.

The Executive Management Team would be responsible for the day-to-day management of demonstrations, knowledge exchange, outreach and networking. This team would be appointed upon set up of NIAB Innovation Farms Uganda/Ghana.

Figure 14 Proposed organisational structure for NIAB Innovation Farms, Uganda/Ghana



Technicians would be appointed to manage the exhibition (glasshouse/field) and conference facilities. This technical team would be responsible for on-the-ground delivery of the NIAB Innovation Farms Uganda/Ghana operations, under Executive Management Team supervision.

Setup and hosting options
The detailed results of discussions with several stakeholders about the setup and hosting options for NIAB Innovation Farms Uganda/Ghana are presented in Appendix A.3.1.5 a, b.

For both countries, setting up an NGO with the structures suggested above, whose operations would be hosted by one of the centrally located public research institutions, was found to be the most viable option. Host choice was influenced by various factors including accessibility, water and electricity supply, administrative logistics, estimates of the cost of setting up and operating NIAB Innovation Farms Uganda/Ghana (in light of issues such as optimum farm size, security, cost of constructing or renting and operating office and conference facilities/visitors' centre, and glasshouse facilities).

It was also important first to decide on the target audience, and then choose a host who is already actively trying to reach that audience. This should improve the link between the host's and NIAB Innovation Farm Uganda/Ghana's goals and objectives.

Host choice Uganda
An analysis was carried out to assess suitability of a couple of potential hosts (see Appendix A.3.1.5a) and as a result it is proposed that NIAB Innovation Farm Uganda be hosted at the National Agricultural Research Laboratory, Kawanda, a NARO Institute. An MOU will be needed to establish clear roles and responsibilities between NIAB Innovation Farm Uganda and NARL to ensure independence and neutrality and avoid duplication of efforts and competition between the two. The Director General of Kawanda would form part of the senior management for NIAB Innovation Farm Uganda.

NARL is host to a number of research and development units, the majority of which are focused on linking research with farmers, markets and industry by customising, optimising and showcasing agricultural technologies. There are numerous ways in which the work at NARL would complement NIAB Innovation Farm Uganda, as host and collaborating partner in dissemination of research information.

NARL is located in Wakiso District in the Central Region, about 15 km from Kampala and a day's journey from most parts of Uganda. Therefore, NIAB Innovation Farm Uganda at this location would be fairly central and accessible to all Ugandans. While crop selections vary with district/region, most of the important crops in Uganda will grow well in the Central Region.

Another advantage of a central facility which showcases and tests out or screens new innovations is the reduction, early on, in the innovations that need to be tested out in regional demonstrations and adaptive trials. This would help cut the costs of innovation while ensuring that there is a central repository of project-based innovations, which would otherwise risk being forgotten once project funding ceases and researchers move on to new projects.

Once NIAB Innovation Farm Uganda has established an identity and asserted its relevance, a second centre relevant to semi-arid parts of the country should be considered: perhaps a satellite located at National Semi Arid Resources Research Institute (NaSARRI), another NARO institute in Serere. Some respondents suggested that there will be need for more than one satellite centre, to be established and run in partnership with locally active development partners whose activity would be enhanced by working with NIAB Innovation Farm Uganda. Others also suggested following the ZARDI system, or operating in parallel to it, to improve local presence for NIAB Innovation Farm Uganda. Adopting either suggestion poses the risk of diluting the efforts of the new organisation and is contrary to the NIAB Innovation Farm concept. Furthermore, there was a feeling among some key players that inter-hub/district/farmer group exchange visits already exist under various programmes, e.g. Agribusiness Initiative (aBi) Trust funded activity within Uganda National Farmers Federation (UNFFE); so travelling to a central place would not be new or difficult. What they thought is missing is a year-round, central facility, akin to the one-week Jinja Agricultural Show, which people could visit for information.

Host choice Ghana
After considering various university and research institutes we concluded that NIAB Innovation Farm Ghana should be hosted at Crop Research Institute (CRI), a CSIR institute in Kumasi. This would be the best host because of its central location, the wide range of crops it deals with, availability of irrigation, as well as conference and hostel facilities. It is also the largest and best managed (in terms of research and outreach operations) of all the potential host institutions. This is despite the potential funding advantages that could come from having a Northern Centre at Savannah Agricultural Research Institute (SARI) or University of Development Studies (UDS) owing to the prevailing developmental/donor focus on the (northern) Savannah Ecological Zone. This focus is temporal and NIAB Innovation Farm Ghana, if it is to be sustainable, would be better off in a place that has a solid history and independently credible forward plan.

With time, it should be possible to establish another site at SARI to cater for the crops and farming systems in the arid and semi-arid parts in the North of the country.

Target audience
The target audience for NIAB Innovation Farms Uganda/Ghana would be small-scale farmers, their advisors, crop researchers and policy makers. While poor, difficult-to-reach farmers are the ideal

target group from an agricultural development perspective, it may be prudent to start off by trying to reach the private sector, extension workers, progressive farmers, politicians, and seed companies. Evidence (from IITA programmes, for example) has shown that training the trainer is more achievable and has greater impact than trying to access individual farmers.

There is evidence from other programmes that targeting school children is a potent way of bringing information about innovations to farmers. To help attract a wide audience, NIAB Innovation Farm Uganda/Ghana could also organise themed exhibitions (or themed tours) targeted at different groups of school or college students.

It came out in various discussions that other NGOs who are interested in improving the agricultural situation in the two countries would be willing to bring farmers and farmer group leaders to a centrally located NIAB Innovation Farms Uganda/Ghana, as they already do it for other services. NIAB Innovation Farms Uganda/Ghana would, where appropriate, provide a low cost transport service for visitors (e.g. coaches for farmer groups) to improve/widen access.

Processing and retailing services could also be established to showcase and market agricultural produce from the demonstrations, to enhance farmers' perception of the demonstrated innovations. The target audience for the facility could extend to include people who come to buy this produce. These visitors could come from all walks of life to buy raw produce or processed food from a restaurant attached to NIAB Innovation Farm Uganda/Ghana. This would be in line with the prevalent value chain approach and also enhance visitors' experiences, e.g. through enabling the carrying out of organoleptic tests on various crop products.

NIAB Innovation Farms Uganda/Ghana would be advertised through broadcast and print media and it would operate a website, alongside a Facebook and Twitter account, and its meeting facilities would be available for use by other organisations – to generate publicity.

Key players and roles

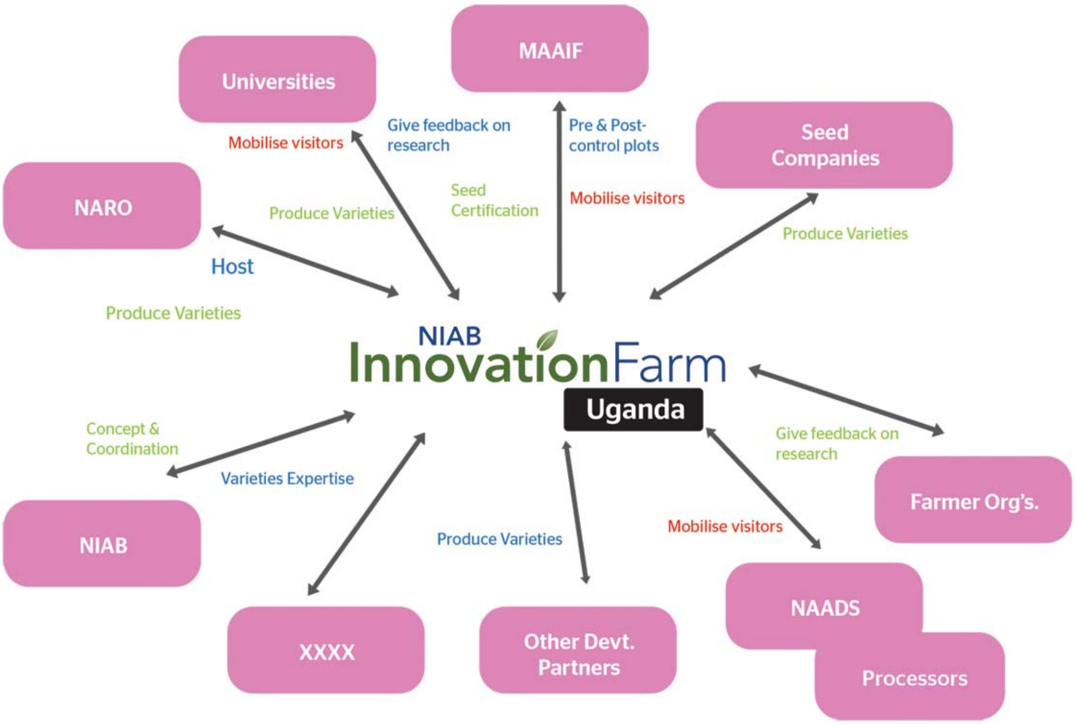
The services that NIAB Innovation Farms Uganda/Ghana would provide would be a public good such that, for greater effect, it should be run with substantial public institution involvement. This would not only leverage public funds ear-marked for promoting improved varieties, but also provide an avenue for NIAB Innovation Farms Uganda/Ghana to access funding from organisations such as the World Bank, which will only fund programmes that involve government bodies. The interaction of these public sector bodies (e.g. research institutes and extension/crop services) with other organisations (universities, agricultural development NGOs, agricultural consultants, seed companies, agro-input dealers, processors, etc.) is outlined in Figure 2 and 3 and discussed in detail in Appendices A.3.1.5 a, b.

Facilities

NIAB Innovation Farms Uganda/Ghana will have the following facilities: visitors' centres for holding meetings and events; glasshouses for controlled environment exhibitions; and field plots for field exhibitions:

- a The visitors' centres will be based in conference facilities which already exist at the hosting institutions.
- b A new glasshouse with compartments for different environments and contained cultivation of genetically modified plants (if grown) will need to be constructed for NIAB Innovation Farm Ghana, while in Uganda there is ample glasshouse space at the host institutions.

Figure 15 Potential participants and their roles in NIAB Innovation Farm, Uganda



c The field demonstration plots will be 15–20m[2] in size, following from the existing practices in the two countries, such that NIAB Innovation Farms Uganda/Ghana would require 1–4 hectares depending on the number of varieties/technologies demonstrated. This land is available at the proposed host sites in both countries. While ample irrigation facilities exist at the host institutions in Uganda, these will need to be installed in Ghana to enable year-round demonstrations and ensure that NIAB Innovation Farm Ghana operations mirror those on the farmers' fields to avoid important events clashing with busy periods on-farm.

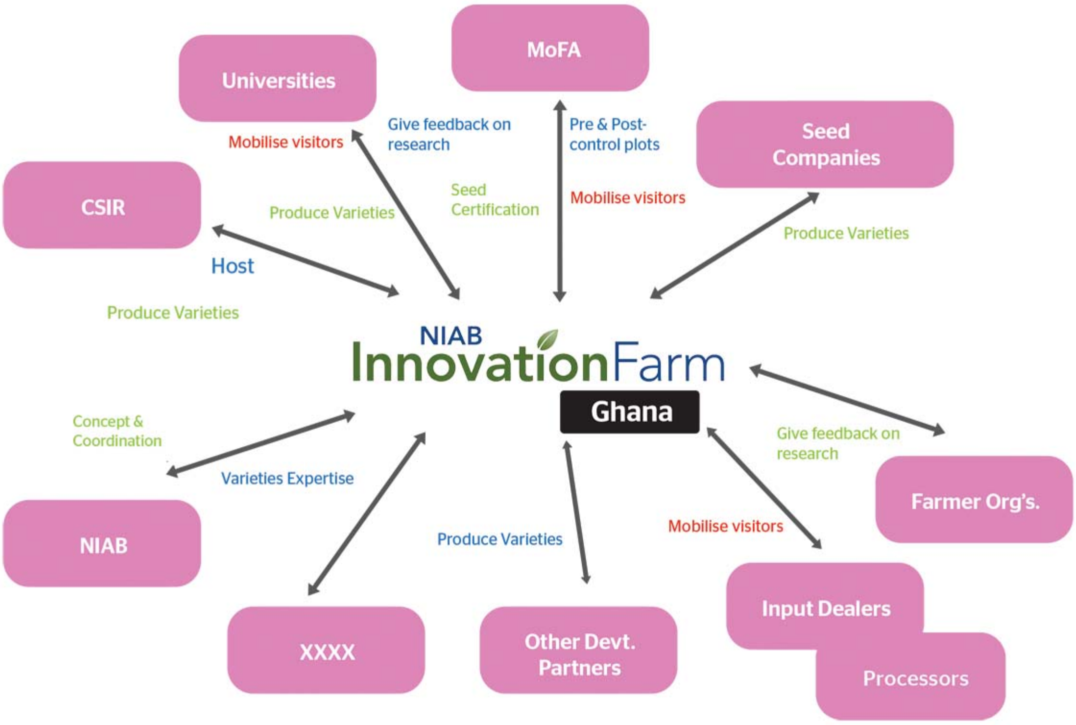
Budgets for setup and annual costs
Estimate figures based on analysis carried out in 2013
a $250 000 set up costs;
b $250 000 p.a. operating expenses for five years;
c Total requirement $1.5 million for five years.

Work plan for implementation
Start off with a five-year programme at NARL in central Uganda and CRI in central Ghana and then, if appropriate and funding is available, expand after two or three years to satellite stations at NaSARRI in north-eastern Uganda and SARI in northern Ghana.

It should be possible to launch both NIAB Innovation Farm Uganda and NIAB Innovation Farm Ghana within 12 months of obtaining funding commitments, i.e. showcasing crops, presenting agricultural innovation, receiving regular visitors.

One issue to be addressed is whether NIAB Innovation Farms Uganda/Ghana can be put on a track to be financially self-sustaining. Indications are that there is sufficient interest from most of the

Figure 16 Potential participants and their roles in NIAB Innovation Farm, Ghana



relevant players in both countries so that charges can be made to showcase and host exhibitions and events, without harming independence, although it is not clear whether they can be entirely self-sufficient, i.e. operate without some donor funds. On the other hand, the Innovation Farms will be providing a clear public good, so are an appropriate medium-term candidate for donor funding.

Potential Sponsors

In the light of the positive outcomes of the scoping study, we have started to approach and engage with potential partners and donors in the UK and internationally to raise funds for developing the concept of NIAB Innovation Farm and launching in Uganda and Ghana. We are adopting a twin-track approach to project development and fundraising (Appendix A.3.1.6).

9 Discussion

Technologies, practices and systems (including improved plant varieties and GM varieties where appropriate, agronomic systems, and disease/pest control methods) that support sustainable intensification of crop production in Sub-Saharan Africa abound. However, adoption rates by smallholder farmers are still low and progress towards food and nutrition security and improved rural income is still limited.

We found that many aspects of the NIAB Innovation Farm approach could be applied to improve awareness and adoption of improved varieties in Uganda and Ghana. In Kenya, setting up NIAB Innovation Farm would not address the gaps/weaknesses that exist in the current systems.

This section will critically evaluate our NIAB Innovation Farms Uganda/Ghana propositions, applying a traditional SWOT analysis.

Strengths

- NIAB Innovation Farms Uganda/Ghana will be tangible (physical), so it is clear how the funding is being used.
- The facilities will provide donors with good metrics (e.g. farmer visitor numbers), there are clear targets, and broad-based delivery mechanisms to achieve them.
- They will be independent organisations able to work with the entire seed system in the target countries, with links and support extending to the wide agricultural sector.

Weaknesses

- There is a need to achieve critical mass for NIAB Innovation Farms Uganda/Ghana to be successful, which depends on the support and participation of the industry.
- NIAB Innovation Farms in Uganda and Ghana may fail to become financially self-sustaining and fail to remain in operation after the initial set-up grants run out.
- It may appear that aspects of what is being proposed are already being done, i.e. there is nothing novel in the proposal.

Opportunities

- NIAB Innovation Farms Uganda/Ghana will be a new development, offering a chance to overcome entrenched problems with other similar entities.
- The concept is a simple and compelling story for donors.
- The facilities offer the agricultural sector the opportunity to get engaged and participate in a way that could deliver beneficial effects on other aspects of agricultural research in the countries.
- If successful, they will become an important independent platform for new agricultural technology, possibly becoming more important than can be imagined.

Threats

- The concept risks being copied by others such that it becomes redundant (although in a way, of course, that would also be a strong indication of success).
- While there may be support on paper, the political context in each country may limit actual participation from the different (sometime competing) agencies.

10 Conclusion

To improve awareness about improved staple crop varieties including GM crops and their use among farmers, key players in Sub-Saharan African (SSA) seed systems need to work together for better provision of plant variety evaluation and demonstration and knowledge dissemination. On the basis of our findings in the three countries, we propose an approach which 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/processors, etc.

We recommend that for Ghana and Uganda, a NIAB Innovation Farm model could be used to establish the necessary framework for this approach, and would be welcomed by stakeholders.

For Kenya, our findings indicate that NIAB Innovation Farm will not be appropriate there. The sort of support necessary to improve knowledge exchange and technology transfer requires further detailed exploration which was not carried out as part of this study. This support could draw on NIAB's broader experience and skills, beyond NIAB Innovation Farm.

For references see Appendix A.3.1.7.

Activity 3.2 Smallholder farmers' sources of information on, and attitudes towards crop genetic innovations in Uganda – a scoping study (with the University of Reading, UK) (see also Appendix B)

Study team

- Graham Clarkson; Peter Dorward; Sarah Cardey and Chris Garforth, University of Reading, School of Agriculture, Policy and Development, UK
- Claudia Canales, Biosciences for Farming in Africa (B4FA), UK

1 Summary

Crop genetic improvements will continue to be an important source of innovation for smallholder farmers in Sub-Saharan Africa as they seek to respond to current and future pressures on food production. Agricultural extension and advisory services in the public, NGO and commercial sectors are a key link between plant breeding institutions and farmers. An understanding of how innovation takes place on smallholder farms is needed to ensure that farmers can access the knowledge, information and inputs they need. A study was carried out to find out how male and female farmers access information about crop genetic improvements, how they use that information and the constraints they face. The research was conducted in Iganga and Nakaseke Districts in Uganda using a mix of qualitative (focus group discussions, key informant interviews), participatory (timelines, innovation histories, participatory budgets, communication maps) and quantitative (questionnaire survey) methods.

Smallholder farming in the study areas is dynamic; farmers actively look for and use new knowledge and information. Innovation takes place not through simple 'adoption' of recommended genetically improved varieties but through a careful evaluation of information and evidence from a range of sources. Key drivers in farmers' search for improved genetic material include intensifying pest and disease pressures, reduced land availability, declining soil fertility and increasingly erratic weather patterns. Genetic improvements over the past ten years have had, overall, a positive impact on household income and food security in a number of crops important in the study area, including beans, coffee, bananas, maize and groundnuts. Other innovations have had mixed results, in particular improved banana varieties.

Information on crop genetic improvements comes to farmers through several routes. For most farmers, their fellow farmers are the main immediate source. At a system level, the public sector advisory service and NGOs are important sources. There is evidence of both outsider-initiated and farmer-led innovation processes. Farmers actively seek information and are appreciative of organisations' efforts to make it available to them. Some sources are more trusted than others, with input dealers among those least trusted because of experience over fake or poor quality seed and other inputs. Despite the large number of sources and channels that farmers have access to, they also report major information gaps including on how to deal effectively with pests, diseases and post-harvest losses. Mass media, radio in particular, seem to be an important source of awareness of new crop varieties, though face-to-face communication and interaction are key ingredients in facilitating innovation at farm level.

There are gender differences in the use of crops for which innovations are sought and used, and in the number and range of sources of information. On average female farmers identified half as many sources of information on agriculture to which they have access to as compared to male farmers who

in turn were more likely to report access to sources beyond the local area. Female farmers also face greater constraints in accessing the inputs needed to incorporate improved crop varieties on their farms. While sharing of information and knowledge within households and communities is an important feature of local innovation systems, farmers also report that information may be withheld or only partially shared in order to secure advantage.

Knowledge of the techniques used by scientists and others to develop improved crop varieties is low but this is not a constraint to farmers' willingness to try new material. Overall attitudes towards crop genetic improvement are positive, though this is not uncritical: farmers will continue with, or revert to, local varieties unless the new material performs well according to their own criteria.

2 Introduction

Agriculture employs close to 70 per cent of the population in Sub-Saharan Africa (SSA) and most people are engaged in agricultural activities even if part of their income is provided by a different type of employment. Agriculture is largely carried out at a semi-subsistence level where producing food for the household is a priority and average productivity levels are the lowest in the world[3]. Africa is the only continent where poverty and malnutrition continue to rise. Since a majority of very poor people are also smallholder farmers, raising agricultural productivity is a key priority for food security and poverty alleviation[4]. Access to high quality genetically improved planting materials and to the knowledge, information and advice on how to make the best use of these are key constraints to improved productivity.

Agricultural extension officers and other intermediaries provide a crucial link between the plant breeding institutions developing improved crop varieties, by conventional and by advanced plant genetic improvement techniques, and the smallholder farmers who use them. Traditional government agricultural extension services in SSA are however largely under-staffed and underfunded, with limited opportunities for further training while other channels of advice including NGOs, commercial input suppliers and the mass media often lack the expert knowledge to give sound advice (Rivera *et al.*, 2001; Anderson and Feder, 2004; Birner *et al.*, 2006; Waddington *et al.*, 2010). A central aim of B4FA was to produce a number of studies to explore how to strengthen the understanding among smallholder farmers and extension service agents of the traditional and modern genetic techniques for improving agricultural production in African nations. This requires a good understanding of:

a how extension and advisory services are configured in the focus countries,
b how farmers use and are influenced by various sources of advice and information in making decisions about crop improvements on their farms, and
c the factors that constrain and facilitate innovation in crop enterprises.

2.1 Crop genetic innovation

Innovation is the integration and use of something new, either individually or collectively[5], and this can refer to a technology, a product or a process. Smallholder farmers have been innovating for centuries and, in terms of crop improvement, this long predates formal efforts of plant breeding institutions in developing improved, locally adapted plant varieties. Farmers apply existing and new knowledge to increase productivity, develop new farming systems and to adapt to changing environmental, economic and political circumstances (Eriksen and Lind, 2009; Garforth, 2010).

[3] For example, actual yields on many smallholder banana farms (5−20 metric tonnes/ha/year) in Uganda are far below the estimated potential yield of 100 metric tonnes/ha/year (Nyombi, 2013).
[4] One of the targets of the National Development Plan 2010/11−2014/15 of the government of Uganda is to raise average yield levels of key crops to reduce poverty. Available at: http://opm.go.ug/assets/media/resources/30/National%20Development%20Plan%202010:11%20-%202014:15.pdf
[5] Innovation refers to something that is 'new' to an area/context irrespective of whether it is new to the rest of the world.

Therefore agricultural innovation is not something that is passed on to farmers in a linear transfer, but is rather a continuous process of creativity and adaptation in which the farmer plays an active role. This process can be supported and sustained if sufficiently understood (Garforth, 2010). Supporting the uptake of agricultural innovation is essential for 'paving the way' for the use of novel genetically improved crop varieties, in particular when the technologies used for developing them are not devoid of controversies, such as genetic modification (GM).

The factors leading to farmers developing, adapting and applying new ideas and technologies are numerous. An extension system that caters to the knowledge and advice needs of farmers needs to fulfil many requirements. The first of these is to acknowledge the importance of local contexts, which include not only the microclimate and the ecosystems in which innovations operate but also indigenous forms of knowledge and existing social and cultural structures. Information on traditional and new technologies and their relative performance in real farm settings is essential for affording farmers the opportunity to make an informed choice. Market opportunities, and the possibility for farmers to investigate and access these opportunities, are equally critical. A deeper understanding of the driving forces for change in farming communities is a further requisite: while economic factors are important, other factors may be more dominant drivers in specific circumstances (e.g. differences in taste and appearance have led to the poor acceptance of improved, higher-yielding varieties, a frequent problem in banana breeding programmes [Nowakunda and Tushemereirwe, 2004]), and these are often neglected. In other words, an extension system that supports and nurtures innovation needs to be built on the farmers' own experience and perspective on innovations, while addressing their needs and priorities.

2.2 Study objectives

The first objective of the study was to develop a detailed description and analysis from a smallholder farmer perspective of the process by which crop genetic innovations are incorporated into smallholder farming systems. This includes farmers' sources of information, influence and inputs; constraints and facilitating factors; and decision-making processes within the household. Secondly, the study aimed to identify smallholder farmers' knowledge about and attitudes towards crop genetic improvement, and their current knowledge, understanding and perceptions of a range of genetic techniques for improving the characteristics and performance of the crops that they grow.

Female farmers are the pillars of African agriculture: over two-thirds of females in Africa are employed in the agricultural sector and are responsible for growing, selling, buying and preparing food for their families (FAO, 2011). Despite their importance, they are, in general, still marginalised in business relations and have minimal access to and control over resources such as land, and inputs such as improved seeds and fertilisers, credit and technology. In addition, due to a combination of cultural economic and logistic reasons, female farmers are commonly disadvantaged by the traditionally male-biased agricultural extension service. The third objective of the study was therefore to take a gendered perspective on the previous two objectives, to determine how improved agricultural extension systems may best serve both female and male farmers, and their needs.

3 Methods

This was a multi-disciplinary study that encompassed desk work, key informant interviews, and field data collection and analysis to respond to the objectives set out in Section 2.2. The fieldwork for the study was completed between June and November 2013 and a dissemination activity was held with farmers in each of the two study sites in March 2014 to encourage discussion regarding the emerging findings and enable farmers to verify the recommendations from the study.

The study encompassed two districts in Uganda, Nakaseke in the Central Region, and Iganga in the Eastern Region[6] (Figure 17), both having economies dominated by smallholder agriculture and a wide range of crops grown both for home consumption and for sale in local markets. Nakaseke is made up of seven sub-counties and borders the districts of Masindi, Kiboga, Nakasangola and Luwero. Crops grown in Nakaseke include banana, maize, rice, cassava, sugar cane and coffee. Iganga is a district with an estimated population of just under half a million in 2010. Main crops grown in Iganga include maize, groundnuts, cassava, coffee, bananas, beans, sweet potatoes and rice.

The history of crop genetics innovation and agricultural change was first explored in both study sites using a combination of participatory methods with members of the community (agricultural timelines, innovation histories and communication maps). These enabled the research team to record when and how key events in the uptake of crop genetic improvements took place in the community and to explore the circumstances, processes and people that may have facilitated or hindered the spread of information and innovations. These methods help to develop an understanding of the economic, social and cultural context in which current and future information will be interpreted and assimilated by farmers. While agricultural timelines provide an overview of historical change in a locality, innovation histories allow the research team to study, in greater depth, the process by which a particular innovation was embraced or rejected by the community. Farmers' main sources of information and the performance of the linkages through which farmers exchange and access information and knowledge were explored in communication maps.

Figure 17 Map of Uganda showing districts

A questionnaire survey was carried out in each of the two sites. The purpose of the survey was to develop an understanding of farmers' experience, knowledge and perceptions of a range of crop genetic improvements. The sample size for the survey was 362 farming households (185 in Nakaseke and 177 in Iganga) and it was carried out by a team of eight enumerators from Makerere University, Uganda. Finally, participatory budgeting methods were used to understand, in detail, the differences

[6] The study sites were chosen based upon specific criteria that were discussed with key informant interviewees. In each of the two districts one sub-county was chosen with guidance from district and sub-county NAADS staff. In each of these sub-counties, seven villages were selected as representatives for the field work. More details are provided in Appendix 1.

(in yield, profit and resource use) that improved crop varieties made on individual farms in each of the districts. For a more detailed description of the methods please refer to Appendix B.3.2.1.

4 Results and discussion

4.1 Challenges to crop production in Uganda (Appendix B.3.2.2)

Agriculture contributes nearly a quarter of Uganda's domestic GDP and is the main source of employment in rural areas. The main crops grown in Uganda are bananas (East African plantains or matooke), cassava, maize, beans and coffee, the latter being the main cash and export crop of the country. Uganda is the second largest producer of bananas after India (FAOSTATS). More than 75 per cent of all farmers grow bananas, the country's staple food, with a quarter of Ugandans depending on bananas as a main source of food and income (Keya and Rubaihayo, 2013).

Key recent events impacting agricultural systems in Uganda include two major disease epidemics in the last decade which have seriously compromised production of the two most important crops of the country: banana and cassava[7] (Alicai *et al.*, 2007). Both these crops are vegetatively propagated and hence not very amenable to conventional plant breeding efforts, in particular banana, which is sterile[8]. For two major diseases – banana bacterial wilt and cassava brown rot disease – there is no known source of resistance in existing crop varieties or wild relative species. The consequence is that technological (i.e. plant genetics) solutions to the two most pressing problems faced by farmers in Uganda currently do not exist, although good crop management practices help to slow the spread of the diseases[9].

Large-scale plant disease epidemics are not new: severe outbreaks of cassava mosaic virus disease were reported in Uganda in 1933 and 1934 although these were eventually controlled by the adoption of disease-resistant cassava varieties (Legg and Thresh, 2000). Nonetheless, a number of factors are contributing to the creation of a particularly pressing situation in Uganda. Significant among them is a major demographic change. According to the 2012 revision of the World Population Prospects[10], the total population in Uganda in 1950 was 5 million, but it had increased to over 24 million by 2000, and to around 34 million by 2010[11]. The population is expected to exceed 100 million by 2050 representing one of the highest rates of growth in the world. Increased population numbers as well as the movement of people and goods tends to accelerate the spread of disease to levels not experienced 100 years ago. Furthermore, while population pressure for available arable land is on the rise, soil fertility is in decline and erratic weather patterns add a further level of difficulty. Additional challenges are provided by poor infrastructure (such as roads, electricity and credit institutions), a weak seed and inputs distribution system where fakes are a major problem and poor access to markets for smallholder farmers, especially females (Cassman, 1999; Müller *et al.*, 2011; The Montpellier Pannel, 2013; Tittonell *et al.*, 2013). These factors, and the interaction between them, are contriving to make the production of key crops extremely challenging in the country.

An analysis of how crop genetics innovations take place on farms and their likely impact on livelihoods will therefore explore a very complex set of circumstances that extend well beyond the provision of agricultural extension and advisory services.

[7] IITA estimates yearly loses to banana bacterial wilt in the range of $200 million. Cassava mosaic virus is estimated to reduce yields by 30 per cent, while cassava brown rot disease often results in near crop failure.

[8] The research community has pursued a short-term strategy of assembling endemic and non-endemic banana germplasm for evaluation for resistance to bacterial wilt and distributing suitable varieties to farmers (e.g. Mpologoma), and a long-term strategy using a combination of conventional plant breeding methods and genetic modification (Kikulwe *et al.*, 2007).

[9] In view of the seriousness of bacterial wilt for the national economy, the government of Uganda undertook a large programme of education and sensitisation to enable farmers to recognise symptoms of infection and take measures for mitigating the spread of the disease. This campaign (which included a number of Presidential Initiatives) involved extension services, media outlets, civic society, local leaders and participatory development programmes at the local level (Tushemereirwe *et al.*, 2006). Despite these efforts, bacterial wilt continues to be the most commonly diagnosed problem in plant clinics in Uganda (Danielsen *et al.*, 2013).

[10] http://esa.un.org/unpd/wpp/unpp/p2k0data.asp

[11] This corresponds to more than 40 per cent increase in population in the last decade – the period of time this study is focusing on.

It is noteworthy that Uganda is actively exploring the use of genetic modification technology to solve some of the constraints that cannot be easily addressed by conventional breeding technologies. Crops developed by public sector agricultural research institutes include the virus-resistant GM cassava; nematode and Black Sigatoka resistant GM banana; and GM banana biofortified with vitamin A and iron. These crops are currently at the field-trial stage.

4.2 Institutional views on crop genetic improvement and challenges to adoption by smallholder farmers (Appendix B.3.2.3)

Key informant (KI) interviews were carried out to gain an understanding of existing approaches to the provision of information and improved planting materials to smallholder farmers in Uganda (Appendix 3). KIs belonged to a variety of organisations from public and private sector involved in the development and/or dissemination of crop genetic innovations to smallholder farmers (Table 1).

Table 4 Key informants' affiliation

Government offices	• Ministry of Agriculture, Animal Industries and Fisheries (MAAIF)
National plant breeding institutions	• Kawanda Agricultural Research Institute (KARI) • Mukono Zonal Agricultural Research and Development Institute (MUZARDI)
Higher learning institutions	• Makerere University
Regional and international organisations	• Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) • International Food Policy Research Institute (IFPRI)
NGOs	• Sasakawa Global 2000 • Volunteer Efforts for Development Concerns (VEDCO)
Private sector	• Victoria Seeds • Agro-Genetic Technologies (AGT)

In terms of government agricultural policy, recent trends described by the KI from MAAIF include an increased emphasis on the promotion of crops for which there is a market demand and a focus on commodity platforms, which address all the actors in the value chain. A consideration is to avoid generating conflicts between cash crops at the expense of food security crops and between crops beneficial at the household level versus commodities important for domestic and export markets. Policies were also designed in response to changes in food consumption patterns, for example the release of NERICA rice aiming to address the increased demand for rice in Uganda, which is currently largely met by imports. A new trend is also an increased cooperation between different government institutions (e.g. MAAIF and the Ministries of Water and of Trade) to address climate change challenges and to increase the competitiveness of the sector. With regards to policies designed for the provision of services to smallholder farmers, MAAIF seeks to increase the participation of farmers in trialling and experimenting with new crops and technologies, for example through Farmer Field Schools. Approaches using ICT platforms to integrate financial services, marketing and data collection are also being considered by MAAIF.

KIs involved in the development of improved crop varieties reported that farmers tend to have, in general, a positive attitude towards plant genetics innovations illustrated by the failure of extension services and commercial companies to meet current farmers' demand for tissue culture banana planting materials (reported by KI from KARI). The impact of improved crops had been, on occasion, extremely significant. For example, the release of disease-tolerant cassava varieties had a major effect on food security in areas where people relied on this crop for their livelihood. But KIs agreed that improved varieties do not always perform as well as expected, especially in meeting important attributes for farmers (e.g. taste) or by being reliant on expensive inputs outside the reach of poor farmers.

The challenges that smallholder farmers face in integrating genetically improved crop varieties in their farms are numerous. Access to inputs and information was reported by all KIs as a major constraint as commonly there is not a system in place for smallholder farmers to source new varieties, especially for crops for which there is no formal seed distribution system in place. KIs also agreed on the importance of taste, with differences in taste from traditional varieties being a frequent reason for rejection of new crop varieties. KIs also concurred on market failures being very common reasons for rejection of new crop varieties: market competition from traditional varieties may result in a farmer being unable to sell his/her crop. KIs also recognised the costs of inputs and increased labour requirements as major constraints, which raise the risks associated with production. Resource-poor farmers with a low diversity of income are generally more averse to these risks, the KI from ASARECA reported. For this reason farmers generally prefer to adopt new varieties only after ascertaining their performance in other farmers' fields. Constraints may also be specific for a given location. An example provided by KARI's KI is that low soil fertility, high incidence of pests and diseases and poor infrastructure (roads and transport) increase the costs of banana production in Uganda's Central Region to the level where farmers are unable to be competitive in domestic markets.

An important theme emerging from the interviews is that plant breeders often fail to understand the needs and priorities of farmers especially the need to spread and manage risks, a situation aggravated by the lack of feedback mechanisms to relate information back from farmers to plant breeders and by the short-term nature of breeding programmes due to funding patterns. KIs agreed on the importance of participatory methods that involve farmers in the selection process for new varieties which is already taking place, for example in banana breeding programmes in KARI. Advantages of farmer participation in breeding trials include the selection of beneficial characteristics that may not be obvious to plant breeders such as reduced secretion of sap during peeling for bananas which reduces labour during cooking. Farmers may give their own name to popular varieties, a sign of ownership (e.g. Kiwangaazi – 'long lasting' – for a banana landrace[12] with a longer mat life span, a name which KARI subsequently adopted to promote dissemination). Also a sign of better understanding of the multiple constraints faced by farmers is a more holistic approach to addressing challenges to production (e.g. KARI has promoted the adoption of livestock by farmers to address soil fertility problems).

In view of these constraints, KIs stressed that farmers tend to adapt 'technology packages' (improved varieties plus the recommended practices for the production) to suit their needs rather than simply adopt them as advised. This commonly involves modifications that reduce both costs of production and labour requirements which is a strategy to reduce the risks associated with innovation. A number of KIs reported that this need is not always understood by plant researchers who tend to focus on attaining higher production levels. Farmers will normally continue to experiment with new technologies to see how far they can modify recommendations and still obtain acceptable results while minimising financial investment. A further reason for the 'partial' adoption of technology packages and their modification is the high prevalence of fake inputs which reduces farmers' incentives to invest in their farms.

[12] Due to the devastating effects of banana bacteria wilt on national banana production, NARO undertook a programme to test the performance of different landraces from all areas of Uganda, and promoted the uptake of some landraces in areas where they were not grown before. In this study these are considered as improved varieties, because they were new to the areas where they were introduced, and new to the farmers.

Farmers are active players in the adoption and adaptation of improved crop varieties, making decisions based on the requirement for innovations to succeed in their own farms, with their own needs and priorities in mind. An example provided was of a tomato variety distributed a decade ago by extension agents but subsequently discontinued; it was disseminated by farmers, eventually reaching the market without the knowledge or support of formal extension services. Further, a farmers' group selected and marketed a sweet potato variety successfully from a variety initially distributed but subsequently neglected by NARO.

Several KIs reported that farmers' groups and associations tend to be the point of contact for extension initiatives. With the exception of NGOs focusing specifically on female farmers' needs (which included both NGOs interviewed) and on nutrition (including VEDCO), extension services tend to address gender issues only by ensuring the participation of both men and women in their activities by focusing on the household as a whole. Extension initiatives aimed specifically at women were reported to potentially strain family relationships by one KI while another interviewee described gender inequalities as a cultural problem whose resolution will require education and leadership over a long period of time.

Constraints to the spread of new crop varieties described by KIs from the private sector were numerous and included farmers expecting free planting materials as a consequence of government and NGO 'hand-out policies'. Poor government programmes and a large number of NGOs acting independently were also reported by private sector KIs to result in, at times, conflicting information, adoption of inappropriate crops (e.g. with no viable markets) and failure to link production of recommended crops to markets. Further challenges reported included the difficulty in obtaining foundation seed and planting materials from the relevant government institutions due to excessive bureaucracy and poor institutional linkages. In addition, poor distribution networks increase the costs for both buyers and farmers. Poor enforcement of legislation, particularly with regards to fake inputs, was also outlined as an important business challenge. Inadequate policies for businesses, including difficulties in obtaining loans and lack of clarity with regards to medium- and long-term government policies for the seed sector further contributed to uncertainty in the seed system.

4.3 Objective I: crop genetic innovation in smallholder agriculture in Nakaseke and Iganga

The paragraphs that follow draw out the main themes emerging from analyses of the data collected from the participatory research and questionnaire survey. The themes are organised under the headings of:

1. events and processes;
2. actors;
3. impact;
4. constraints and challenges;
5. sources of improved planting materials;
6. sources of information and knowledge.

4.3.1 Events and processes

The main source of income for the majority of households surveyed was agriculture with an average of 63 per cent of a households' income coming from crops and no significant difference between genders. Important crop innovations in Nakaseke included improved varieties of beans, bananas, coffee, maize varieties, groundnuts, improved sweet potatoes, cassava and bananas (Appendix B.3.2.4).

The adoption of improved crop varieties concerned all the main crops cultivated in both sites and comprised crop varieties that are bred for improved characteristics including disease resistance and high-yielding potential, but also disease-free stocks, such as tissue culture banana and clonal coffee. The average number of improved crops adopted was 4.4 per farm in Nakaseke, and 4.1 per farm in Iganga. Respondents were asked to identify the two most important crop genetic innovations they had adopted in the last ten years (Table 5).

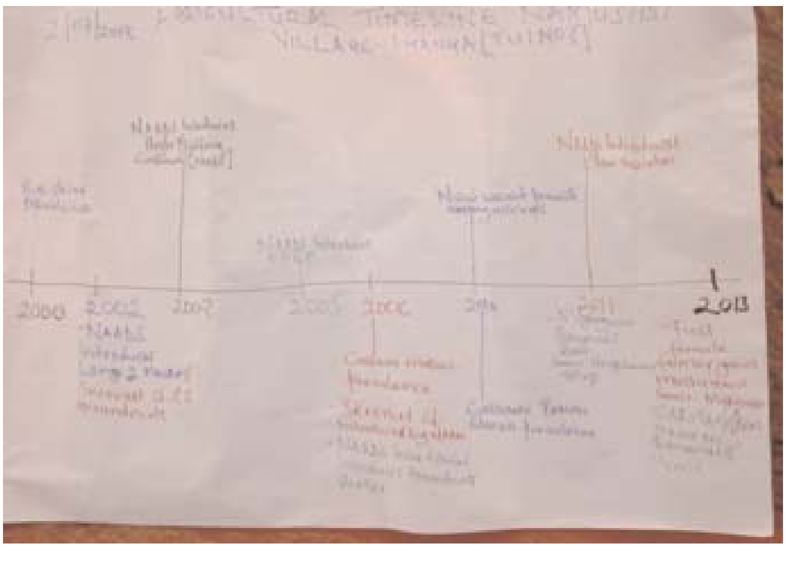
Table 5 Most important improved crop varieties that farmers in Nakaseke and Iganga have used in the past 10 years

Nakaseke (n=185)	%	Iganga (n=177)	%
Beans	55	Maize	70
Bananas	43	Groundnuts	26
Coffee	37	Sweet potatoes	23
Maize	29	Cassava	19
Cassava	16	Bananas	19

With the exception of coffee, which is exclusively a cash crop, improved varieties were important for both home consumption and for commercial purposes, although the relative proportions varied for specific crops and was different for male and female farmers[13]. A larger proportion of females grow improved crops either solely for subsistence or a mixture of subsistence and cash when compared to males (Appendix 3.2.4).

Changes in the farming systems in the last decade in both study sites mostly relate to the intensification of practices driven by the increased incidence of pests and diseases (a major driver for change; Figure 18; Appendix B.3.2.5). Reduced arable land availability, declining soil fertility, and erratic weather patterns also lead farmers to explore new varieties to increase crop yields. Changes include an increased use of inputs such as fertilisers, manure, herbicides and insecticides, and a diversification of the crops grown (e.g. the adoption of upland rice in Iganga) in addition to the use of new (to the area) crop varieties.

Figure 18 Example of an agricultural timeline. Changes in the last 13 years in Namusiisi village, Iganga, as reported by female farmers (Appendix B.3.2.5)



[13] For example, in Iganga a significantly larger proportion of males compared to females (79 per cent versus 60 per cent; $p < 0.01$) considered maize as one of their two most important crops. By contrast, a significantly larger proportion of female respondents compared with males (40 per cent versus 23 per cent; $p < 0.02$) considered improved groundnuts to have had an impact in their household.

A key aspect of the adoption of improved varieties is the adaptation by farmers of the recommended practices for the cultivation to suit their specific circumstances and priorities. Commonly this involves reducing the amount of inputs used and minimising labour investment in production. Female farmers are reported to do this to a greater extent than men since the price of inputs and labour requirements tend to be bigger constraints to production for them (Andersson *et al*., 2013; Aterido *et al*., 2013). Examples that illustrate this trend from this study were modifications to recommended banana practices by female farmers in Nakaseke (digging smaller holes for planting), and coffee (reduced spraying by women; Appendix B.3.2.6).

4.3.2 Actors

The initial stimulus for the adoption of crop genetic innovations came from a wide range of actors (Appendices 5 and 6). In several cases, the formal advisory service (National Agricultural Advisory Services – NAADS) introduced a new variety for farmers to try either through their own initiative (e.g. bananas in Nakaseke and groundnuts in Iganga) or in response to interest expressed by farmers (e.g. new maize varieties in both Nakaseke and in Iganga) who had heard about the variety from various sources (Appendices 5 and 6). Alternatively NAADS suggested a specific crop innovation and a prominent farmer took up the suggestion and started growing the new variety with other farmers following suit (e.g. Mpologoma banana variety in Nakaseke). In other instances new varieties were introduced by NGOs, a source of crop innovation particularly important in Nakaseke, or by a commercial seed company that promoted a new variety in a community (e.g. improved maize in Iganga). In others, it is a farmer who brought back new seed either from a visit to an agricultural show or from a visit to another village. In two cases a local politician distributed planting material to farmers (e.g. a new cassava variety in Nakaseke, or clonal coffee in Iganga).

In all cases, and whatever the source of the initial stimulus, what emerges is a process involving multiple actors each playing a role in the uptake, adaptation and evaluation of the new variety. The main actors mentioned are male and female farmers, local councillors, local farmer groups, the district farmers' association, NAADS, input dealers, traders (who buy farmers' produce), seed companies, NGOs, politicians and institutional purchasers of produce (boarding schools in the district). The roles of these actors are not fixed as individuals and organisations respond to local circumstances to support and contribute to the process of innovation. NAADS features as an important actor for promoting change, as are prominent farmers in the community, NGOs, and in some cases private companies. NGOs appear to play a more important role as the initial stimulus for trying new crop varieties in Nakaseke compared to Iganga where formal service provision is mostly carried out by NAADS. A possible reason for this difference may be that the villages visited in Iganga were further away from main roads and larger towns than the villages visited in Nakaseke.

A broad characterisation of the processes seen in the innovation histories in Iganga would be a distinction between farmer-led and outsider-initiated processes. A number of groups described farmer-led processes. In one example in Iganga (IUIN01) a farmer brought a new (to the village) maize variety from a nearby village. He encouraged others to take it up, subsequently the NAADS sub-county coordinator supported them with training for local farmer groups and then local input supply shops begin to stock the seed. In another (IUIN07) a farmer brought a new cabbage variety from an agricultural show in another district. Although he did not specifically promote it, other farmers in his village asked him about it because it seemed to have attractive characteristics. He shared seed with them, subsequently NAADS began to promote it locally and traders encouraged other farmers to grow it because it sold well.

Examples of outsider-initiated processes include the introduction of improved groundnuts by NAADS, subsequently promoted by an input supply store and local government officials. In a second example, NAADS introduced improved maize varieties, and prominent farmers then took a role in advising other farmers and promoting the use of the innovation. The outsider-initiated processes may seem at first sight to conform to the conventional linear model of adoption of innovations. However there is nothing linear about a process in which a succession of actors become involved assuming a range of different roles which reflect their own interests or mandate but which together produce a complex process of learning and interaction between multiple actors in which professional advisers and input suppliers learn from farmers as well as the other way round.

There are no passive participants in the innovation processes. Farmers are actively evaluating, accepting, rejecting and adapting ideas and inputs that others involved (including other farmers) are introducing them to. This is also the perception farmers have about their own role in the adoption of crop innovation. When asked about their main sources of encouragement to try and use new crop varieties in the questionnaire, over half of respondents stated they had started and continued to grow new crops through their own initiative for most of the crops studied. Fellow farmers, extension workers and input stores were always identified as less important sources of encouragement (Appendix B.3.2.4).

A key part of the process in all the innovation histories (Appendix B.3.2.6) is the interaction that goes on between farmers: seeking and sharing information, asking about appealing crops on other farmers' land, borrowing and lending seed, and working together to buy inputs. The relationship between farmers is however complex[14]: farmers were reported to sometimes deliberately deceive their peers with false information. This may be a reflection of the lack of opportunities to access markets which limits the amount of produce that can be sold and results in competition amongst producers. As a consequence farmers resort to visual observation to determine the trustworthiness of the information received and to guide their decision on whether to try a new crop or not (in other words they may use the information received from one of their peers only if they can verify that the person sharing the information is also applying it him/herself). Farmers are not a homogenous group and their ethnicity, social standing, education *inter alia* will impact upon their relationships with fellow farmers and the information that they access and/or share.

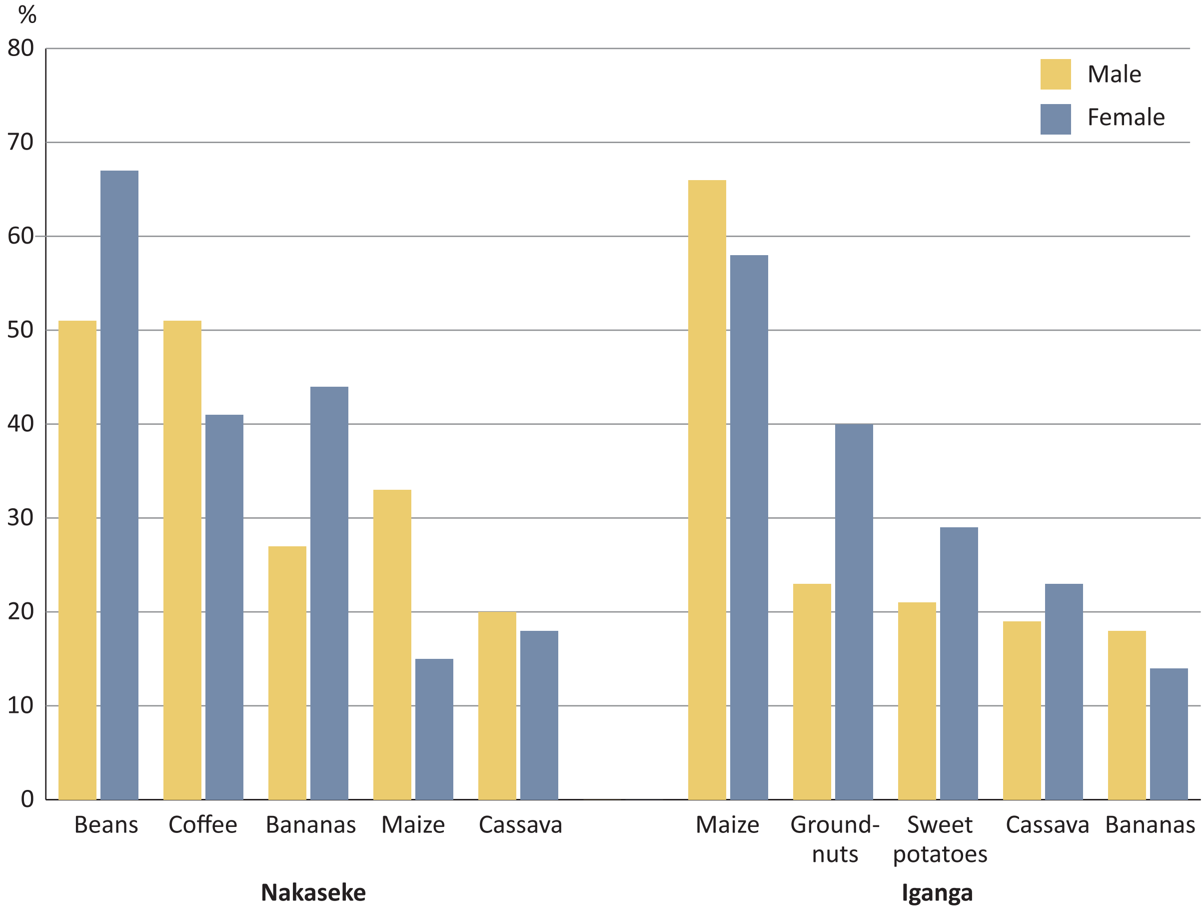
4.3.3 Impact

The reported impact of new crop varieties is often positive, with increased food security and additional income available for the household. These positive impacts came from both the higher and the more reliable yields from improved varieties. The impact of specific improved crop varieties was often different for male and female farmers. For example, in Nakaseke improved beans and bananas were considered to have had greater impact by significantly more female respondents while improved coffee and cassava were reported to have had more impact by male respondents (Figure 19; Appendix 4). Males were more likely to report increases in income while females more likely to point to greater availability and reliability of food supplies for the family[15]. However, male and female participants acknowledged both of these types of impacts. Social benefits were also mentioned by one group of participants in Iganga who suggested the sharing and borrowing of new planting material contributed to the strengthening of social bonds. Increases in income were used according to most groups to pay for children's school fees (irrespective of gender) and buy household goods (mostly females).

[14] Farmers are not a homogenous group and their ethnicity, social standing, education inter alia will impact upon their relationships with fellow farmers and the information that they access and/or share.

[15] In Iganga, improved groundnut varieties were mainly grown for a mixture of cash and food (60 per cent of respondents) or solely for food (38 per cent of respondents). Females were much more likely to grow improved groundnuts solely for subsistence (46 per cent compared to 26 per cent of males).

Figure 19 Improved crops that have had the biggest impacts on the household



A further positive impact reported by several female farmers was the increased financial independence they had earned through selling surplus production of new crops. However, this was also reported as a negative impact by some male farmers who viewed it as a disruption of traditional family relations. Increased income for male farmers was also reported by female farmers as a

Table 6 Proportion of respondents stating that traditional varieties provide advantages over improved varieties for specific characteristics[16]

	Beans (n=101) %	Bananas (n=80) %	Coffee (n=68) %	Maize (n=54) %	Cassava (n=29) %
Tolerance to drought	18	45	56	26	34
Tolerance to sunshine	22	55	56	28	31
Better yields	10	5	18	6	17
Better taste	23	38	6	26	45
Market value	3	4	3	2	0
Resilience	14	15	24	4	10
Tolerance to pests	20	21	25	26	34
Tolerance to diseases	16	19	16	24	28
Reliable yields	2	4	9	4	3
Cost of materials	7	4	0	4	0
Less inputs required	9	6	3	6	0
Less labour required	1	3	0	7	0

[16] These answers were provided by respondents without prompting.

negative consequence of crop innovations. Gains did not necessarily translate into benefits for the whole family due to intra-household dynamics (for example, by increasing the consumption of alcohol and inducing men to marry more wives and abandon their domestic responsibilities).

Not all new crops performed well in the local conditions (e.g. the Mpologoma banana variety is very susceptible to drought and intense sunshine so many farmers abandoned its cultivation) and crops failed to attain their potential yields due to the high incidence of pests, diseases and weeds. In some cases improved varieties (e.g. some new bananas and cassava varieties) also performed worse than traditional varieties in terms of taste and appearance (for example, the colour of beans is considered an important attribute in Nakaseke).

A further negative impact of the introduction of new varieties reported is that traditional varieties are being lost, in particular seed-propagated crops. Farmers were concerned about this loss with the majority of survey respondents recognising the importance of saving traditional varieties. In Nakaseke (Table 6), newer varieties were considered better for size and reliability of yields and for increased market value but traditional varieties were seen as advantageous when considering tolerance to environmental conditions (such as drought or intense sunshine). For some crops, notably banana and cassava in Nakaseke and bananas groundnuts and beans in Iganga, traditional varieties were reported as being superior in terms of taste[17] (Appendix B.3.2.4).

The impact of crop genetic innovations was explored in more depth using participatory budget methods (Appendix B.3.2.7). This analysis indicated that the different improved crop varieties had varying impacts for the households that grew them (Table 7). This is consistent with the reported impact of innovations being context-dependent (World Bank, 2006).

The pattern was similar for Nakaseke and Iganga: of the eight participatory budgets that were undertaken in Nakaseke, five showed an increased profit for the improved crop variety while three showed a loss for the innovation and in Iganga, six showed an increased profit for the improved crop variety while two showed a loss for the innovation. New crop varieties were consistently more costly in terms of inputs and requiring more labour, however they also brought the farmer more income from sales of the produce (balance in Table 5 in Appendix B.3.2.7). Though the earnings that a household achieves from their agricultural enterprises are important, the cash balance is not the only measure of success for all improved varieties. Most of the crops grown in the two sites were used for both cash and subsistence and improved varieties in both Nakaseke and Iganga led to increased produce for the

Table 7 Participatory budget balance sheet – Nakaseke and Iganga.
Figures given are UGX per acre per year

Nakaseke	Improved crop	Balance difference	Balance incl. family labour	Iganga	Improved crop	Balance difference	Balance incl. family labour
NKPB01A	Coffee	-88 000	-154 666	IGPB01A	Coffee	121 500	71 500
NKPB01B	Coffee	1 148 500	1 443 666	IGPB01B	Coffee	118 741	126 398
NKPB02	Banana	-78 571	-345 713	IGPB02	Beans	820 000	994 000
NKPB03	Banana	-94 375	-43 518	IGPB03	Maize	552 500	13 500
NKPB04A	Beans	358 742	358 742	IGPB04A	Banana	-136 000	-328 000
NKPB04B	Beans	872 000	638 000	IGPB04B	Banana	-140 000	62 200
NKPB05	Coffee	404 764	144 675	IGPB05	Beans	-368 000	-448 000
NKPB06	Beans	320 000	334 040	IGPB06	Groundnuts	746 000	764 000

[17] For example, the large majority of respondents in Iganga (91 per cent) preferred the taste of traditional bananas over the newer varieties, and more than half of respondents who have grown groundnuts prefer the taste of traditional varieties.

household, for consumption, for subsequent planting and/or for payments in kind. This was not uniform and some improved crops left households' with less produce for consumption (Appendix B.3.2.7).

The overall impact of using improved coffee, beans and maize appeared to be positive but the adoption of improved bananas was mixed with farmers in both locations making a loss especially with Mpologoma variety. While the sample size is too small to extrapolate these results, this analysis indicates the yield is by itself not a good indication of the impact of an improved crop at the household level and that many other factors (including labour, market opportunities and food security) are at the forefront of farmers' minds when considering improved crop varieties.

4.3.4 Constraints and challenges

The most important constraints reported during the participatory methods include the costs and availability of planting materials (e.g. tissue culture banana planting materials, hybrid maize seed). Improved varieties were also reported to require more labour and increased use of inputs such as fertilisers and pesticides, constraints that affect females more than males. Lack of access to markets to sell surplus production, fluctuating prices and inability to obtain reliable market information were also listed as key challenges as was the inability to access financing institutions. In terms of knowledge needs, farmers felt there was a major demand for information on how to deal with pests and diseases, and specifically which chemical inputs to use.

Challenges faced by farmers when using improved crop varieties were further probed in the survey questionnaire. Diseases featured as the most important challenge for farmers using improved cassava varieties in both locations, and pests and diseases were the main challenges farmers in Iganga faced when using improved maize varieties[18]. Increased labour was reported as a challenge by a smaller proportion of farmers, the highest values being recorded for bananas in Nakaseke for both males and females. Interestingly, a considerable number of respondents reported they had faced no challenges ranging from under a fifth of respondents for coffee in Nakaseke to nearly half of respondents for sweet potato in Iganga (Appendix B.3.2.4). This may be a reflection of the fact that the innovations discussed were those selected by the farmers as having had the biggest impact on his/her farm, introducing a bias towards positive examples.

Respondents were also asked to describe the challenges they face when considering using improved varieties in general. In Nakaseke the challenge stated by the largest proportion of respondents was 'pests and diseases', followed by 'access to finance', 'access to land', cost of planting materials and cost of complementary inputs. Significantly more male than female respondents[19] stated that fake planting material was a challenge which may be a reflection of the fact that more males than females source inputs from stores. In Iganga, access to finance was reported as the biggest challenge by the majority of respondents[20]. Pests and diseases were also considered a major challenge by respondents with more than half reporting this as a key challenge in Iganga. Other challenges included the cost of planting materials and the cost of complementary inputs. Access to information in the local language was considered to be a 'significant challenge' by a larger proportion of females than males.

4.3.5 Sources of improved planting materials

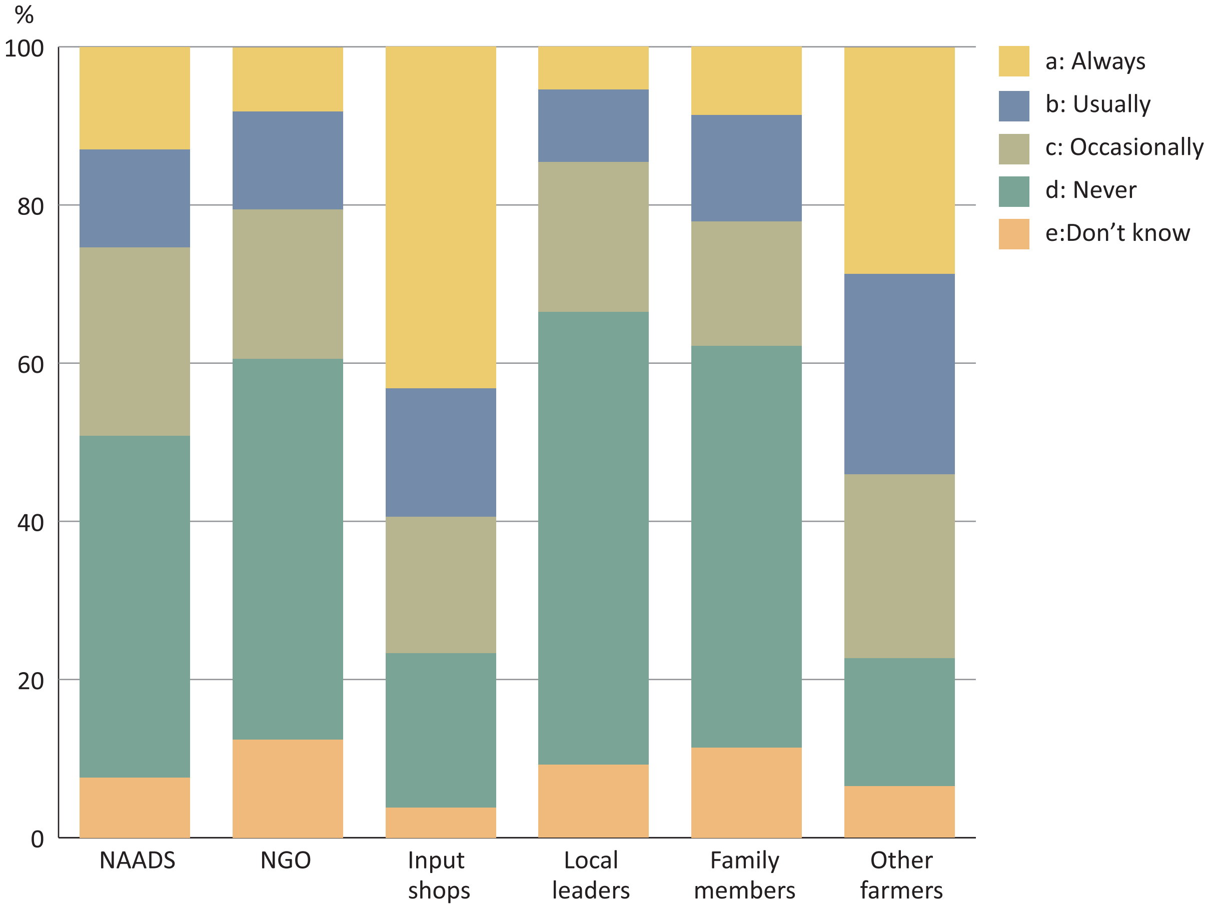
Respondents were also asked to list the sources where they had obtained improved crop varieties. The two most important sources in Nakaseke reported without prompting were input supply stores and other farmers and family members (Appendix B.3.2.4). Other sources of

[18] 33 per cent of respondents reported this was a challenge for female and 28 per cent for males.

[19] 14 per cent versus 5 per cent; $X2 = 4.47$; $p < 0.05$.

[20] Access to finance was identified as 'key' by a larger proportion of female respondents (55 per cent) than male respondents (48 per cent).

Figure 20 Actual source of planting materials in Nakaseke



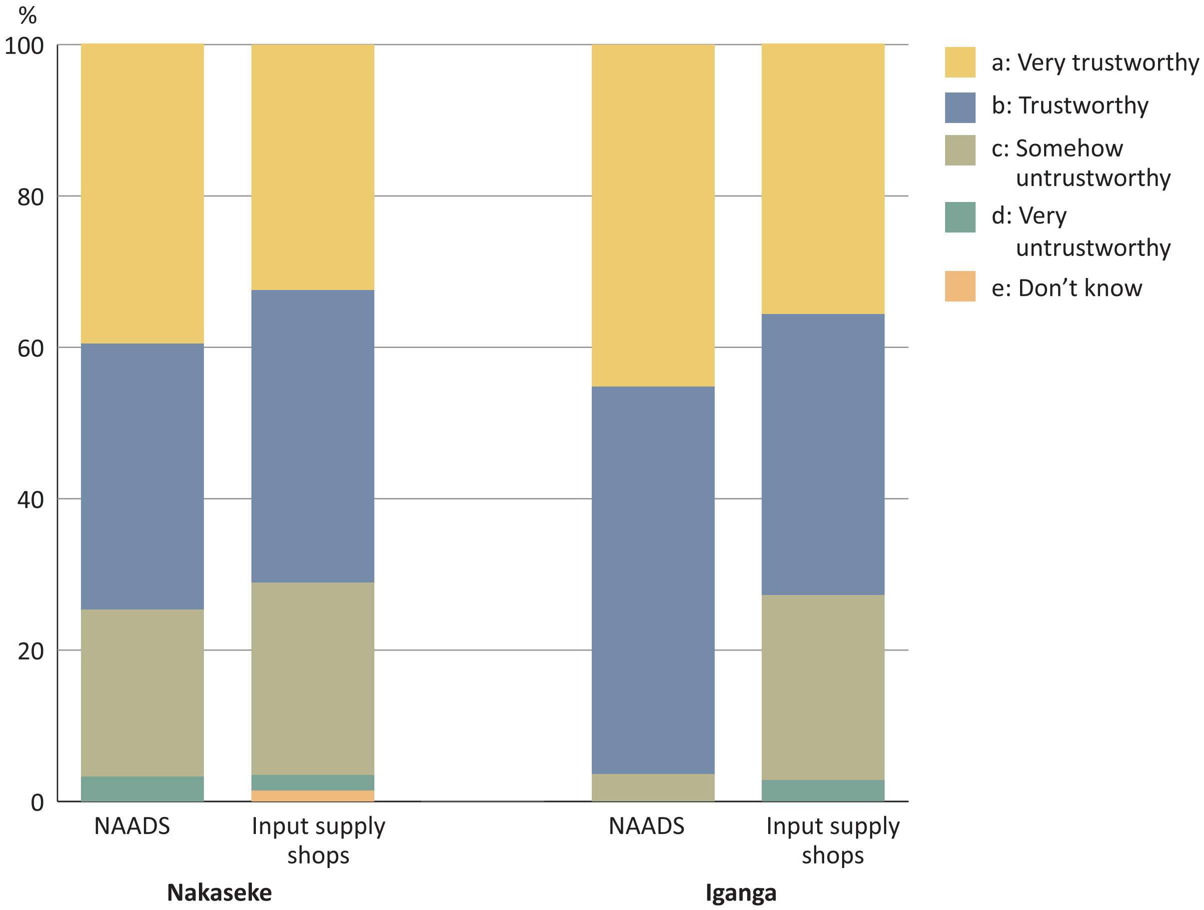
material for improved crop varieties included the sub-county NAADS office (32 per cent of respondents), NGOs and local leaders. When probed further for the regularity of contact, male farmers were significantly more likely to source their inputs from input stores than female while females were significantly more likely to source materials from the sub-county NAADS office than males[21]. Nearly half of respondents stated that they never sourced improved planting materials from the sub-county NAADS office (Figure 20).

Input stores were also the most important source of genetically improved planting material in Iganga cited unprompted by 70 per cent of respondents, followed by the sub-county NAADS office and fellow farmers. When probed further for the regularity of contact with the different sources, the importance of fellow farmers was significantly higher with nearly half of the respondents reporting as a source of improved planting materials. Almost half of the respondents in Iganga reported that they never sourced improved crop varieties from the sub-county NAADS office.

Although input supply shops were the most important source of planting materials for farmers in both locations, farmers also described them as the least trusted source of inputs. Over a quarter of respondents felt that input supply shops were untrustworthy in both locations. NAADS scored differently in both locations with regards to trustworthiness. While a quarter of respondents in Nakaseke also reported low levels of trust in the materials provided by the sub-county NAADS office, almost all respondents in Iganga reported NAADS as a trustworthy source of planting materials (Figure 21). NGOs were considered to be the most trustworthy source of planting materials in Nakaseke.

[21] 63 per cent of males compared to 50 per cent of females source planting materials from input stores ($X2 = 4.55$; $p < 0.05$). 62 per cent of females compared to 50 per cent of males source inputs from other farmers; and 41 per cent of female farmers source inputs from the sub-county NAADS office compared to and 24per cent of males ($X2 = 3.67$; $p < 0.06$).

Figure 21 Trustworthiness of source of planting materials



The availability of improved planting materials is crucial and timeliness is a critical part of this availability. If the planting materials are late then a farmer will very likely have missed a window of opportunity to plant a specific variety under the conditions in which it thrives. In terms of timeliness of supply of improved planting materials the sub-county NAADS office was considered to be 'always untimely' by nearly three-quarters of those respondents who receive planting materials from NAADS in Nakaseke and by nearly half of those who source materials from NAADS in Iganga. The sources considered most likely to be timely in their provision of improved materials by the majority of respondents in both locations were input supply shops, family members, and other farmers (Figure 22).

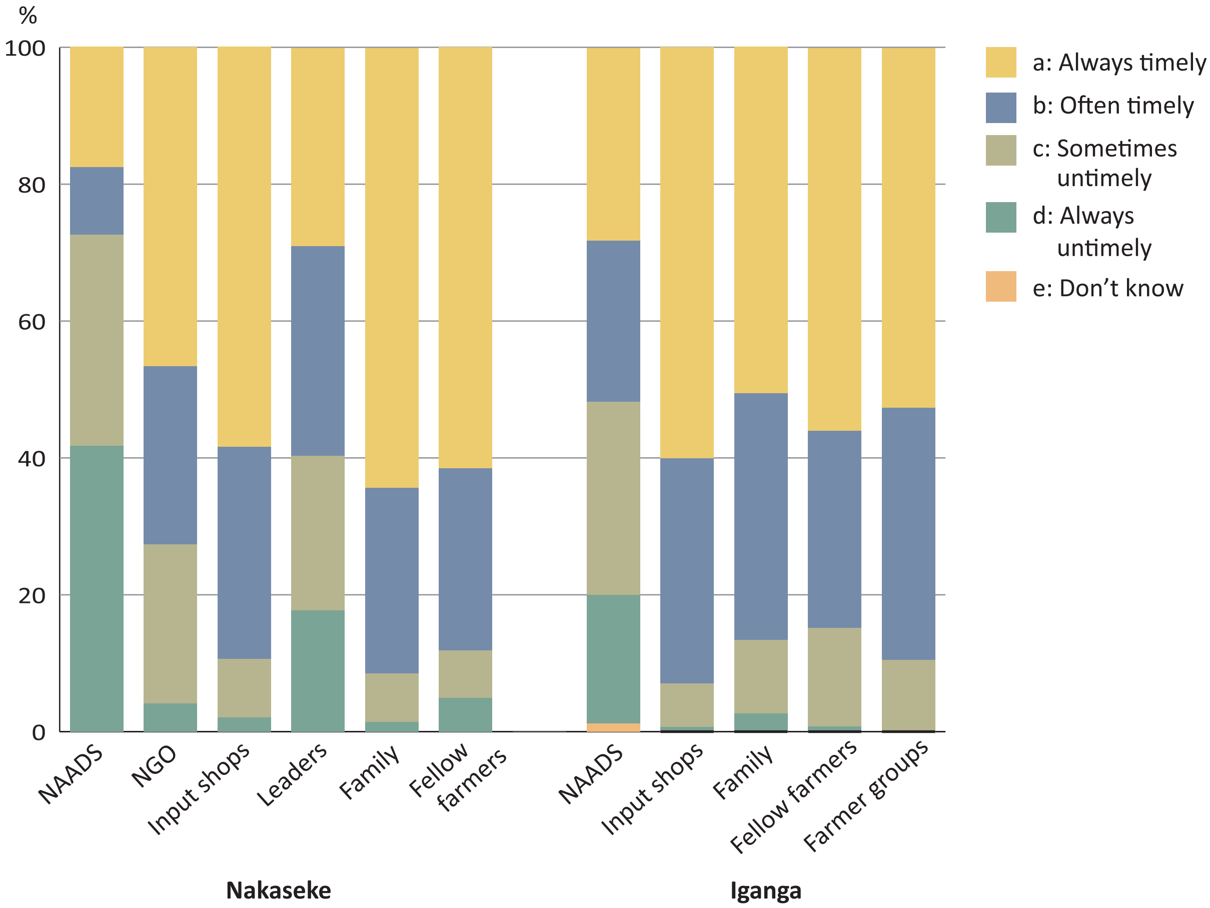
4.3.6 Sources of information and knowledge and information needs

The sources of information on improved planting materials important for smallholder farmers were explored using communication maps (Appendix B.3.2.8) and in the questionnaire (Appendix B.3.2.4).

Analysis was done in two steps. First, the number of occurrences of each source was recorded and analysed by gender. Then data for each map from the template and the visual outputs were scrutinised and recurring themes identified. Analysis was done in two steps. First, the number of occurrences of each source was recorded and analysed by gender. Then data for each map, from the template and the visual outputs, were scrutinised and recurring themes identified.

The maps show a rich range of sources from which farmers can access information relating to their farming. In total 32 sources or contacts were mentioned. There were differences between the two Districts: 19 sources were mentioned in Iganga of which eight did not appear in the Nakaseke maps, and

Figure 22 Timeliness of sources of planting material



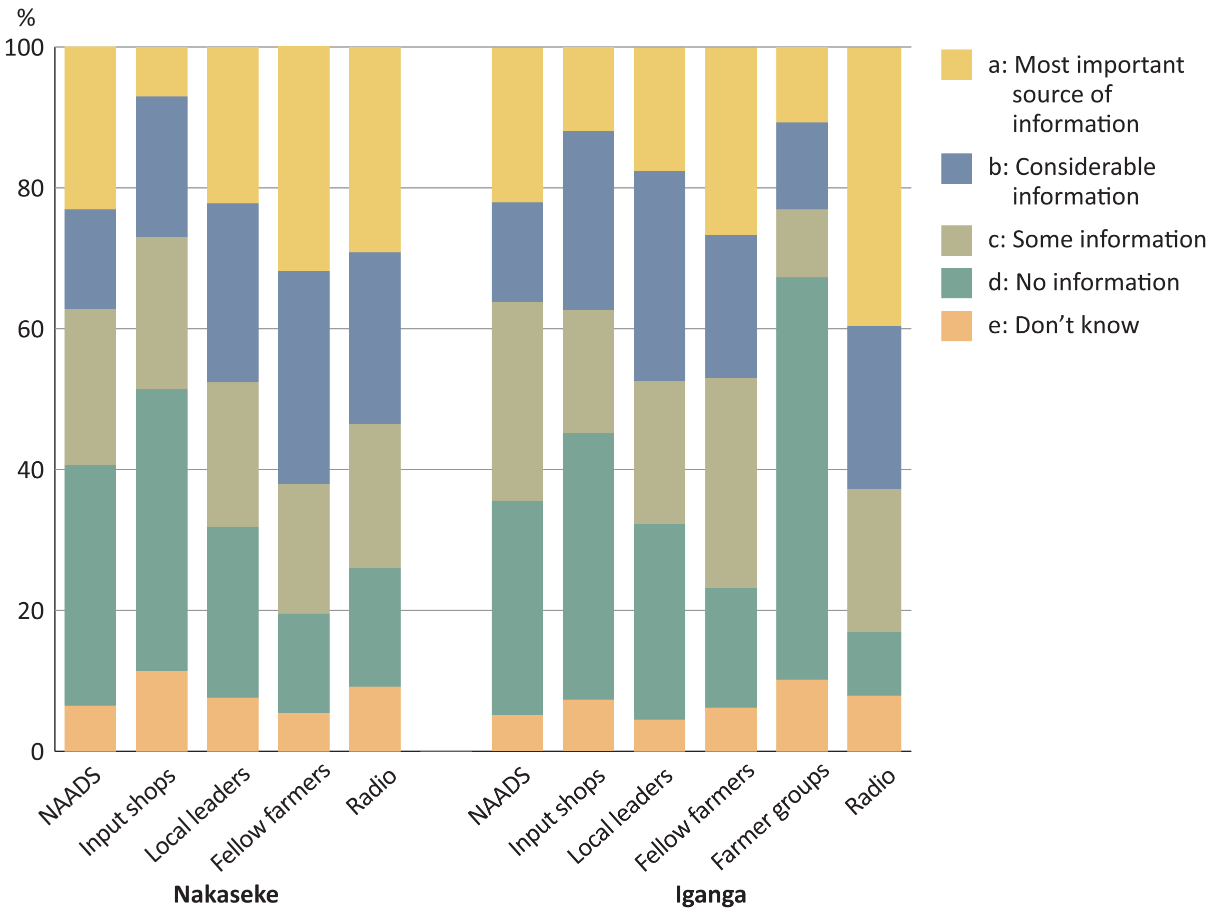
21 in Nakaseke of which 12 were not mentioned in Iganga. The differences between Districts reflect the presence of different sources (e.g. different NGOs), their relative accessibility (e.g. NARO, Members of Parliament) and the institutional set-up within each District. The only sources mentioned by half or more of the groups were other farmers, and National Agricultural Advisory Services (NAADS) personnel at District and Sub-County levels. The number of sources/contacts mentioned ranged from two to twelve with a mean in both Districts of six. There were notable gender differences in the number and type of sources. Females mentioned on average about half the number of sources/contacts mentioned by men and a higher proportion of the sources mentioned by men were from District and national levels. Females and males were, however, equally likely to mention radio (Appendix B.3.2.8).

In the questionnaire (Appendix B.3.2.4), survey respondents were asked to list the sources from which they receive information regarding improved crop varieties. In Nakaseke a third of the farmers reported fellow farmers as their most important source whilst a similar proportion considered the radio as the most important information source (Figure 23). Around a fifth of farmers listed their sub-county NAADS office and their local leaders[22] as important sources. Almost half of female respondents reported that they receive no information from input supply stores and, in Iganga, almost a third of respondents (31 per cent) reported that they receive no information from their sub-county NAADS office.

Radio was even more important in Iganga (Figure 23) with nearly half of repondents reporting it as the most important source of information on improved crop varieties. Other important sources of information in Iganga included fellow farmers, the sub-county NAADS office and local leaders. Female

[22] During the dissemination activity farmers reported that the information they receive from their local leaders is about opportunities for training organised by other information sources, rather than information on actual improved crops.

Figure 23 Sources of information in Nakaseke and Iganga (from questionnaire survey)

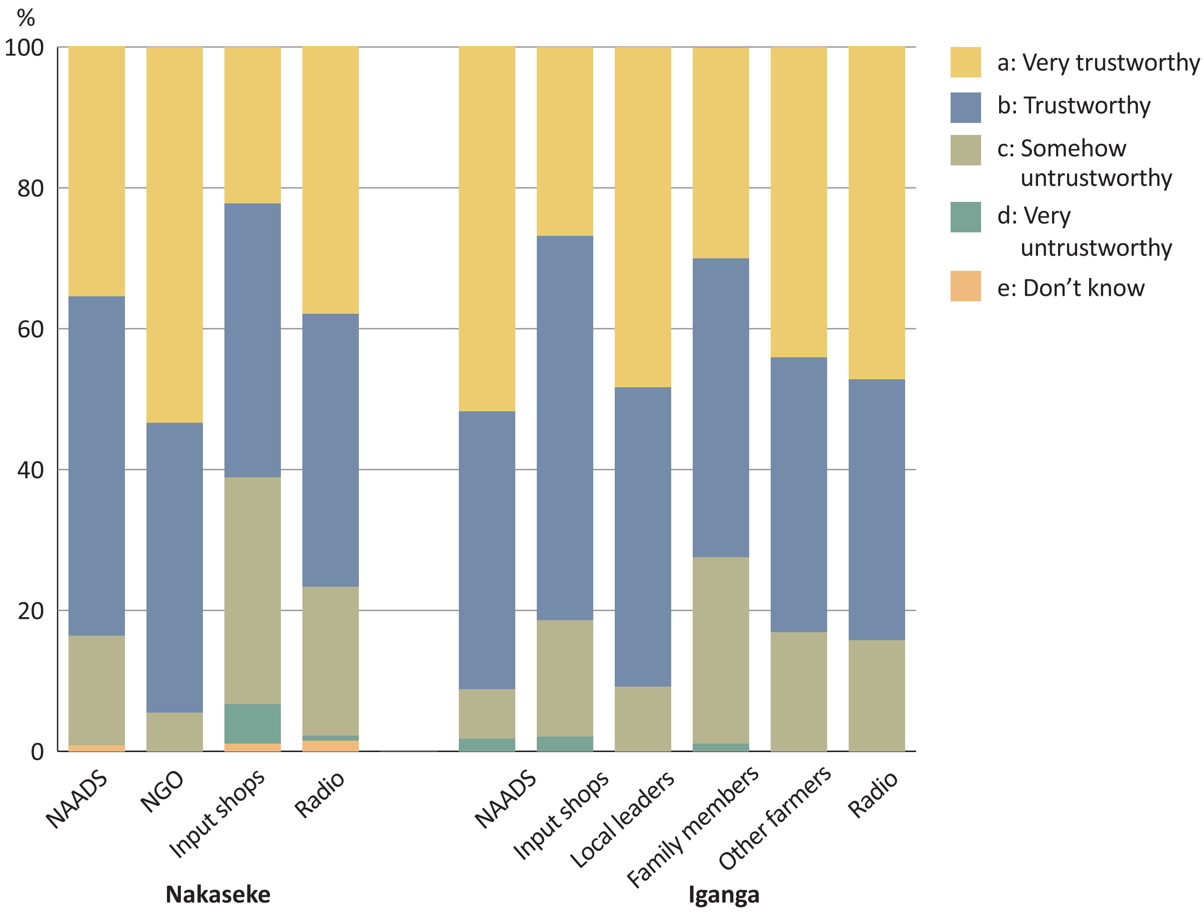


farmers were significantly more likely to source their information on improved crop varieties from fellow farmers (34 per cent compared with 20 per cent of males; $p < 0.05$). Almost a third of Iganga respondents reported that they receive no information from their sub-county NAADS office whilst more than half reported that they receive no information from farmer groups and over a third state that they received no information from input supply shops.

In terms of trustworthiness as a source of information, in Nakaseke NGOs were considered by the majority of farmers to be their most trustworthy sources of information (Figure 24), followed by local leaders (see footnote 24) and the sub-county NAADS office. Input supply shops were the least trustworthy source of information. In Iganga, the most trustworthy source of information was considered to be sub-county NAADS office. The radio was also considered to be a trustworthy source of information as were local leaders. A fifth of respondents in Iganga considered input supply shops to be untrustworthy. The source of information that was considered to be least trustworthy was family.

In terms of timeliness (Figure 25), sources of information considered to be very timely in Nakaseke included family members and 'other farmers' as well as input supply shops and NGOs. However, the sub-county NAADS office scored again very low on timeliness with two-thirds of respondents reporting NAADS as being late in its provision of information. This is important as it is one of the key sources of information that farmers receive. In Iganga, the most timely sources of information reported included input supply shops, local leaders and fellow farmers. The sub-county NAADS office is considered untimely by 38 per cent of those who utilise the information that it produces and the radio, the most widely used information source, is considered untimely by nearly a third of those who use it.

Figure 24 Trustworthiness of information sources in Nakaseke and Iganga (from questionnaire survey)



Trends emerging from this analysis include, according to farmers, a distinct trade-off between accessibility and reliability of sources. Local, informal sources are relatively accessible but more distant and less accessible sources are seen as experts and inherently more reliable as sources of information. Other farmers, for example, are accessible and can be very useful sources of information. However their credibility as a source of useful and reliable information depends on the perceived expertise and success of the individual farmer concerned as well as on his or her personal characteristics and commitment to sharing their expertise.

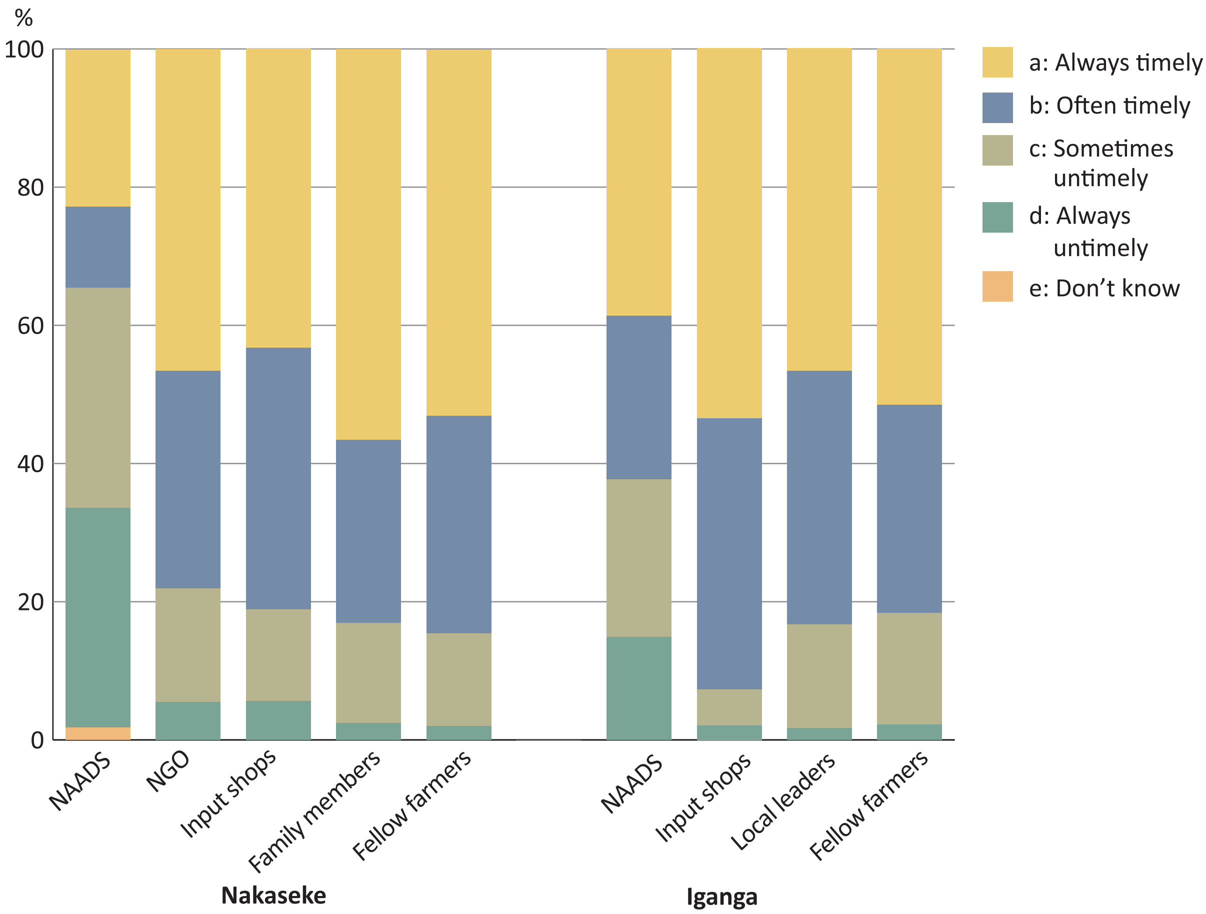
More generally, communication skills and ability to engender trust are critical for key information providers especially for men engaging with female farmers. If information is delivered or provided by a popular person or source, positive adoption rates and transformation are likely to happen. However several groups made the point that information alone is not always enough for them to improve their farm enterprises particularly where they lack money or sources of supply to acquire recommended inputs. Timeliness of information can be a problem, for example when NAADS information or training comes late in the season.

Several groups identified information gaps or expressed an interest in having access to more information particularly on market prices, how to use inputs including pesticides and fertilisers, modern farming methods and the prevention of post-harvest losses.

4.4 Objective 2: smallholder farmers' knowledge and perspective on plant genetics innovations

Although farmers were not aware of the plant breeding techniques used by researchers to improve crop

Figure 25 Timeliness of information sources in Nakaseke and Iganga (from questionnaire survey)

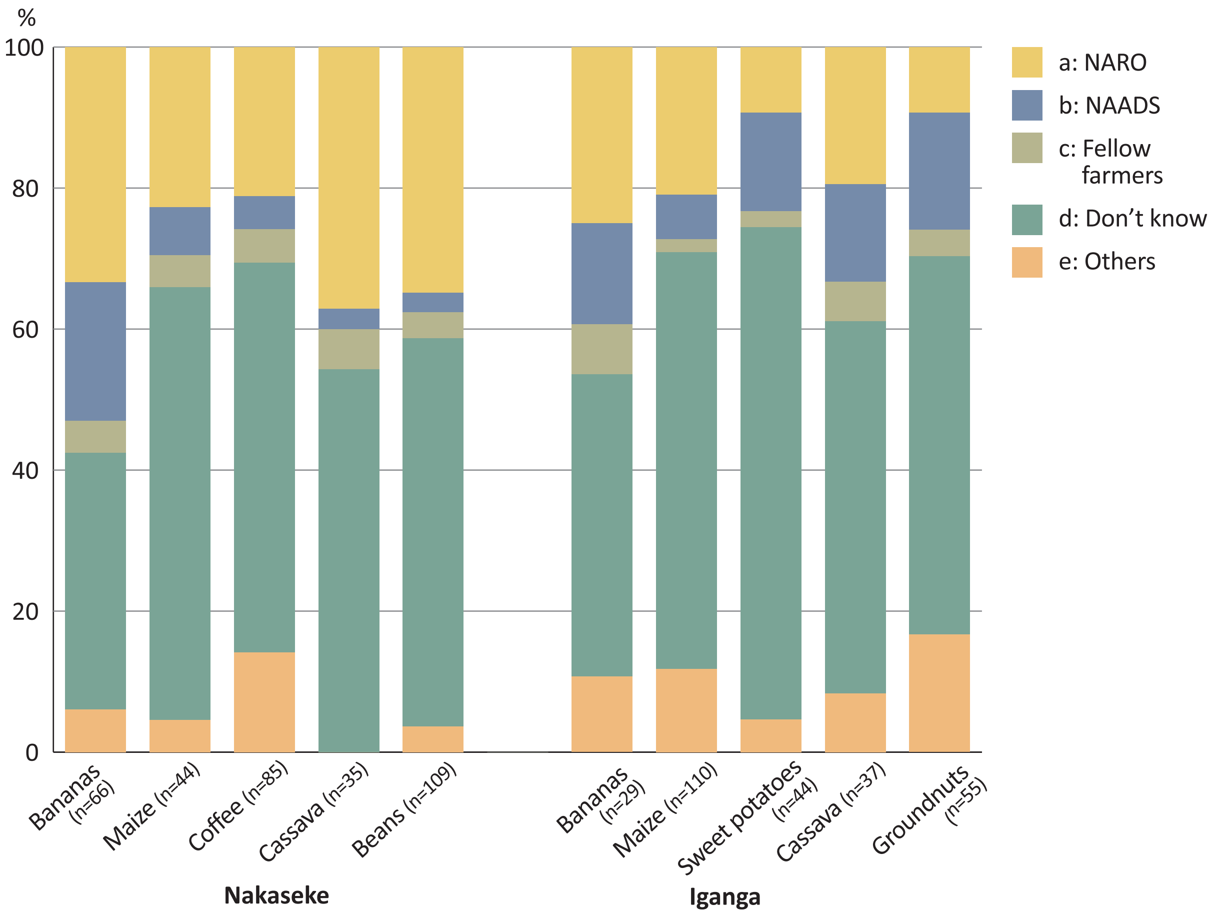


varieties, they were aware of crop improvement taking place and of the need of new improved varieties to be adapted to the local agro-ecological conditions to be successful. Participants understood crop innovations as changes in crops that led to high yields and provided greater resistance to pests and diseases or as varieties with traits not present in traditional varieties. Attitude towards crop genetic innovations was in general positive although farmers reported they would stop growing new varieties if the traditional varieties performed better in the local conditions (including prevalent pests, diseases and climatic conditions). Other reasons reported for preferring traditional varieties included that they required less labour, their planting materials were more accessible (cheaper or free) or they tasted better even in situations where improved crops gave a higher yield (Appendices B.3.2.5 and B.3.2.6).

Smallholder farmers' knowledge of who developed improved crop varieties
Knowledge and perception on crop genetic improvement was also explored in the questionnaire. Respondents were first asked to state who they believed had developed the improved crop varieties previously selected (by the respondents) as the two most important crop innovations. In all cases the largest proportion of respondents did not know the answer to this question, the values ranging from a third for banana farmers in Nakaseke to nearly two-thirds of sweet potato farmers in Iganga. Of those who reported that they knew who developed the improved variety in question, the largest proportion said that it was NARO although a significant proportion believed it was NAADS (Figure 26).

Smallholder farmers' perception of responsibility for developing genetically improved crop varieties
Respondents were also asked who they believed had the key responsibility for developing improved crops. In Nakaseke, over half of respondents stated that the key responsibility lay with NARO while

Figure 26 Farmers' knowledge of who developed improved crop varieties



a third of respondents believed it belonged to the sub-county NAADS office. A range of other organisations were considered to have differing levels of responsibility when considering the development of improved crops including universities, farmers and district production offices. In Iganga the largest proportion of respondents (45 per cent) stated that NARO had the key responsibility for developing improved crop varieties followed by the sub-county NAADS office and universities.

Smallholder farmers' perception of responsibility for spreading information on improved crop varieties
Respondents were asked who they believed should take responsibility for disseminating information regarding crop improvements. The largest proportion of respondents in Nakaseke stated without prompting that their fellow farmers should spread information on improved crop varieties as well as the sub-county NAADS office, local leaders and the radio. When probed further, the sub-county NAADS office was considered to have a key responsibility for spreading information regarding crop improvements by over half of respondents. Local leaders and the radio were also seen as 'key' by half of the sample. By contrast, the largest proportion of respondents in Iganga stated that local leaders should be responsible for spreading information regarding improved crop varieties followed by the sub-county NAADS office, fellow farmers, district production offices and the radio. When probed further, more than two-thirds of respondents considered local leaders to have a 'key responsibility'[23] and with slightly fewer reporting the same for radio and the sub-county NAADS office.

Smallholder farmers' perception or responsibility for distributing improved planting materials
Respondents in both Nakaseke and Iganga believed the sub-county NAADS office and local leaders should take the largest responsibility for distributing improved planting materials.

[23] During the dissemination activity farmers reported that the information they receive from their local leaders is about opportunities for training organised by other information sources rather than information on actual improved crops.

Smallholder farmers' knowledge and perception on methods of crop improvement
To be able to raise the level of awareness and understanding of the potential for traditional and modern genetic techniques in improving agriculture in Africa, it is important to understand how farmers are influenced by various sources of advice and information in making decisions about crop improvements on their farms. It is also important to identify smallholder farmers' knowledge about, and attitudes towards, crop genetic improvement and their current knowledge, understanding and perceptions of a range of genetic techniques for improving the characteristics and performance of the crops that they grow.

The level of knowledge smallholder farmers have of different crop genetics techniques was further analysed in the questionnaire (Appendix B.3.2.4) and in focus group discussions with farmers specifically addressing knowledge and perception of crop genetic improvement techniques (Figure 27; Appendix B.3.2.9). Respondents were asked a number of questions about the following methods of crop improvement: seed sorting, tissue culture, hybrid seeds and genetic modification.

The vast majority of respondents, irrespective of gender, were aware of farmer seed sorting as a crop improvement method mostly through informal information exchange with family members or fellow farmers. Three-quarters of respondents in Nakaseke were aware of tissue culture for crop improvement. In the majority of cases information had been sourced from fellow farmers or from NAADS. More than a third of respondents who were aware of tissue culture crop development had used crops developed by this method. In Iganga, however, just over a third of respondents were aware of this technique. Information regarding tissue culture crop development had been sourced largely from fellow farmers or from NAADS. A quarter of respondents in Iganga who were aware of tissue culture crop improvement had actually used crops developed with this method.

With regards to hybrid seed production, just under half of all respondents were aware of this technology. There was a significant difference between male and female responses with a larger proportion of male respondents having heard of this technique than of female respondents[24]. Just under half of the respondents who were aware of hybrid seed production had received most of their information from fellow farmers with a small proportion having learned about the technique from NAADS. Almost three-quarters of respondents in Iganga were aware of hybrid seed production which is most likely a reflection of the fact that improved maize varieties were reported as the most important crop genetic innovations used by respondents over the previous 10 years. Significantly more male respondents are aware of hybrid seed production methods than women (77 per cent compared to 61 per cent; $p < 0.05$). Sources of information included fellow farmers, radio, NAADS and input supply stores. Of those respondents who are aware of hybrid seed production, slightly over a third had actually used F1 hybrid seed.

Genetic modification (GM) techniques were unknown to the majority of respondents. Only a quarter of the farmers surveyed had heard about GM in Nakaseke and a fifth of farmers surveyed in Iganga. Fellow farmers had again been the main source of information regarding genetic modification of crops in Nakaseke and NAADS had been the most common source of information in Iganga. Of the four crop improvement methods discussed with respondents, genetic modification is the only one which considerable numbers of respondents had learnt about via the radio.

4.5 Objective III: gender issues in the use of improved crop varieties by smallholder farmers
This study sought to unravel the process by which crop genetic innovation takes place in smallholder farms from the perspective of female farmers, to determine how the provision of agricultural services may better serve them.

[24] 57 per cent of males, and 40 per cent of females; $p < 0.03$.

Figure 27 Farmers' knowledge and perception regarding crop improvement methods

What is crop improvement?

- Improved crops are *'treated'* and become high yielding and fast maturing
- *'Taking good care of your crop: weeding, planting and mulching'*
- Taking a crop from its original form and *'transforming it into something else'*
- *'Mixing fertilisers with plant husks (maize or coffee) and leaving them to rot in the soil'*
- *'Mixing fertilisers with plant husks (maize or coffee) and leaving them to rot in the soil'*
- *'Taking good care of the crops'* (i.e. weeding and minimising pests)

How do scientists improve crops?

- By *'grafting a local tree with improved trees'*
- *'Scientists come and collect seeds from farmers; they add science and chemicals and then bring them back to farmers'*
- Scientists have two gardens and plant different varieties in each garden to see which do best, testing them in different conditions
- For bananas, the scientists get the planting materials, they shorten them and remove the roots and then they bring them back to the farmers for planting
- Scientists use good conditions to help them improve crops and that they also choose the best seeds
- For tissue culture plantlets, scientists grow bananas and leave them to ripen before cutting the seeds from the middle of the fruit, plant them, and then distribute the resulting plantlets to farmers
- Scientists have large pieces of land which give them the room to make improvements to the crops
- Scientists are also able to 'share knowledge' which helps them to develop new varieties to bring to farmers
- Sort good seeds, apply insecticides, and then package them well before distributing to farmers
- *'Use scientific knowledge in developing crops that are suitable to given environments'*
- Scientists have *'machines that are capable of seeing inside seeds/crops to see which ones are good or bad'*
- Grafting an orange tree with a lemon tree

What is seed sorting?

- To *'destroy non-performing seed'*
- Sorting climbing beans from non-climbing beans Removing seeds that are not desired
- *'Farmers sort out the plants with desired attributes while they are still in the garden, after which they dry and store the seeds for planting in subsequent seasons'*
- *'Sorting can be based on the seed size, colour and whether it is disease-free'*
- Higher yielding plants are *'labelled by tying a banana fibre around the plant during growth'*
- For bananas, *'big and healthy looking suckers'* are selected
- For cassava, plants growing vigorously, higher yielding and free from diseases are selected for cuttings

What is marker assisted selection?[1]

- *'It is good because it helps scientists to deal with diseases'*
- It is a commendable practice as long as it improves the survival of the crop and ensures food availability
- *'If a rat can eat wild cassava and die then mixing of crops can be dangerous to humans who eat the food crop'*
- *'Traditional characteristics'* like taste and longevity are lost
- Grafting a finger from a variety of bogoya with a local banana variety, *'creating a new variety that is not as tasty as the local type'*
- The method could be *'hazardous to health, especially if the selection is done with wild cultivars, since they are not meant to be eaten'*
- Using *'specialised machines that know which seed is good'*

What is tissue culture?[2 3]

- Plantlets come from seeds of ripened bananas
- The process involves grafting two varieties
- *'Scientists'* add chemicals to TC bananas in order to make them disease resistant

What is Genetic Modification?[4]

- A process similar to grafting
- Merging the genes of a pig with the genes of a cow

[1]Only one group had heard about varietal selection by plant breeders. All the comments were provided after research assistants explained
[2]Participants in each of the three groups in Nakaseke had heard about tissue culture but they did not necessarily know the process behind it
[3]Two of the groups in Iganga had not heard of the tissue culture method
[4]None of the groups in Iganga had heard of GM

An analysis of the demographic and socio-economic data collected in the questionnaire already points to key differences between male and female respondents. In Nakaseke nearly three-quarters of the households surveyed were male-headed, 63 per cent of respondents were household heads and, when divided by gender, over twice as many of these were male as opposed to female respondents. In Iganga, 55 per cent of the households surveyed were household heads, with significantly more male household head respondents than female (83 per cent versus 24 per cent).

In terms of levels of education attained, females scored lower in both locations. In Nakaseke only a quarter of female respondents had completed secondary education compared to over a third of males. In Iganga almost a fifth of household heads had no formal education with a significant proportion of female heads (40 per cent) not having attended school when compared to their male counterparts (15 per cent). Only 12 per cent of women heads had been to secondary school as opposed to 26 per cent of their male counterparts.

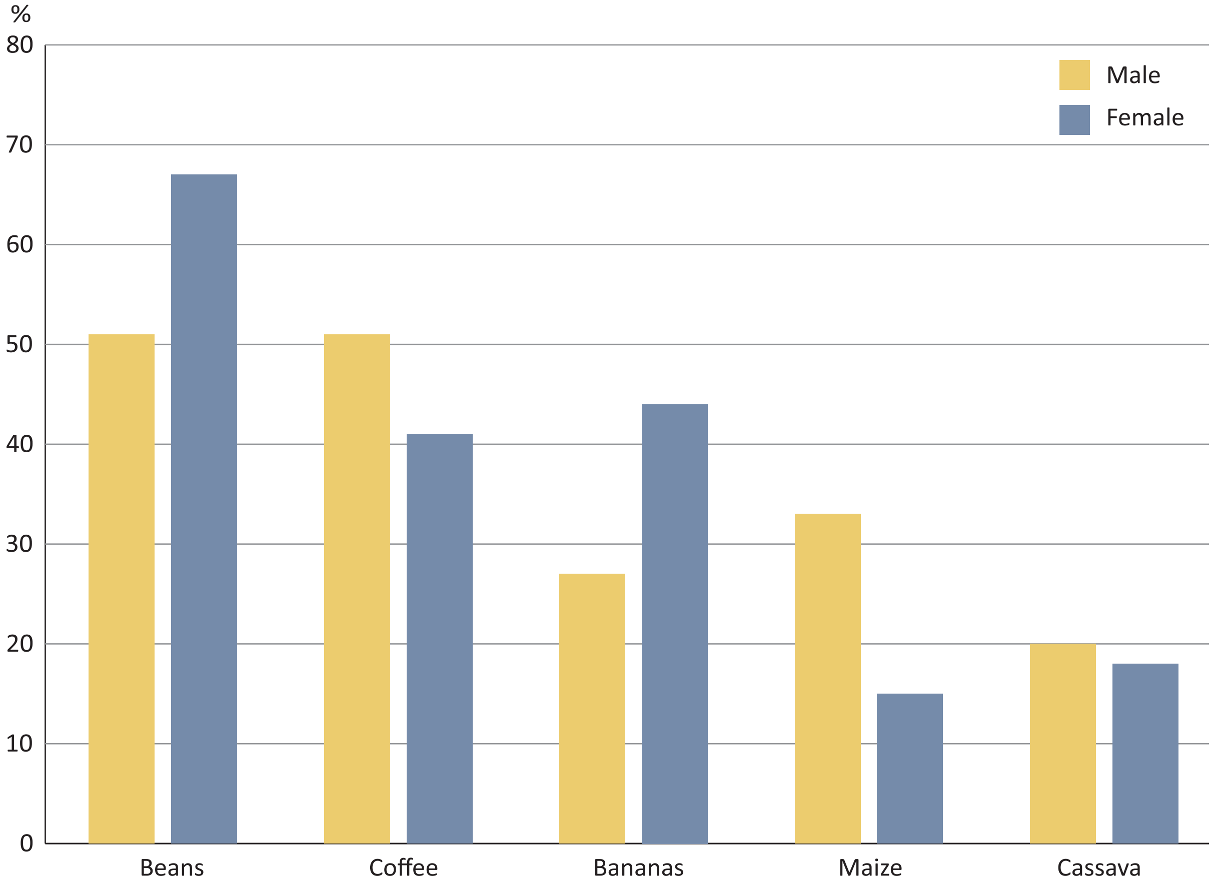
Female-headed households also cultivated on average a smaller area of land than males, were less likely to hire labour and were less likely to rent more land when compared to male-headed households in both Nakaseke and Iganga. In terms of assets, while the majority of households in both locations had mobile phones, in Iganga male-headed households were significantly more likely to own mobile phones (84 per cent) than female-headed households (50 per cent; $p < 0.001$)[25].

In the focus group discussions, crops are often distinguished as 'male crops' or 'female crops' by farmers. The factors that distinguish 'male crops' from 'female crops' are reported to be the price and accessibility of planting materials and required inputs, the labour requirement for growing the crop and the profitability of the enterprise. Cash crops that require higher monetary investments for planting materials and inputs and need more work for their management such as coffee are generally 'male crops' although females may grow them if they are the heads of the household. Males also tend to take control over the most profitable crop enterprises. Historical events may also account for gender preferences, for example coffee was forcefully promoted to male farmers during the colonial period). Females tend to prefer crops that provide food for the household as a first priority (Figure 28), and may also provide income by selling surplus production for crops such as bananas, beans and sweet potato. This is consistent with literature on the gendered nature of agriculture (Negin *et al.*, 2009; Njuki *et al.*, 2011; Fisher and Qaim, 2012). However, Figure 26 suggests that this distinction does not always apply as coffee in Nakaseke was reported as over a third of female respondents surveyed stated that clonal coffee had a big impact on their household (Appendix B.3.2.4).

In terms of provision of services (information and improved planting materials), male and female farmers in Nakaseke reported during the focus group discussions that females are often the first point of contact between extension agents and farmers because they attend training sessions in larger numbers, sometimes directed by males. Another reason given by males is that females spend more time at home than males and consequently visiting NAADS officials tend to speak to them. An example is how improved coffee in Nakaseke was first used by females (reported by IUNK05, a female group; Appendix 6) as the chances of obtaining seedlings were greatly improved by attendance at meetings/training sessions. This trend is also supported by the questionnaire data, which indicate that more females receive inputs from NAADS than males in Nakaseke (41 per cent of females versus 24 per cent of males; $p < 0.06$). However, in Iganga this is reversed, and males were significantly more likely than females to 'usually' source their inputs from NAADS (31 per cent versus 18 per cent; $p < 0.05$). Females were also less likely in both locations to source improved planting

[25] The difference between male and female-headed households in Nakaseke with respect to mobile phone ownership was not significant.

Figure 28 Improved crops that have had the biggest impact on your household – Nakaseke



materials from input stores and, conversely, more likely to obtain planting materials from family members and fellow farmers (Appendix B.3.2.4).

How the information received by female farmers is then passed to male members of the household is nuanced, reflecting complex relations in terms of control over farming decisions and access to the innovations. Females may opt to share all of the information received, or withhold part or all of it. Both male and female farmers identified access to extension services as key constraints.

With regards to decision-making[26] across all of the crops in Nakaseke, males and females each reported that they were the main decision makers on all questions[27]. There were generally large discrepancies between their responses, as males reported themselves as primary decision makers most often, followed by joint decisions between males and females and then females being the main decision makers least often. In contrast, females tended to report that they were the primary decision maker, with lower levels of joint decision-making. This split was particularly evident with regards to improved coffee, a cash crop. Discrepancies between male and female responses were the least distinct and most evenly spread for improved beans, a consumption crop. This is particularly interesting in light of the reports that beans are the most important crop for females and grown largely for either both cash and subsistence or just subsistence. Decision-making differed by crop and type of decision (information seeking, trial and adoption, land use, and marketing). These results can be expected to present a more positive picture of female decision-making power in the household than exists in reality because the questions asked referred to specific innovations that had had high impact on the respondent's household. Therefore a

[26] Respondents to the questionnaire survey were asked about decision making on trialling, purchasing, planting (where and on what proportion of land) and marketing of individual crops.

[27] This can be explained partly by the fact that the questions on decision-making referred to the two crops reported by the respondent as having had more impact in his/her household. Hence replies would be expected to represent instances where the respondent took an active role in adoption, and reflect personal involvement.

bias towards positive innovations that were available and accessible to respondents is expected. Conversely, innovations that were too expensive or out of reach of respondents will be less represented. Resources constraints will affect female farmers to a greater degree than male farmers.

Decision making across crops in Iganga was mixed but respondents reported higher proportions of male decision making than Nakaseke. This varies by individual crop though some patterns emerge. Both males and females reported lower proportions of males as main decision makers about improved bananas versus females. However, with regards to sweet potatoes, cassava, and beans, males and females have contrasting perspectives on male and female decision making. This is particularly the case with regards to land allocation, crop placement, and marketing. Overall, males and females indicate that they are the primary decision makers in each area of decision making respectively. They also indicate that the opposite gender has a significantly lower proportion of primary decision-making. Males as main decision makers appear more dominant for maize and rice. Overall, these responses suggest that females have less decision making power when compared to males. However, they do indicate the possibilities for significant discrepancies in decision-making power within the household with regards to resource allocation for land and marketing for cash versus consumption crops.

5 Recommendations

1 It is important to specifically target and support smallholder farmers' informal information sources for improving access to credible information sources on crop genetic innovations (model farmers, local leaders, input suppliers). Particular attention should be given to strengthen sources targeting female farmers who are not well served by current information sources.

2 The information provided to smallholder farmers on improved varieties should be improved. Information should be made available on the relative performance of improved varieties as compared with traditional varieties so as to enable farmers to make an informed choice and minimise their risks. The focus should not be placed exclusively on yield potentials and greater emphasis should be given to attributes addressing environmental (such as climate change, drought) and biotic constraints (pests and diseases).

3 In terms of plant breeding efforts, initiatives aimed to develop improved crop varieties that reduce the need of external inputs such as fertilisers and pesticides should be given high priority in the research agenda. These crops include improved water-use and nitrogen-use efficiency, and disease-tolerant varieties.

4 While it is essential to increase funding of plant genetics research addressing key constraints to productivity, it is just as critical to ensure the products of such research are not prevented from reaching farmers' fields by barriers to implementation. Access to finance for purchasing improved seeds/planting materials and inputs is a key challenge, in particular for female farmers. Hence holistic solutions that also address this problem will be essential for the uptake of products derived from advanced plant breeding technologies, especially those which are more expensive, such as F1 hybrid seeds.

5 Taste and appearance are critical factors for adoption. These characteristics need to be taken into account in plant improvement programmes.

6 Information on current crop genetic improvement methods and their products including advantages and limitations needs to be provided. For example, information on the inability to save

seed for planting in F1 hybrid crops should be made available to assist farmers in making informed decisions about which crop varieties are best suited to their needs and financial means.

7 Farmers base their decision-making on the use of new crop varieties based on critical evaluation of their attributes relative to those of traditional varieties and not on the genetic improvement method used. However, making available scientific and balanced information on controversial technologies is important to allay fears and concerns of the farming community. Communication on biosafety institutions and their responsibilities should be a priority.

8 Radio was reported as an important source of information on crop genetic improvements by both male and female farmers. It is important to strengthen the capacity of this medium to deliver accurate and timely information.

9 NAADS was reported as a good source of inputs in terms of quality by the farmers who are served by this organisation. However it scored very low in terms of delivering inputs on time for planting. It is important to improve the reach and timeliness of information and inputs from NAADS.

10 Improving governance and quality control of input dealers is of paramount importance. Fake seed and inputs were reported by smallholder farmers to be a problem about a third of the time they sourced materials from inputs stores. Enforcement of current laws to ensure a functional seed system is in place is urgently required.

11 Initiatives to develop the capacity of individual and community seed saving initiatives to preserve traditional varieties should be promoted.

For Farmer Information see Appendix B.3.2.9; Dissemination leaflets B.3.2.10; References B.3.2.11.

Activity 3.3 A digital learning platform for strengthening extension services in Africa – a scoping study

- Tumaini Eribariki, Sixmund Stephen, William Mwakyami, Claire Allan, George Strunden – Farm Africa;
- Tilahun Zeweldu, Frank Shotkoski – Agricultural Biotechnology Support Project II, USAID/Cornell University;
- Jon Knight, Ross Taylor – Taylor Knight Solutions Ltd;
- Erik Childerhouse – My Language Ltd;
- William Prasifka – St Edmund's College, University of Cambridge;
- Max Marcheselli, Claudia Canales – B4FA.

(see also Appendix C)

Summary
Access to knowledge and information on genetically improved crops and on how to best make use of these are key barriers for improved productivity for smallholder farmers in Sub-Saharan Africa. We set to determine whether a Digital Learning Platform (DLP), initially developed to teach English and numeracy to children and young adults in Malaysia and India, could be deployed to strengthen existing initiatives promoting the use of improved planting materials in Sub-Saharan Africa. Two collaborations to run pilot projects were established: 1) with the NGO Farm Africa to deliver training on sesame production and

marketing in northern Tanzania; 2) with the Agricultural Biotechnology Support Project II, a Cornell-led and USAID-funded project to develop and disseminate hybrid and GM bananas in Uganda. The project involved the development and deployment of two modular courses and their deployment to smallholder farmers and to agricultural extension agents in smart tablets. Significant development to the back-end of the application was also required to adapt it for off-line deployment in remote rural areas with no electricity. Preliminary observations indicate that the DLP is a powerful platform to deliver information to smallholder farmers, with good potential for scaling up to reach a large number of users and for delivering integrated solutions to address knowledge barriers to productivity.

1 Introduction

1.1 Agriculture and economic development

Agriculture is an important engine of growth and poverty reduction in developing countries by generating income and employment in rural areas and providing cheaper food for urban areas (Mellor, 1999; Thirtle *et al.*, 2003; Self and Grabowski, 2007; Christiaensen *et al.*, 2011; Dethier and Effenberger, 2011). Agricultural growth is particularly effective in reducing poverty among the poorest of the poor[28] (Christiaensen *et al.*, 2011). The source of agricultural growth also matters for its impact on poverty reduction. Agricultural growth in East Asia has been achieved with technologies increasing productivity and has led to large reductions in poverty. By contrast in Africa, gains in agriculture have been small and most growth has arisen from expansion of land under cultivation, and poverty reduction has been low (de Janvry and Sadoulet 2009). Higher farm productivity reduces both absolute as well as relative poverty (Ravallion and Datt, 1996; Datt and Ravallion, 1998). Since about three-quarters of the poor people in the world live in rural areas and derive the major part of their income from the agricultural sector and related activities, increasing farm productivity is therefore a pressing developmental concern.

There are two broad problems with raising agricultural productivity in African countries. One is the lack of appropriate technologies for many of the constraints facing agricultural production in the continent. The second is barriers to adoption of existing technologies and knowledge. The first problem has been partly recognised reflected in the increased recognition by policy makers and international donors of the importance of agricultural research and development. This has resulted in an increase by about 20 per cent of investments in agricultural R&D in Sub-Saharan Africa (SSA) between 2001 and 2008, after more than a decade of stagnation (Beintema and Stads, 2011). However, much remains to be done[29].

In terms of the second problem, despite some adoption of new crop varieties in Africa adoption rates remain far below Asian rates[30] (Gollin *et al.*, 2005). Even if new and more productive technologies are available farmers may be unable to access these, may lack information about their existence, knowledge about proper implementation techniques or may be unable to afford them. This situation therefore demands a reduction in the barriers to adoption which include low education, missing credit market, improved infrastructures and conducive institutional arrangements.

A recent trend in the agriculture sector is an increasing dependency on information. Farmers require a wide range of scientific and technical knowledge for effective decision-making (Cash, 2001). Information

[28] A study using cross-country econometric evidence indicated that agriculture is significantly more effective in reducing poverty among the poorest of the poor (as reflected in the $1-day squared poverty gap). It is also up to 3.2 times better at reducing $1-day headcount poverty in low-income and resource rich countries (including those in Sub-Saharan Africa), at least when societies are not fundamentally unequal.

[29] Most of the increased spending has been the result of government commitments to raise incommensurately low salary levels and to rehabilitate neglected infrastructure, after years of underinvestment. Increases in investments on research activities have been relatively low. Furthermore, most of this growth occurred in only a handful of countries: over one-third of the growth in public agricultural R&D spending during this period is attributable to a $110 million increase in spending in Nigeria. Ghana, Sudan, Tanzania, and Uganda also experienced relatively high increases in total spending of between $25 million and $56 million each. The 'Big Eight'—Nigeria, South Africa, Kenya, Ghana, Uganda, Tanzania, Ethiopia, and Sudan—accounted for 70 per cent of regional public agricultural R&D spending and 64 per cent of all researchers in 2008.

[30] For example, in 2000, African adoption rates of modern varieties of rice, wheat and maize per area harvested were less than half those of rates in East and Southeast Asia (Gollin *et al.*, 2005).

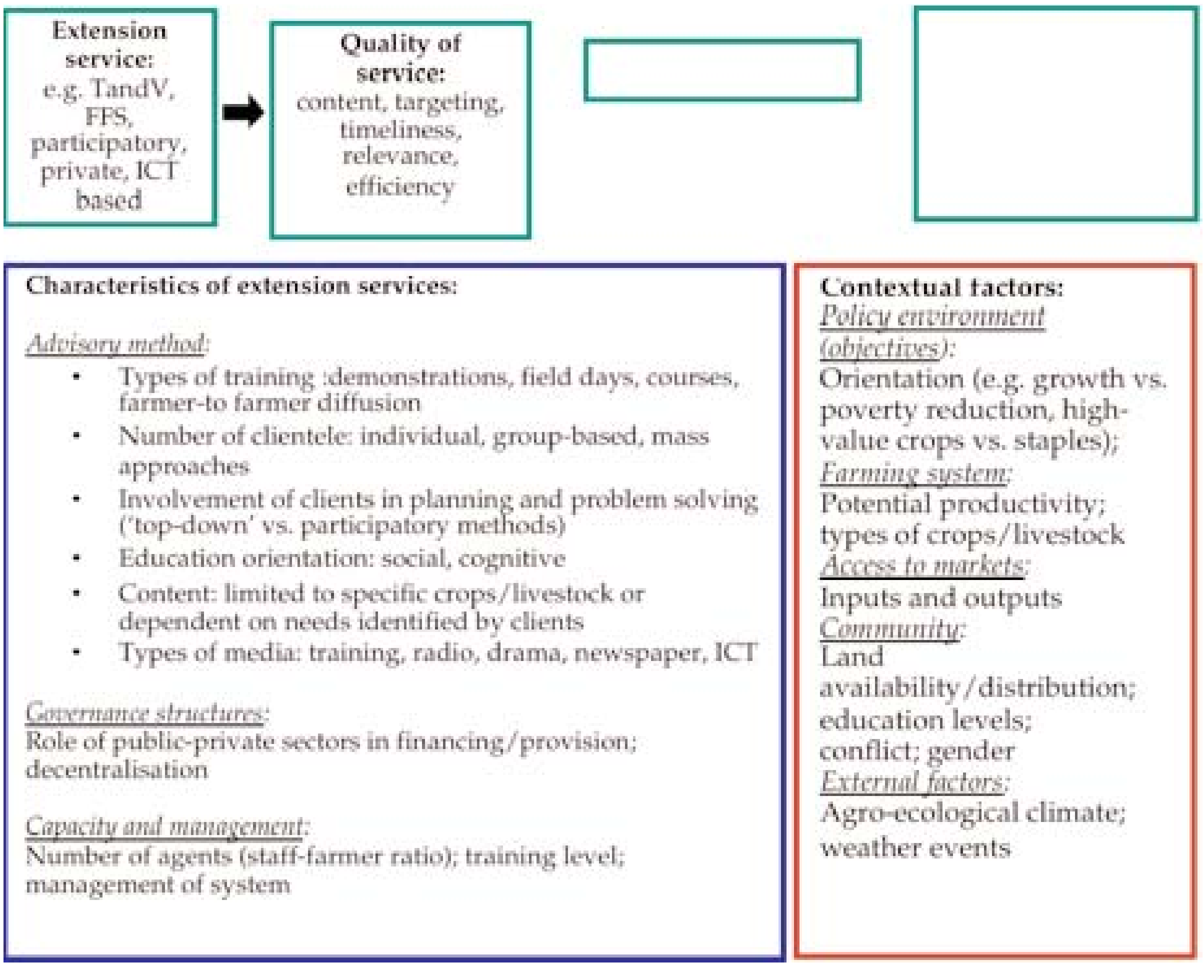
and knowledge are important factors for accelerating agricultural development through appropriate production planning, adoption of improved seeds and planting materials, suitable cultivation practices and effective post-harvest management and marketing. One of the major problems facing smallholder farmers in developing countries is large-scale information asymmetry which generates inefficiencies in production and can also result in the exploitation of the farming community (Ali and Kumar, 2011).

The importance of making inputs and relevant information available to farmers has long been recognised (Schultz, 1980[31]). Schultz proposed the concept that poor farmers are rational decision-makers who maximise the returns from the resources at their command and respond appropriately to incentives. Farmers may fail to leave poverty but this is typically due to lack of real opportunities and incentives, and not because they are unwilling to innovate and experiment (Schultz, 1980).

1.2 Agricultural extension services for improved productivity and farmer welfare

Extension services are educational provisions that are intended to teach and provide information to enable farmers to use and effectively manage new technology. An effective agricultural extension involves the adequate and timely access by farmers to relevant information on improved technologies that are suitable for the agro-ecological and socio-economic characteristics of the area. Critical for adoption is first of all the availability of such improved technologies for farmers, suitable access to other inputs and resources needed, and profitability at an acceptable level of risk to the

Figure 29 Causal model and characteristics of services and underlying conditions influencing uptake and effectiveness (Source: Birner *et al.*, 2006; Waddington *et al.*, 2010)



[31] Theodore William Schultz was the 1979 winner (jointly with William Arthur Lewis) of the Nobel Memorial Prize in Economic Sciences.

farmers (Anderson and Feder, 2004). Agricultural extension models can take several forms, and are typically supported by governmental and non-governmental organisations. The most common approaches are Training and Visit (TandV), Farmer Field Schools (FFS) and fee for service (Figure 29; Anderson and Feder, 2007; Davis, 2008; Van den Berg and Jiggins, 2007; Wunder *et al.*, 2008).

The dissemination of information and knowledge on improved agricultural technology and practices in Sub-Saharan Africa is a public good and hence the responsibility of government extension services. These however are typically underfunded and understaffed and suffer from poor planning, weak accountability and governance issues (Rivera *et al*., 2001; Anderson and Feder, 2004; Birner *et al.*, 2006; Waddington *et al.*, 2010; Figure 29). The following main challenges undermine the performance of public extension services in developing countries, in particular those targeting smallholder farmers, have been highlighted (Anderson and Feder, 2004):

1 Scale and complexity of services needed. Extension services in developing countries with a predominantly rural population are intended to serve a very large number of smallholder farmers. The problem is worsened by the fact that the information needed for improved productivity is very location-dependent in terms of agro-ecological and socio-economic characteristics, and these vary greatly in different geographical areas. Poor infrastructure (roads and communications) which increase the cost of delivering information and inputs make it more difficult and expensive for extension services to perform well.

2 Effectiveness of extension services is highly dependent on the broader policy environment. Extension management has often little control over complementary policies and institutional actions that determine effectiveness, such as availability of credit and inputs, price incentives, access to markets and human resource development.

3 Poor institutional links between public extension organisations and the institutions responsible for generating the knowledge and information to be disseminated (national agricultural research services, universities and private companies). Research-extension linkages are generally weak and as a consequence research priorities are often not aligned with extension priorities and needs. In addition, there are almost no formal systems in place to feed back information and knowledge generating from farmers into research and extension institutions to improve breeding and extension programmes.

4 Difficulty in attributing impact to specific extension initiatives because of the large number of factors that affect farm productivity in complex ways. Impact evaluation typically involves measuring the relations between extension activities and farmers' knowledge, the adoption of improved technologies and practices and farm productivity and profitability. However, it is very difficult to account for other factors known to influence farmers' decisions such as the weather, price constraints and the influence of other sources of information. Impact assessment is compromised by methodological difficulties of determining causality and quantification. For example, it is well documented that the level of education attained and belonging to a higher social category with more income and ownership of larger landholdings are all factors that have a positive impact on the quality of decision-making by farmers (Binswanger and Rosenzweig, 1986; Agwu *et al.*, 2008; Taragola and van Lierde, 2010; Ali and Kumar, 2011; Ali, 2012). This problem has very important consequences on the accountability of extension agents both to their managers and to the farming community they are meant to serve. It also affects budget allocation, staff incentives and undermines the drive of extension agents to update their skills and knowledge.

5 Weak accountability: extension agents are not generally held accountable for their performance, a problem related to the challenges described above. Little attention is given to systematic participation by the farming community in problem definition, problem solving and in setting the agenda of extension services and plant breeding programmes.

6 Weak political support and low fiscal sustainability are challenges also related to the inability to accurately measure the effectiveness of extension services.

1.3 Use of ICTs in agriculture
ICTs can deliver information that is important for the development of rural areas in the long term (such as education) and in the short run (such as market information). While ICTs have the potential of delivering real-time information to smallholder farmers at a larger scale and at a lower cost there is limited empirical evidence as to how ICT interventions are enabling the farmers to take informed decisions (Aker, 2010; Ali and Kumar, 2011; Ali, 2012).

In a study of the impact of ICTs[32] for agriculture in India, the availability of information was not found to have a significant impact on socially lower classes across user and non-user farmers, since the quality of decision-making was almost equally poor in this category (Ali and Kumar, 2011). Availability of information and knowledge was found to make a significant impact on the quality of decision-making on most activities across the agriculture supply chain when the user farmers had a moderate level of education (Ali and Kumar, 2011). A more detailed analysis of the data revealed a number of activities across the agriculture supply chain for which the decision-making becomes significantly enhanced with availability of information across most socio-demographic profiles. These activities included the adoption of crop-rotation practices, use of certified seeds, sorting and grading, and market analysis. These four activities should therefore be the core focus of information dissemination of ICT-enabled extension. On the contrary, soil testing, use of bank loans, and record keeping fell within the activities for which availability of information does not seem to make a significant impact on decision-making for poorly educated, low income social groups, perhaps due to resource constraints (Ali and Kumar, 2011).

The implication of these findings is that the farmers with low levels of education are not always able to effectively implement the information being provided to them. A further implication is that extension initiatives should follow a holistic approach and focus on providing integrated solutions to the users with particular attention to the provision of financial services to enable poor farmers to make use of the information made available to them. In addition, the analysis indicates that extension activities should also aim to raise the general level of education of farmers.

1.4 The Digital Learning Platform (DLP)
The DLP is a digital learning system with pedagogic principles developed by the Malaysian Commonwealth Studies Centre (MCSC) and the Cambridge Malaysian Education Development Trust (CMEDT). The platform was developed with the aim of delivering online courses in English language, mathematics and public health to children and adults in Malaysia and India, in collaboration with the Malaysian and Indian Ministries for Education, respectively.

The courses contain a variety of text, images, videos, and audio files, and employ the most up-to-date and advanced e-learning technologies. Over 70 different activity types in the online version of

[32] e-Choupals is a private-sector (Indian Tobacco Company) lead ICT initiative designed to provide mostly transactional services. The major function of this initiative has been procurement of farm produce directly from the farmers and providing complete information solutions to the farming communities. It is based on the model of the traditional choupal system where farmers gather in a group mostly in the evening to discuss village level issues (Rao, 2008; Ali and Kumar, 2011).

the DLP represent a broad range of pedagogical approaches to engage learners effectively in developing a variety of skill sets. These include student-centred, active, project-based and inquiry-based learning. Live tutorial support, model answer feedback and self-assessment are all part of the DLP. The DLP has been carefully designed to be as learner-centred as possible and adaptable to reflect user-location, reaction and changing circumstances and learning needs. Each course can be given its own visual style or 'skin' to give it a unique 'character' tailored to specific audiences.

A key strength of the DLP is its Content Management System (CMS). The CMS has been designed and developed to work dynamically, making it simple for non-technical administrators to provide learning and translation data, administered and updated in 'real-time'. Due to its ease of use, a course containing a glossary, culture notes, feedback files, help files, subtitles for videos, and voice-overs for learning extracts can be created in a short amount of time. The front-end application supports both multilingual course content and system text so the application interface can be provided in a student's native language. In addition, since each learner has a unique username, the DLP will collect user information, such as login details, number of activities attempted and the score obtained in tests. This information is not intended to 'catch out' the student, but rather to allow an ongoing improvement of the course to ensure the content is suitable for, and clear to, the target audience.

The DLP can be made available on a large scale but at a low unit cost to all types of learners with different levels of computer literacy through a range of media, including online via a desktop computer or laptop, or as an application on smart-phones and tablets. A key question is whether an application originally developed as a language learning tool for relatively advanced learners can be adapted to successfully deliver agricultural extension information to smallholder farmers in Sub-Saharan Africa.

2 Preparatory work (see Appendices C and D).

The first stage of the project (July to mid-September 2013) aimed to:

i map out existing programmes and initiatives that focus on training small holder farmers in East Africa, with a focus on Uganda and Tanzania
ii establish contact with key organisations to explore the development of a joint programme
iii develop a work plan with key partners for pilot projects to assess how the DLP is best deployed as a teaching tool in a rural setting in Sub-Saharan Africa

This part of the study consisted of a combination of desk research and contacting key individuals and organisations on the ground leading to several reports (Appendices C.3.3.1, C.3.3.2 and Appendix D.3.3.3, D.3.3.4, D.3.3.5).

Two collaborations were established to run pilot projects:

1 A joint project with Farm Africa (farmafric.org) to deliver a modular course on sesame production and marketing in northern Tanzania (Case Study 1).
2 A joint project with the Agricultural Biotechnology Support Project II (ABSPII- http://absp2.cornell.edu/; Case Study 2). ABSPII is a Cornell University led and USAID-funded consortium of public and private sector institutions that ABSPII focuses on the safe and effective development and commercialisation of bio-engineered to boost food security, economic growth, nutrition and environmental quality in Africa, India, Bangladesh and the Philippines. ABSPII's partners in Uganda include the National Agricultural Research Laboratories, Uganda, funded by USAID.

3 Case Study 1 – Farm Africa's sesame production and marketing project

3.1 Introduction

Farm Africa's Sesame Marketing Project (Tanzania Smallholder Sesame Production and Marketing Project Phase II – TSSPMP II) aims to reduce poverty and improve food security through increased household income of smallholder farmers through the cultivation of genetically improved sesame varieties (Lindi white, Naliendele and Ziada) in the Babati District of Tanzania.

Farm Africa has delivered training to agricultural extension agents, 'trainers-of-trainers' (contact farmers) through workshops and demonstration farms. Information provided include advice on selecting the right improved varieties to suit the farmer's requirements, improved agronomy practices to maximise potential yields, post-harvest handling and marketing. The project's mid-term review by independent consultants estimated that knowledge disseminated by TSSPMP II had improved sesame productivity resulting in increased harvests from 602.57 tonnes of sesame produced in 2011 to an estimated 1 191 tonnes in 2012 and a concentric diffusion pattern of adoption experienced beyond the targeted 4 600 adopter farmers.

A key question is whether this success can be expanded to include a larger number of farmers not only in Babati district, but also in other areas of the country or the region suitable for sesame production. While the traditional method of training using demonstration plots is effective, it is expensive both in terms if personnel and inputs required for setting up and maintaining the plots (seeds, fertilisers and chemical pest and disease controls). A scale-up of this initiative would hence require a training method with a low unit cost per farmer, and with a level of quality that is independent on the number of farmers trained. A digital learning application available on mobile devices and operational offline would fulfil both of these requirements.

3.2 Stages in sesame production

The cycle of sesame production in northern Tanzania starts late in October/early November with production planning followed by the preparation of the land for sowing. The process can be divided in three broad set of activities: production planning, cultivation and post-harvest management and marketing (Figure 30A).

Before deciding whether to cultivate sesame, farmers should have performed an analysis of the market to determine where they intend to sell the produce, the current market rates and have made initial arrangements for storage and bulk selling, for example in a cooperative or warehouse. Planning production involves a number of decision making activities for the farmer:

1. determining whether the land available to him/her is suitable for sesame cultivation;
2. deciding on the size of land to be planted with sesame;
3. deciding whether their land requires specific soil and water conservation interventions (such as terracing), and seeking expert advice for implementation;
4. determining monetary and labour investments required for production and potentially obtaining credit;
5. choosing the method of land preparation and securing farm machinery if needed (usually hired);
6. deciding the time of planting;
7. and selecting and sourcing the seed variety most appropriate for the site or time of planting (i.e. early versus late maturing for a late or early sowing, respectively).

Cultivation following the recommended practices for increased productivity also involves a number of activities. Farmers should plant in lines (as opposed to the traditional method of seed dribbling) with

Figure 30 The Sesame Production and Marketing Digital Course

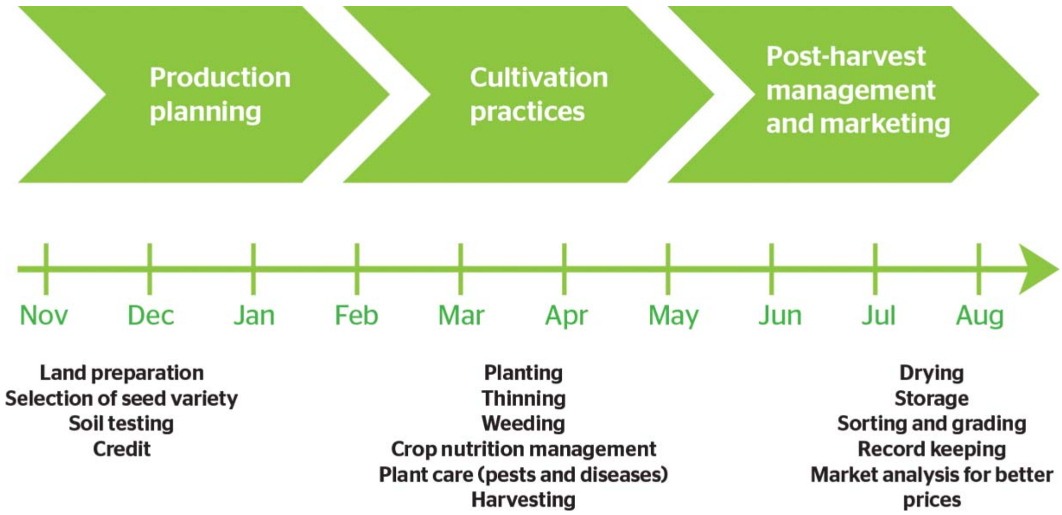
A Stages and activities in sesame production and marketing in northern Tanzania (top)

B Modules of the digital sesame production and marketing course (2nd)

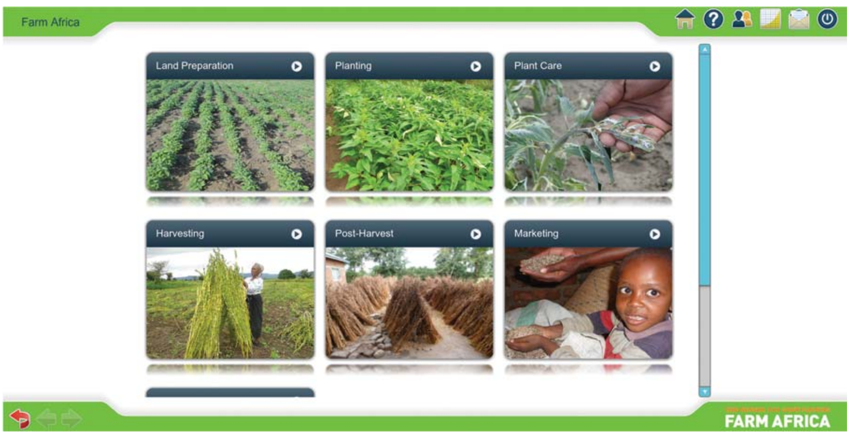
C The English online version of the course (3rd)

D A learning extract of the course (bottom)

A

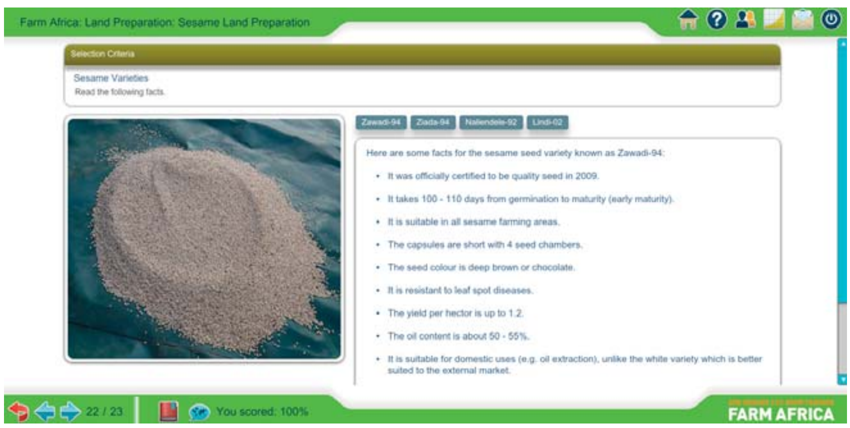


B



C

D



the correct spacing between plants which varies according to the seed variety used. Thinning is also very important as too many plants competing for water and nutrients in the same hole will increase water stress and susceptibility to pests and diseases and severely reduce overall yields. Soil fertility needs to be managed, adding organic of inorganic fertilisers in the correct dosage. Farmers also need to remove weeds, two rounds of weeding being required in the season, and look after the health of the plants, potentially spraying the field against pests and diseases. Yield is also maximised by harvesting the crop at the right time: too early and not all the sesame seed will have grown to full size, too late and some of the seed will have been scattered and lost.

The final stage in the cycle is composed by post-harvest management practices and marketing. Activities in this stage include selecting the right conditions for drying and storing seed; seed grading; and any arrangements for selling the produce, such as bulk sales.

Failure in a single one of the activities will potentially compromise the whole harvest with very significant losses in terms of missed revenue and financial and labour investments. The availability of relevant information and the ability to make use of it will have a strong impact on decision making along the process for a successful harvest.

3.3 Project objectives

The main objective of this study was to determine whether the DLP could be used to strengthen the sesame production and marketing project and offer a viable solution for scaling up the training to reach a much larger number of farmers. To achieve this aim, two parallel activities were carried out:

1. a modular course on sesame production was produced in English and Swahili, and
2. further development work on the DLP was undertaken to optimise it as an offline application in smart tablets for learners with no previous IT skills.

Farm Africa contributed to the pilot project by hiring a new member of staff in Babati for nine months; purchasing eight smart tablets; and supporting local travelling and training costs for the project, including the incentives for conventional and tablet trainers (Section 3.6).

3.4 Methods

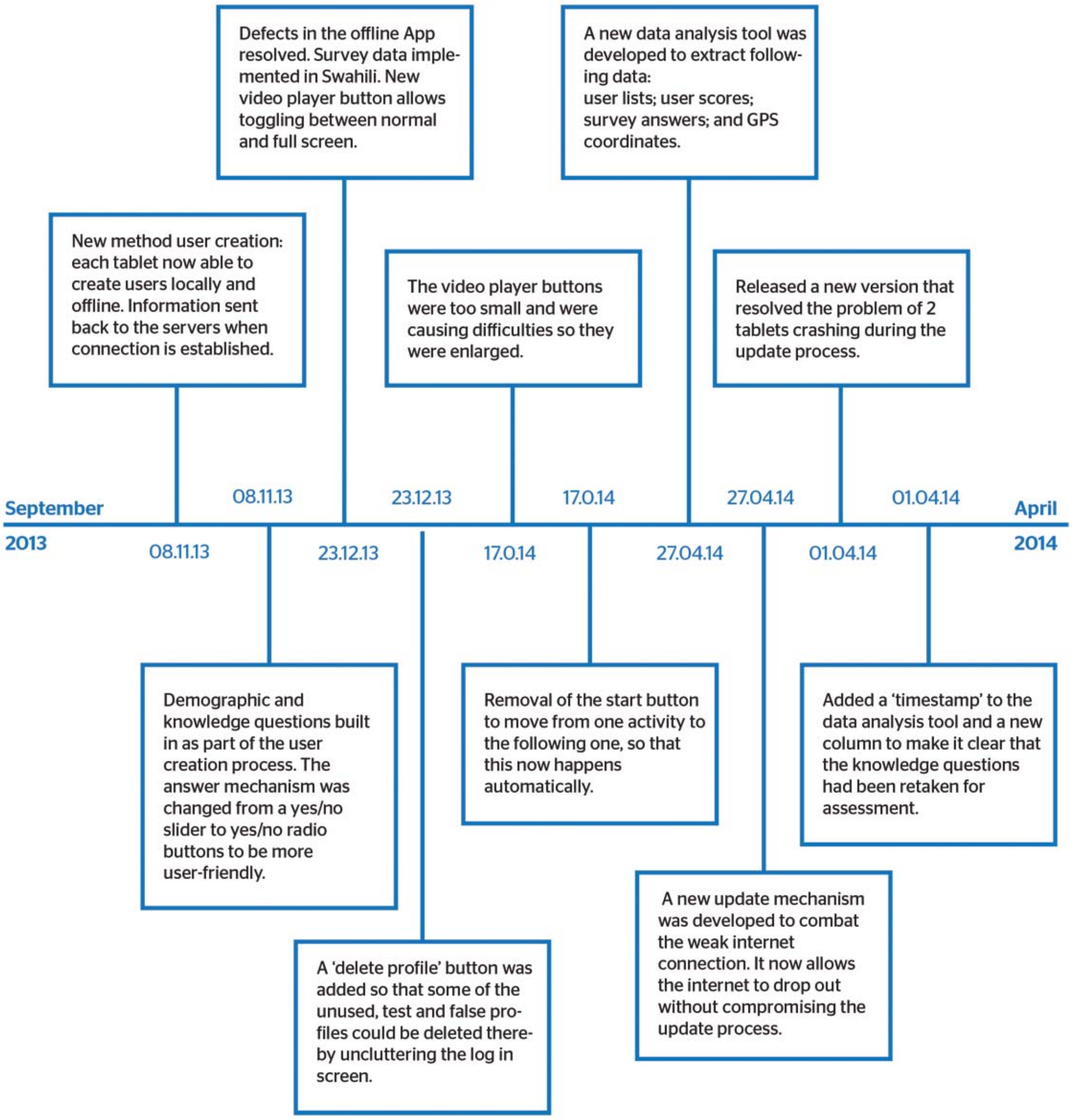
Production of the sesame production tablet course

The content for the course was provided by Farm Africa's sesame agricultural extension specialist, Tumaini Elibariki. The information was split into modules (Figure 28 B–D) corresponding to discrete stages in sesame production. Photographs, audio materials and short video files were produced in Babati to supplement textual information. A number of interactive learning activities and self-tests were designed and included in the modules (see Appendices C.3.3.1 and 3.1.2).

3.5 Development of the back-end of the offline learning platform application

While the DLP was initially designed to be used by high school children and young adults on desk-top computers, the sesame production and marketing course required the application to work offline on smart tablets or phones. One of the principal focus of the development team since February has been the application update and data upload procedures. The intermittent nature of the connectivity in the field has presented a unique set of challenges. The initial design of the application was to background push the uploaded information (principally scores and survey data) whenever a network was available. This strategy was revised when it became clear that local conditions meant that there would be no opportunity to update aside from when the tablets were returned to the hub.

Figure 31 Changes to the offline DLP application for improved functionality: September 2013–April 2014



There have been four major releases in the last quarter, version 0.9.914 on February 19th, version 0.9.916 on March 13th, version 0.9.917 on April 3rd and version 0.9.919 on April 13th (Figure 31). Each of the 4 major releases have, as well as improving the networking and synchronisation, incorporated the defect resolutions from the other projects using the DLP with numerous fixes and enhancements across the whole application. Work is in progress for a new release which will further improve the feedback from the update process. It will also offer native support for the x86 CPU in a Galaxy Tab 3 which will offer a significant performance increase. Changes executed are summarised in Figure 29

3.6 Dissemination of the course

Smart tablets with the digital course were distributed to 'Community Agents' (CAs), farmers in charge of delivering the course to members from the community. Two villages in Babati province were chosen as 'tablet' villages with five CAs each. In parallel, traditional training was carried out in two 'control' villages, Endagile and Magara (Figure 32). In these, five farmers were trained in a classroom

Figure 32 Location of the study sites
Left: Map showing the location of Babati, Tanzania
Right: Location of the ‘tablet’ villages (Kakoi and Endadoshi) and control villages (Endagile and Magara) villages

setting on sesame production and were provided with advice and inputs (improved seed and fertilisers) to set up a demonstration plot in their village.

The criteria for choosing the tablet and control villages were as follows:
1 located within one hour drive from Babati town;
2 with suitable soils and agronomic conditions for sesame production;
3 no previous training on sesame production had been carried out by Farm Africa in the village;
4 a small number of farmers cultivated sesame, but without using improved seed varieties and following traditional production practices (for example, using seed scattering instead of line planting with recommended spacing between plants); and
5 all villages were isolated from each other.

CAs and farmer trainers in the control villages were selected with the following criteria:
1 farmers actively involved or interested in pursuing sesame farming;
2 willingness to attend training sessions; and
3 willingness to share information with their peers.

CAs and farmer trainers were mixed gender groups and included youth. The process of selection of CAs and farmer trainers in control villages involved first meeting the District leaders to inform them about the initiative and obtain their approval. A district agricultural extension agent then accompanied Farm Africa staff to all the villages for the project inauguration. The delegation was met by village government leaders, who assisted in the identification and selection of CAs. Two tablets with the course were also provided to two government agricultural extension workers for them to become familiar with the tablet course and assist in the supervision of CAs.

The modules, in Swahili, were released sequentially at the appropriate time of the year to enable decision making (Table 7). Training on sesame production in the conventional villages was provided in a classroom approximately at the same time as new digital learning modules were released.

Access to the digital learning course requires registration after which each learner is allocated a unique username. Learners could log-in when it suited them to view new material or to revisit past modules. The administration system kept a record of when a learner had accessed the course and also a log of the activities completed, scores obtained and the geographic location of the tablet at the time. This information is sent back to the administration system as soon as the tablets are connected to a Wi-Fi.

CAs were remunerated with $50/month with the target to each train 50 other farmers from their community. Remuneration for trainers in the control villages was provided in the form of improved seeds and inputs (fertilisers and pesticides).

Table 7 Structure of the digital sesame production course and dates of release to farmers (in Swahili)

Modules of sesame digital sesame production course	Date released
Module 1 Land preparation	Nov 2013
Module 2 Planting	Dec 2013
Module 3 Plant care	Jan 2014
Module 4 Harvesting	Apr 2014
Module 5 Post-harvest management	May 2014

Table 8 Number of households engaged in sesame production before and since the start of the project

	Households engaged in sesame farming		
Village	2012–13	2013–14	Total
Magara (control)	34	57	91
Endagile (control)	47	62	109
Kakoy (tablet)	63	137	200
Endadoshi (tablet)	81	329	410

3.7 Project evaluation

A first assessment of the impact of the course was establishing the number of households that switched to sesame production since the start of the training in both tablet and control villages with the assistance of local government and extension officials (Table 8).

The data show that the number of farming households that started cultivating sesame increased by nearly four times in Endadoshi, while increases recorded were much smaller for the rest of the villages. Increases were also lightly larger in the second tablet village (Kakoi) compared to the control villages. While the tablet training is undoubtedly a factor in the effects observed, other factors also played an important role. The weather is one of these: rains in Endadoshi were early this year, which meant that farmers sought improved seeds for planting when stocks were ample. On the contrary, the supply of improved seeds had ran out by the time rains started in Kakoi, later in the season. These observations indicate that while access to information is crucial, a set of enabling factors needs to be in place to allow farmers to make use of the knowledge they have gained. Training programmes, although extremely valuable, are not able to substitute for critically needed policies to improve smallholder farmers' access to finance, inputs and markets.

In order to assess the retention of knowledge, the baseline knowledge level was estimated in both tablet and control villages prior to the start of the training. A questionnaire was included at the start of the digital course for the tablet villages after registration. The same test as a paper questionnaire was carried in each of the two control villages by the trainers with 50 randomly selected farmers. Knowledge retention will be assessed in both control and tablet villages in the next couple of months, after all the training modules have been delivered and at the end of the sesame growing season.

Socio-economic data of learners[33] were also collected prior to the start of the training for project evaluation purposes in both tablet and control villages (Appendix D.3.3.3). The questionnaire was part of the digital learning course and the learner agreed to complete it before accessing the course

[33] Consent to use the data for the project evaluation was obtained from the farmers..

Figure 33 Development and delivery of the sesame production tablet course
From left to right, top down: Tumaini Elibariki updating the learning application in the Wifi hub in Dareda; William Mwakyami handing over the tablet to a young CA; Tumaini training CAs on the use of the tablet; CA training a fellow farmer in Kakoi village, with Max Marcheselli and Sixmund Stephen; Goodness Mrema (Farm Africa) training farmers with the tablet; Gorowa traditional dancing group incorporates recommendations on improved sesame production practices in their performance during the Tablet Project Farmers Field Day (April 2014).

material for the first time. In control villages this information was collected in a questionnaire at the same time as the baseline knowledge survey (Appendices D.3.3.4, D.3.3.5).
Also a part of the evaluation was a visit to four randomly selected farms in all villages, carried out in April 2014 to assess the uptake of recommended practices by farmers (Appendix D.3.3.6). Practices assessed included:

- correct land preparation;
- use of improved seed varieties;
- timely planting;
- proper spacing of plants, in rows;

- weeding and thinning;
- recommended control of pests and diseases.

While the number of farms visited in all villages is too small to allow making any comparisons, a number of trends were identified (see also Appendix D.3.3.6):

- not all the farmers had used improved seeds, but this was mostly due to limited availability, rather than the farmers' decision;
- only one farmer (in Magara village) had broadcasted the seeds instead of line planting.
- while most farmers used the recommended spacing, heavy rains (which move the seeds in the soil) followed by drought had affected the distribution of mature plants;
- thinning practices were often not implemented, which indicates that these need to be emphasised more in the course. Farmers perhaps consider it a waste of inputs to remove plants. High density increases competition for nutrients susceptibility to pests and water stress, and lowers yields, so thinning is a very important practice and it should be stressed more;
- pests and diseases were a problem in most farms, with farmers being unsure on how to deal with the situation, therefore greater emphasis needs to be provided on plant care in the course. Advice on which specific chemical controls is needed;
- weather had severely affected all locations: rains have been late and inconsistent. The use of conservation agriculture will be increasingly important as Africa is predicted to be particularly affected by climate change. Example of conservation agriculture practices include no-till or reduced tillage practices so as to increase the moisture-retention ability of soils. Burning of waste should be discouraged, favouring instead heat composting;
- due to lack of labour one farmer had failed to do the second recommended thinning, which will result in significant reductions in yield. A module of basic business skills for agriculture promoting budgeting for all activities and planning production so as to maximise returns on inputs used and minimise waste would be very beneficial.

4 Case Study 2: promotion of hybrid banana in northern Uganda, Agricultural Biotechnology Support Project II

4.1 Introduction

Uganda's National Agricultural Research Organization (NARO) has identified the most serious constraints to banana production to be Black Sigatoka, nematodes, bacterial wilt, and weevil infestation. Conventional banana breeding relies on crossing cultivated varieties with wild relatives followed by extensive backcrossing—a long, laborious and often unsuccessful process. Genetic engineering offers the possibility to achieve the desired resistances in the appropriate banana germplasm in a more precise and timely manner. Since 2000, the Government of Uganda has contributed funds to the International Network for the Improvement of Banana and Plantain (INIBAP) to carry out a programme on its behalf to address three constraints of banana production, Black Sigatoka, nematodes, and weevils, through the use of genetic engineering. The USAID/ABSPII banana biotechnology project builds on this work to accelerate the development of Uganda's biotechnology programme.

A sub-project of the banana biotechnology initiative (Sub-project 5) entails trainings and demonstration farms to promote hybrid banana adoption in northern Uganda, to generate a demand for innovation and so 'pave the way' for the adoption of improved hybrids and GM bananas when these become available to farmers. This programme recognises the importance of education/ communication activities to precede the release of controversial yet potentially very beneficial technologies.

Figure 34 Production of videos for the hybrid banana course
From top clockwise: 1. Technician in the NARO model plot for hybrid technology dissemination. 2. Left to right: technician; Wilson Okorut; technician; Pamela (Acholi translator) and Tilahun Zeweldu before video shooting. 3. Wilson Okorut and Pamela.

Northern Uganda has been chosen for several strategic reasons: 1) the conditions are suitable for banana production, and there is high market demand for the crop, also for export to Sudan and Rwanda; 2) the area is recovering from conflict and displacement, and since bananas require relatively little labour, fruit all-year-round and are both cash and food crops they have the potential of increasing food security in the region; 3) banana is not a typical crop in northern Uganda, so the incidence of pests and disease is low; 4) since farmers are not used to a specific banana landrace in terms of taste, the fact that hybrid bananas taste a little different should not be a problem (this is an important constraint in the Central Region).

4.2 The hybrid banana production and marketing course
The course on banana hybrid production was officially launched on January 28 and 29th in Gulu, northern Uganda, to coincide with a local training on entrepreneurship for banana producers, and with the participation of local officials and the media in addition to farmers groups.

The course (Figures 34 and 35) consists of the following modules or chapters:

1 Welcome to ABSPII;
2 Hybrid Bananas;

Figure 35 Screenshot of the banana production and marketing ABSPII course

3 Banana Farming;
4 Site Selection;
5 Land Preparation;
6 Soil Fertility Management;
7 Water Management;
8 Planting;
9 Plantation Management;
10 Intercropping;
11 Crop Protection;
12 Harvesting and Post-Harvesting;
13 Marketing.

Two female extension agents each have a tablet for teaching farmers in a collective learning setting. The course has been translated to Acholi. Due to constraints in resources we did not plan a large-scale release or an evaluation programme at this stage. This case study will therefore not be discussed further.

5 Discussion

We developed and delivered a modular course on sesame production and marketing to smallholder farmers in northern Tanzania. The preliminary results of the impact of the training using the DLP and smart tablets appear largely positive, and these will be confirmed at the end of the growing season by a more structured evaluation process for the retention of knowledge and adoption of recommended practices.

It is important to note that for the pilot study the production of the training material (including text, video and audio files produced locally); on-going development work to the back-end of the application for offline deployment in rural areas with no electricity or connectivity to the Internet; and the delivery of the course to farmers all happened in parallel. Many of the problems encountered due to the time constraints of the pilot would not affect a scale-up project to the same extent since there would be more time for preparation.

The logistical problems encountered were significant and involved collecting the tablets for recharging and also travelling 30 km to the nearest WiFi connection for uploading new content and technical upgrades to the application. Solutions for these problems have been identified and include the use of solar panels for recharging in the villages and the use of tablets with SIM cards to use mobile Internet for updating. For future scale-up activities, a completed course could be saved directly into the hard drive of tablet/smart phones at the factory stage and this would increase the stability of the application and reduce the frequency of updates needed.

Another challenge identified by the pilot is the importance of developing a functional reward system for contact farmers (CAs) that ensures the sharing of the information with other members of the community is maximised, and at the same time does not cost the project so much as to make it unviable on the longer run. Business models to promote sustainability of the project need to be considered.

Despite all the challenges encountered and the resource and time constraints in which the pilot project operated, the DLP delivered on time to smallholder farmers a course containing locally developed information material (hence directly relevant). The pilot was also extremely useful in identifying what changes need to be made to the production and delivery of the course to increase impact and make it a viable option for a scale-up. Critically, the DLP could now be deployed to teach a large variety of subjects, and is now better prepared to face the most challenging conditions in terms of infrastructure (or lack of infrastructure, rather)

6 SWOT analysis

Strengths

- The DLP is suited to deliver high quality information in a timely fashion, so that this is available at the time when it can influence decision-making processes.

- The information can be developed locally, in the learners' native language, and easily incorporated into the administration system to be immediately available (provided learners have access to the Internet). Locally generated resources/teaching materials increase both the relevance of the material provided, and help promote local ownership of the course. Materials generated by farmers (e.g. farmer-to-farmer videos) which are very effective for sharing information, can be easily incorporated.

- The ability to make extensive use of video and audio files is particularly suited to cultures with an oral tradition of learning and sharing of information, and for targeting users with low levels of literacy, which is a pervasive problem in rural communities in Sub-Saharan Africa, especially for women.

- The information is available in discrete modules for repeated viewing, which was identified by farmers taking the course as a key benefit. During traditional trainings information about a long process (e.g. sesame farming from land preparation to value addition) is often provided at once and only one time, which makes it very difficult for learners with very limited formal education to remember or note down information that may be useful for them in a later stage.

- The flexibility provided by the DLP for learners to access the information when and where it suits them is particularly beneficial for women, especially when the consent of their husbands is required to assist training or when other household and family chores prevent them assisting day-time training.

- A key strength of the DLP, and one not offered by any other training method, is the ability/requirement to individually register learners, and to record demographic, socio-economic information and their baseline level of knowledge. This allows to over time: 1) track progress, not only in terms of knowledge retention, but also 2) determine whether this knowledge translates into increased productivity, and ultimately also into higher benefits for the household.

- The ability to register users offers another major advantage to the DLP: content can be tailored to address information demand of specific users' groups, taking into account factors such as geographic location, agro-ecological conditions, level of formal education, and gender issues. Therefore the DLP is to our knowledge the only available teaching platform that allows steering away from the 'one fits all' solution to teaching. Since the most dispossessed and vulnerable proportion of the population is very hard to reach and assist by traditional training efforts, this is an extremely valuable asset.

- The availability of socio-economic and demographic information of users, and knowledge of how it changes over time, is particularly important in cases when increased family labour involvement in production of a cash crop, such as sesame, could detract time and energy for other economic and domestic activities, in particular for women, and perhaps affect time at schooling for children. There is significant evidence that increased commercialisation of agricultural products controlled by male farmers can in fact harm women and negatively impact on household welfare even if productivity and profitability increase at the village/region level (Negin *et al.*, 2009; Njuki *et al.*, 2011; Fisher and Qaim, 2012; this current project as reported above). The DLP could be effectively used to monitor household effects and design interventions to mitigate these potential adverse effects.

- The level of education of learners and their socio-economic status is know to affect the ability of learners to put into practice new knowledge and information received. The DLP is suited to teach any subject, so could be deployed to strengthen areas of knowledge that would increase the ability of farmers to apply the information they receive. Basic business skills, numeracy and literacy courses, and nutrition and public health are examples of subjects that could be simultaneously deployed. It could also be used to promote economic diversification, key to sustainable increases in productivity and welfare.

Weaknesses

- A current weakness of the system is that it relies on expensive hardware for delivery; smart tablets or phones. Therefore the service it provides is only available to resource-poor farmers through an intermediary who needs to receive a financial incentive to share the course. This problem will be lessened with time as mobile devices become cheaper and more widely available, and if the DLP becomes more widely available on devices not provided by the project, perhaps as a paid downloadable subscription at a price farmers can afford. In the meantime, a good reward plan for contact farmers, which is effective, sustainable and appropriate for large numbers of trainers needs to be implemented.

- Another weakness is reliability on a reliable source of electricity and to at least occasional access to the Internet to update the application with new content and technical improvements, and to gather user data.

Opportunities

- Ability to target a wide variety of learners with information packages to suit specific needs, and which not need to be confined to a given topic, providing the opportunity to deploy an integrated approach addressing several barriers to the successful implementation of new knowledge. The DLP allows estimating the success of specific interventions to a greater degree compared to other methods of training.

- The DLP is also suitable for sharing indigenous knowledge and farmers' innovations, increasing the relevance and potential impact of the training.

- Packaging important information in a way that it also provides entertainment to communities is a very powerful tool for promoting change, as proven by the song competition on sesame production organised during the Farmer Field Day in Endadoshi in April 2014 (Appendix C.3.3.1; Figure 33) and the DLP is be very suited to incorporate this type of information.

Threats

- While access to information and knowledge is critical for improved productivity, information by itself is not sufficient. Fair access to land, finances, improved seeds and inputs, enabling infrastructure and markets opportunities are all essential for improved economic welfare. Any training project, and one making use of the DLP would not constitute an exception, needs to be aligned and supported by initiatives and policies that address simultaneously all the barriers to increased productivity along the value chain.

- Changes to weather patterns and decreasing and unreliable rainfall, are a major threat to agricultural production, especially in rain-fed areas such as northern Tanzania. Should the rains fail and result in significant loss in production the effect for farmers would be devastating. While sesame production is a very profitable enterprise with stable and growing markets, the financial and environmental risks associated with focusing on a single economic activity should not be underestimated.

7 References – Appendix D.3.3.7

Associated projects (Appendix D.4.0)

The purpose of these independent studies funded by the Foundation was to examine the barriers to progress and the socio-economic implications of introducing new plant breeding technologies which are relevant to smallholder farmers. Overlaps between these 14 projects and #15625 Can GM crops help to feed the world? may provide synergistic opportunities and an appointee was identified to facilitate these possibilities. In every other respect the management and reporting of the outputs and outcomes of the individual projects rests with the Foundation.
Facilitator: Patrick J. Mitton
Period of role: October 2012 – June 2014

1 Introduction

Soon after the granting by the John Templeton Foundation of awards to 14 Project Leaders at various universities and institutes in the autumn of 2012 (Annex X), it was decided by the Foundation to amend the grant for this project to make an award to Patrick J. Mitton for the purpose of facilitating potential synergies between the Project Leaders and their project activities. The role of facilitator would encourage connectivity between Project Leaders and thereby add greater value to the sum of the individual awards granted to the Project Leaders. In many cases, despite working in similar fields, the Project Leaders did not personally know each other prior to the facilitation activity. Participation in connectivity was not a requirement of the grant awards to Project Managers, however all 14 elected to participate.

2 Key milestones of activity

2.1 Face-to-face meetings with Project Leaders and Managers:

At the outset to the facilitation process, Patrick Mitton who has long experience of working in this area held face-to-face meetings with Project Leaders. This activity helped to ensure a buy-in to the connectivity between the Project Leaders, investigate potential common ground and encourage the synergy processes. These initial meetings took place in the period October 2012 to February 2013.

The meetings took place on site at the individual universities or institutions. This process enabled participation by the majority of team members assigned to each project. For example, nine team members attended the Rutgers University meeting. In most cases, the USA Project Leaders ensured Faculty Heads participated at some stage during the meetings and visits. This proved significant in promoting at high level the intent and support by the John Templeton Foundation to the award-winning universities.

The initial round of Project Leader face-to-face meetings took place at eight USA universities, two UK universities, one Canadian university and the Center for Strategic and International Studies, Washington, DC.

2.2 Project Leaders' workshop I

The 1st Project Leaders' workshop was held at the conference centre of the National Institute of Agricultural Botany in Cambridge UK on 16–17 May 2013. This event was instigated to bring all Project Leaders together and create the opportunity to share project processes to date. All 14 Projects were represented. Project summaries outlining project intent and methodologies were provided to all participants before the meeting and, together with media presentations of project summaries, were added to the B4FA website.

The networking opportunity of the workshop ensured the creation of ongoing relationships for the remainder of the project period.

2.3 Local workshop held at University of Missouri

A 'local' US workshop was held at the University of Missouri, Columbia MI on 14 October 2013. The purpose of the workshop was to bring together four of the Project Leader teams based in Missouri. These were the teams headed up by Project Leaders, Professor Willi Meyers, Professor Glen Stone, Professor Harvey James and Professor Claude Fouquet. Presentations were given by the four project teams to the agriculture faculty at the University of Missouri, Columbia MI, on their project activities to date. The event attracted c.50 members of the faculty, mainly post-graduates plus members of teaching staff and local press. Summaries of projects and project outcomes to date were presented followed by positive and lively Q and A sessions. The event was a public manifestation of the synergy links between projects – in this case four of the funded projects, as well as a positive platform for the John Templeton Foundation funding initiative.

2.4 Project Leaders' workshop II

The 2nd Project Leaders' workshop was held in Cambridge UK on 9–11 April 2014. All 14 projects were represented at the workshop. The intention of the workshop was to extend the synergy development across projects in relation to common ground and to investigate the complementary aspects of the project outcomes to date. Two of the 14 projects have reached their conclusions by this stage (CSIS and ISAAA). All others were within the final months of their grant period but were able to present indications of project outcomes (albeit waiting peer review). Each Project Leader gave a 15 minute presentation, followed by a 15 minute Q and A session. The B4FA Africa Journalist Fellows, participating in a UK visit at the same time, were invited to hear the Project Leader presentations for those projects with a particular focus on Africa (eight of the 14 projects).

As part of the synergy process and workshop outputs, an internet file hosting site (Dropbox), accessible for all the Project Leaders, was set up to file presentations and project outcomes.

3 Project Reports

3.1 Center for Strategic and International Studies, Washington, DC.

(see also Appendix C)

The first project to report outcomes took place on 21 October 2013. This being CSIS in Washington DC, who held the event at their new office in Washington, DC. The event attracted an audience of Washington influencers of c.55 participants and was attended by Patrick Mitton. CSIS published three reports in relation to their John Templeton Foundation grant, namely:

- *Trade and Tribulations, An Evaluation of Trade Barriers to the Adoption of Genetically Modified Crops in the East African Community*, By John Komen and David Wafula, May 15, 2013;
- *Pathways to Productivity, The Role of GMOs for Food Security in Kenya, Tanzania, and Uganda,* Oct 17, 2013
- *Biosafety of GM Crops in Kenya, Uganda, and Tanzania,* By Judith A. Chambers, Dec 17, 2013

The public launch of the CSIS Project Reports was important as it represented the first of the public presentations of project outcomes to date. Webinar filming of the Report launch took place enabling outreach to the extensive network of influencers and contacts known to CSIS. The Report was given positive coverage in the Washington Post.

3.2 The International Service for the Acquisition of Agri-biotech Applications (ISAAA)

ISAAA is the second funded project to have released reports, including DVDs, entitled Cadres of Change: Transforming Biotech Farmers in China, India and the Philippines. The ISAAA team shared their findings with the Project Leader group during the April 2014 Cambridge workshop.

All remaining projects have established timetables for outcome reports and launch conferences commencing August 2014 inwards.

4 Recommendations

The synergy activity has clearly indicated that encouraging all 14 Project Leaders to participate in the connectivity across the group has produced tangible benefits and added value to the John Templeton Foundation awards to the individual projects. Patrick has developed a close liaison and held regular meetings in person and electronically with all Project Leaders and with the B4FA team. This has proved invaluable in ensuring that maximum benefit was gained from this investment.

A number of the projects will continue beyond the end-date of grant #15625 because of the late start of certain projects for administrative reasons. However, a key outcome has been the significant interest by group members, their teams, stakeholders in genetics and various observers, into the outcomes of the funded topic: '*Can GM Crops Help to Feed the World?*'

The idea has emerged that collating project summaries of key points and outcomes into a publication in readily accessible form for a non-specialist readership would have significant interest across a wide range of stakeholders. Such a publication would add significantly to the investment of the initiative to date, would bring together complementary aspects of the project topics and outcomes and satisfy a real desire for a comprehensive summary in a book format. It is therefore a recommendation of the synergy initiative that such a publication is produced.

Overall comment

Implementation by communication has been the theme of this project in response to the Big Question posed by the John Templeton Foundation – *can GM crops help to feed the world?*

African countries could certainly benefit from the adoption of GM crops as has been demonstrated in the uptake in many developing countries where the expansion of these crops has been striking and in some cases, as in Argentina and Brazil, the most rapid of any technology in the history of agriculture. Continental, regional and local differences, however, are critically important and should not be overlooked. Visual demonstrations of the suitability of GM crops to particular environments, as well as conventionally bred crops, will go far in persuading smallholder farmers of benefits and risks as illustrated in the Innovation project (Activity 3.1). In addition, as signatories of the Cartagena Protocol on Biosafety, most African countries will be required to put in place appropriate and effective legal measures and administrative structures or measures in order to implement the Protocol effectively, as outlined by the Academy of Science of South Africa (2012) to which members of the B4FA team contributed (www.assaf.org.za). Only in this way could GM crops be grown commercially.

At the instigation of Dr Jack Templeton, and after extensive peer review, Project #15625 was initiated to see how advances in science and technology, and genetics in particular, could help to lift smallholder farmers out of the poverty trap. His father and founder of the John Templeton Foundation, Sir John Marks Templeton, was deeply interested in how scientific progress and breakthrough discoveries in various scientific fields could be beneficial to humankind. He once wrote, *'should we be overwhelmingly grateful to have been born in the 20th century? Is the slow progress of prehistoric ages now speeding up? It seems that centuries of human enterprise are now miraculously bursting into flower. Is the development of human knowledge accelerating? Is the present generation reaping the fruits of generations of scientific thought?'* [Possibilities, p. 51].

The fruits of scientific endeavour are clearly evident in the advances in the genetics of plant breeding by both conventional and transgenic technologies. They are bursting upon a new phase of global food production and offer some prospect of being able to feed a burgeoning human population of about 9 billion by 2050. All technologies will be needed and our project which spanned a period of only three years corresponded with the publication of several notable reports about progress in reducing poverty worldwide and to which the scientific enterprise has contributed in no small measure. However, of all the continents Africa has fared less well. A 2014 account – *Africa Progress Report 2014, Grain, Fish, Money: Financing Africa's Green and Blue Revolutions* – emphasised that agriculture must be at the heart of transformation in Africa. '*Most Africans, including the vast majority of Africa's poor, continue to live and work in rural areas, principally as smallholder farmers. In the absence of a flourishing agricultural sector, the majority of Africans will be cut adrift from the rising tide of prosperity*'.

Today there is a greater area of GM crops grown in developing countries than developed nations. Four plants make up most of the world's GM crops, five countries lead the world in GM crop production, most major crops in the USA are GMOs, and commercial seed are in few hands. Yet in Africa there is a continuing hesitation about moving in this direction and this is what we have addressed in various balanced ways. Project #15625 has focused on four African countries and how the implementation of scientific and technological advances in the genetics of plant breeding could contribute to a flourishing sector.

Communication with the general public and with smallholder farmers through the media is a crucial element. Our highly successful programme with Media Fellows has far exceeded the contractual requirements of the original proposal making the financial investment much more rewarding (Activity 2). Media Fellows have progressed immensely in their knowledge and experience of genetics and plant breeding, and the issues surrounding GM crops. They have displayed great confidence in dealing with scientists, NGOs and the general public probing with well-informed questions and writing with insightful comment and interpretation. They have more to do in terms of quality of writing (but that can also be levelled at some in developed countries). They have become an invaluable, essential and prolific cohort for radio, print and television in Africa in topics previously sidelined by editors – but no longer. The evidence for this observation is well documented in this and subsequent volumes of the full report.

A second element of communication has been achieved through the publication of the book *Insights* soon to be followed by its successor *Viewpoints*. The use of this model has attracted much interest being designed specifically as accessible to a wide range of readers from farmers' leaders to academics, policy makers and decision takers. The essays have also been recorded in an African voice and are freely available for radio transmission by radio stations, a major route of communication in African countries.

Personal stories of Africans and citizens with long experience of living and working in Africa include that of Joe deVries in his essay on building a seed industry –
'... *there is still nothing, for me, equal to the thrill of seeing a smallholder farmer reaching out to receive a new batch of improved seed. That moment always seems to bring a sparkle of hope to the eyes of even the most downtrodden farmer… farmers would line up for hours, often in the rains of the new planting season, some of them clothed in tatters and some of them wrapped only in pounded tree bark, since their clothes had long since rotted away after years of being trapped in the bush. But the gleam in their eyes when they walked away with the seed packs we were distributing always betrayed them: somehow there was hope within the despair brought on by unspeakable hardship: These were people who had lived and died by the viability of the seed all their lives. They understood the magic that could be embodied within a seed, and they had new seed!'*

Or Media Fellow and senior journalist, Michael Ssali, who changed his view of GM crops – *'Major food and cash crops, like in the case of Uganda, are set for total extinction unless quick steps are taken to reverse the situation. This is an issue that gives ordinary African farmers like my wife and I sleepless nights, worrying about our dwindling crop yields. The efforts to apply biotechnology for genetic transformation of the crops to make them disease or drought resistant must be encouraged and supported'.*

A major objective of our project was to explore the use multiple channels by which to inform on the one hand smallholder farmers of new options, and on the other hand policy makers of how they might move ahead to take advantage of the new science and technology. As mentioned previously, the introduction of the appropriate national legislation is crucial, binding and essential if new GM crops are to be adopted and used safely and beneficially to address the nutritional needs of impoverished communities, and to lead to trade outlets both within the continent and beyond, so alleviating poverty. It is not just a matter of making GM seeds freely available but recognising that there are international protocols to respect in order to achieve legality and credibility.

The B4FA programme aimed to establish a sustainable effect rather than short-term returns that fade when support has disappeared. The Media Director formed a programme that provided ongoing

support and direction for Fellows over at least two years. The B4FA website was constructed, and has attracted much attention, with its up-to-date news and interviews, and it has provided invaluable and freely available educational content initially for Media Fellows. For example, it gives information about genes, conventional plant breeding, transgenic technology, F1 hybrids and the latest advances in GM plants (Activity 1). Both *Insights* and *Viewpoints* are freely available for downloading from the website reflecting the B4FA stance of supplying balanced information notwithstanding the challenges of potential environmental and ownership issues surrounding new technologies. A recent essay by Phillip Aerni illustrates that we have not shied away from controversy:
'*... Europe is the largest donor in Africa as well as the largest importer of food from Africa, it has considerable clout in imposing its view on African government and non-government organisations. The result is that institutional capacity development of national agricultural innovation systems have further been 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 thanks to the proliferation of public sector bodies and foreign NGOs*'.

The purpose of three scoping studies as specified in the proposal was to identify future opportunities. Detailed discussion with potential partners resulted in studies of the value of developing innovation farms to demonstrate to smallholder farmers the new genetic varieties of crops and their agronomy (Activity 3.1). Only four African countries have the legal and regulatory structures in place to produce GM crops commercially, and three of our four target countries are approaching that point, albeit slowly. Some have facilities to demonstrate crop breeding as indicated in the NIAB project, but much remains to be done to inform smallholder farmers about GM crops, the necessary agronomic management, and the significance of different environments on varietal success and promise. Failure to attend to this aspect will impede the successful adoption of GM crops in the future and steps have been taken by NIAB International to seek funding for this work.

A second scoping study investigated how smallholder farmers in Africa, who are mostly women, gain knowledge of advances in crop production and seed availability in an environment where advice is provided mostly by male extension officers (Activity 3.2). This is where we heard the voice of the Ugandan smallholder farmer which emphasised perceptions gained elsewhere (see also Appendix 3.3.8). Among many other observations, radio communication was essential. Decisions about the use of new crop varieties depended more on a critical evaluation of their attributes relative to those of traditional varieties rather than an assessment of the genetic improvement method used. Making available balanced information on controversial technologies was essential to allay fears and concerns of the farming community. Communication on biosafety institutions and their responsibilities was a priority.

A third scoping study showed the possibilities of a new ICT invention that belongs to the Cambridge Trusts, MCSC and CMEDT, and that may assist smallholder farmer with GM crop management and production (Activity 3.3). This pilot study indicated that smallholder farmers could learn the rudiments of a Samsung tablet for use in the field with downloads of information about plant breeding, quality seed, harvesting and marketing. Numerous practical challenges came to light but the study showed sufficient promise that our partner, Farm Africa, is keen to collaborate further and seek funding to discover ways to scale up the necessary training of tens of farmers to thousands. They have asked that we become partners in a future project. Lessons learned from such a study could help to make GM crops for smallholder farmers a reality once they are approved.

We have benefitted immensely from partnering with internationally recognised institutions (NIAB, University of Reading and Farm Africa) as envisaged in our original proposal. The outcomes of the scoping studies met our intentions, as can be seen from the content and recommendations of the reports above, and the scene is now set for the continuations of these studies and the translation of genetical science into practice.

Among the highlights of this project have been invitations to participate in the African Technology Policy Studies Network conference in Addis Ababa, 2012, The World Food Prize, Des Moines, Iowa, October 2013, the pan-African Journalists conference in Addis Ababa, Ethiopia, 2013, the American Association for the Advancement of Science, Chicago, February 2014, and to hold an Africa celebratory event at the House of Lords, April 2014. In addition, there have been numerous invitations to present special lectures and seminars, as well as consultations with experts in the area about methodologies and outcomes.

Finally, a parallel international competition arranged by the Foundation in the area of genetics resulted in the funding of 14 associated projects focused on the socio-economic, socio-political and other challenges associated with the introduction of GM crops globally. Recognition at an early stage that there were potentially valuable synergies to be gained by linking this latter category to the head project resulted in specific support for a Facilitator. This decision has reaped many rewards not least for Media Fellows but also in bringing together a substantial body of research which, together with that of the head project will lead to significant publications including a book in readily accessible form after the model of *Insights* and *Viewpoints* in the foreseeable future.

The strategy of this ambitious project was to aim for far-reaching outputs that had an impact on an audience ranging from the poor smallholder farmer to political leaders. Reasons for this strategy are exemplified in the apt expression of Templeton-Prize winner Archbishop Desmund Tutu when addressing members of his congregation – 'Christians shouldn't just be pulling people out of the river. We should be going upstream to find out who's pushing them in'.

Appendices A, B, C and D.

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