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A Strategy for Banana Research and Development in Africa

banana 2008

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A strategy for banana research and development in Africa

A synthesis of results from the conference **banana2008**, held 5–9 October 2008, Mombasa, Kenya

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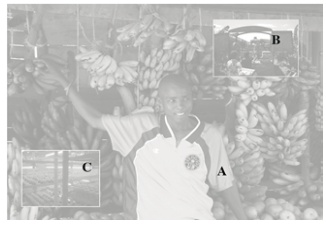
Cover Photos

A. Roadside stall in Mto Wa Mbu, Tanzania, selling locally grown dessert bananas. Photo by Piet Van Asten, IITA.
B. Organically grown bananas are loaded in Sudan for one of the first export shipments to the Middle East. Photo by Wayne Hancock, Bioversity.
C. Commercial tissue culture growth room at Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya. Photo by Thomas Dubois, IITA.



was organized by the International Institute of Tropical Agriculture

in partnership with Bioversity International, the Forum for Agricultural Research in Africa, the International Society for Horticultural Science and the Kenyan Agricultural Research Institute

Endorsement

This strategy document is the product of expert opinion and detailed discussion among diverse stakeholders in Africa's banana sector. FARA considers that it provides an informed and realistic foundation for prioritizing banana research and development. The goal is to use this strategy to invigorate the commercial banana sector in a sustained manner, while protecting food security, by encouraging partnerships that increase the impact of research and adoption of technological innovations. FARA encourages international, regional and national public research organizations, development agencies, NGOs and the private sector to use the priorities set out herein to guide their activities and investment decisions.

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Profiling country perspectives: Victor Mshani (Ministry of Agriculture Malawi), Chair; Judith Francis (CTA), Convener

Tracking adoption and impact: Mgenzi Byabachwezi (Agricultural Research Institute (ARI) – Maruku), Chair; Jeremias Gasper Mowo (African Highlands Initiative), Convener
Turning farmers into business people: Sunday Akinyemi (National Horticultural Research Institute (NIHORT)), Chair; Martha Niko-Stambuli (Consultant), Convener

Strategy

Plenary (building strategies to mobilize the banana sector): Fen Beed (IITA), Chair; Paula Bramel (IITA), Convener
Dessert banana: Steffen Abele (IITA), Chair; Charles Staver (Bioversity International), Chair; Sue Canney (Pipal), Convener
East African highland banana: Fen Beed (IITA), Chair; Inge Van Den Bergh (Bioversity International), Chair; Sarah Hearne (IITA), Convener
Plantain: Stefan Hauser (IITA), Chair; Richard Markham (Bioversity International), Chair; Warren Wilson (Intersol Group), Convener
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Anne Moorhead performed the tasks of editing, design and layout for this publication. Anne is a freelance science writer and editor, and can be contacted at annemoorhead@gmail.com.

Useful websites

banana2008 conference website: http://www.banana2008.com

Source of:
- peer-reviewed publications published in *Acta Horticulturae*
- short strategy document
- presentations during the event
- pictures of the event

Open Access Banana Platform (interactive geo-based banana database): http://banana.mappr.info

Banana production data from FruiTrop: http://passionfruit.cirad.fr

Banana production data from FAO: http://faostat.fao.org

Abbreviations and acronyms

AATF	African Agricultural Technology Foundation
ACP	African, Caribbean and Pacific (group of countries)
AGRA	Alliance for a Green Revolution in Africa
AMF	arbuscular mycorrhizal fungi
ARC-ITSC	Agricultural Research Council – Institute for Tropical and Subtropical Crops
ARI	advanced research institute
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASPS	Agricultural Sector Program Support
ASTI	agricultural science, technology and innovation
BACCESA	Banana Consortium for Central, Eastern and Southern Africa
BanMMV	banana mild mosaic virus
BARNESA	Banana Research Network for Eastern and Southern Africa
BBrMV	banana bract mosaic virus
BBTV/D	banana bunchy top virus/disease
BDD	banana dieback disease
BecA	Biosciences eastern and central Africa
BSV	banana streak virus
BVX	banana virus X
CAADP	Comprehensive Africa Agriculture Development Programme
CABI	Centre for Agricultural Bioscience International
CARBAP	Centre Africain de Recherches sur Bananiers et Plantains
CGIAR	Consultative Group on International Agricultural Research
CIALCA	Consortium for Improving Agriculture-based Livelihoods in Central Africa
CIAT	Centro Internacional de Agricultura Tropical
CIRAD	Centre de Coopération Internationale en Recherche Agronomique
CMV	cucumber mosaic virus
COMESA	Common Market for Eastern and Southern Africa
CRS	Catholic Relief Services
CTA	Technical Centre for Agricultural and Rural Cooperation
DGDC	Belgium Directorate General for Development Cooperation
DR Congo	Democratic Republic of Congo
EAPIC	East African Phytosanitary Information Committee
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FHIA	Fundación Hondureña de Investigación Agrícola
GM	genetically modified
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Institut National pour l'Etude et la Recherche Agronomique
IPDN	International Plant Diagnostic Network
IPM	integrated pest management
ISAAA	International Service for the Acquisition of Agri-biotech Applications
ISHS	International Society for Horticultural Science
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KARI	Kenyan Agricultural Research Institute
MUSACO	Réseau Musa pour l'Afrique Centrale et Occidentale
NARES	national agricultural research and extension systems

NARO	National Agricultural Research Organization (Uganda)
NEPAD	New Partnership for Africa's Development
NGO	nongovernmental organization
NIHORT	National Horticultural Research Institute (Nigeria)
PIBID	Presidential Initiative on Banana Industrial Development (Uganda)
RLS	Reliance Life Sciences (India)
SADC	Southern African Development Community
WECARD	West and Central African Council for Agricultural Research and Development

List of figures and tables

Introduction

Nobody knows who brought bananas to Africa or exactly when, but it is estimated to have been between 2,000 and 6,000 years ago, long before the arrival of other important crops such as maize and cassava. What is certain is that bananas were adopted with enthusiasm, both as a vital staple food and, more recently, to generate income. Today, people in the highlands of Central Africa eat more bananas than anyone else in the world, some deriving up to 35% of their daily calories from the crop. In the lowlands of the Congo Basin, farmers grow a greater diversity of plantains than anywhere else. Bananas are a crucial money-earner for smallholder farmers, mainly sold in nearby markets as fresh fruit or fermented or distilled into alcoholic beverages. In the Great Lakes areas of East Africa alone, the crop is worth some US$1.7 billion annually to 14 million resource-poor farmers. Moreover, these tough perennial plants are the backbone of many farming systems, protecting the soil from erosion and surviving floods, drought and civil conflict, to recover quickly and provide people with food when they need it most.

Yet the banana sector in Africa remains relatively static, compared to other crops in Africa and compared to banana enterprises in other continents. The vast bulk of production is carried out by smallholders, who face challenges such as declining soil fertility, pests and diseases, pre- and postharvest losses and poor market linkages. Only a small minority of African banana farmers are organized for effective production or marketing of their crop and to ensure that their voices are heard. When they do succeed in selling their fruit into distant markets, the majority lack adequate information on prices and, selling through an inefficient chain of intermediaries, receive only a small fraction of the price paid by consumers. Most of the bananas produced in Africa are sold as perishable fruit, with high loss of quality and value along the way. The news is no better for export markets: although Africa grows almost one-third of the world's bananas, it accounts for only 4% of world trade in the fruit.

The economy of Africa is dominated by agriculture, and this sector therefore offers a route to equitable development. Research has shown that economic growth generated in agriculture is much more effective than growth generated in other sectors in benefiting the poorer section of the population. Paradoxically, the underdevelopment of the banana sector means that it has huge potential as a driver of development. With a large production base already in place to supply local needs, the groundwork is laid for bananas to respond to increasing demand from expanding markets both in the region and internationally.

Relatively modest investments in banana marketing, processing and production could greatly expand income opportunities for banana farmers. Products made from bananas and banana plants include beer, wine, juice, sauce, mats, handbags, envelopes, postcards, flour, soup and breakfast cereals. Bananas are increasingly being targeted for commercialization not only within Africa, but also for lucrative and emerging markets such as the Middle East. Recently, large international banana producers have announced plans for long-term strategic investment in sub-Saharan Africa, with a view to shifting banana production for European markets from Latin America to Africa.

So what will it take to transform this ubiquitous but neglected crop into an engine of economic growth for Africa? This is not a simple challenge. It must be seen against the backdrop of a rapidly changing world – growing population, rapid urbanization, fluctuating food prices, evolving consumer preferences and an unpredictably changing climate are just some of the factors currently in flux that have significant implications for all food systems. In developing a strategy for banana to promote economic growth, the vital role of banana for food security among the rural poor must not be overlooked. Any strategy for banana

in Africa must address both food security and income generation, but these objectives are potentially in conflict. Food security depends on increasing production while keeping prices low – while improving income often focuses on higher value products.

Recognizing these needs and challenges, a consortium of national, regional and international organizations came together in 2008 to seek ways of mobilizing Africa's banana sector. They organized a conference – **banana2008** – which was the first of its kind in Africa. The conference brought together 400 people from 45 countries, representing the broadest possible range of stakeholders from the private and public sectors, policy makers and development investors, researchers and economists, and of course banana farmers. Using innovative approaches, this conference bridged the gap between research, production, and markets and trade. Linkages, and in particular the importance of public–private sector partnerships, were a high priority, and reflected in the broad spectrum of stakeholders attending, many from non-scientific backgrounds. The meeting made every possible effort to capture the full range of perspectives represented: conveners gathered the key issues from three days of thematic presentations and discussions and on the fourth day participatory methods were used to focus the collective wisdom of all the participants on developing the elements of a strategy for banana in Africa.

This issue of *Scripta Horticulturae* is dedicated to the outputs of the conference. The context is set in a background section, which describes production systems and production figures for bananas in Africa, including problems associated with the availability of reliable data. An explanation of the conference process follows, and a synopsis of presentations further sets the scene for the final section – the strategy. This section uses the results of the participatory sessions to identify the priorities of 'what needs to be done' for each of the main types of banana in Africa – plantains, highland cooking bananas and dessert bananas – and for each market sector: local, regional and international; how to address these priorities; and who (and what partnerships) are best placed to take action. The goal is to create more efficient and equitable market chains, that can deliver economic growth while assuring food security. The strategy aims for achievable change in the short and medium term (the next 10 years), while respecting issues of long-term sustainability. In the longer term, the aim is to change banana production and development from a donor-supported system to one which is sustained by the private sector.

No single organization has the mandate or authority to implement such a strategy. However, the priorities identified should serve to guide and link the actions of stakeholders. The conference generated a unique consensus and essential buy-in from the many and diverse groups involved. It is now up to the private- and public-sector development investors to take the next steps, to build on this momentum and carry forward the enthusiasm demonstrated by the conference participants to transform the banana sector in Africa into an economic driver for development.

Background: banana in Africa

In Africa, bananas have traditionally been grown and consumed locally, mainly as 'starchy staple' foods or fermented beverages. Plantains predominate in the humid forest zone of West Africa and in lowland Central Africa, while East African highland bananas are prevalent in mountainous areas of Central and East Africa. Both are grown by smallholders, mainly in traditional farming systems. Dessert bananas were introduced to Africa much later, during the colonial period, as a plantation crop for export, and continue to be cultivated in this way.

These three systems account for the majority of banana production in Africa. However, the distinctions are becoming blurred as increasing quantities of dessert bananas are grown by smallholders, and as all three types are sold as cash crops in local or more distant, urban markets. Moreover, other types of banana – including dessert 'finger' bananas, Asian cooking bananas, and modern hybrids – have been widely introduced and are becoming increasingly important.

The box 'Banana types and origins' describes in more detail the different types of bananas grown in Africa today. For simplicity, however, discussions in this document focus on the three main banana types – plantain, East African highland banana and dessert banana – and the term 'banana' is generally used to encompass all three.

Production and trade

Plantain

Nigeria and Ghana are Africa's largest producers of plantains, with significant production also in Cameroon, Ivory Coast and Democratic Republic of Congo (DR Congo). While plantains have traditionally been a starchy staple food of rural populations in the humid lowlands, farmers are increasingly selling plantains as a cash crop to urban consumers; with rapid urbanization and the growing prosperity of city-dwellers, demand is outstripping supply, prices have risen and the rural poor are turning to other crops, especially cassava, for food security. Most plantain production is still from low-input, mixed farming systems and productivity in such systems is falling, due to declining soil fertility and increasing nematode problems, associated with increased pressure on land and reduced bush-fallow periods. Attempts to introduce more intensive plantain production techniques from Latin America and to organize a more consistent year-round supply have had only limited success.

A substantial cross-border trade in plantains is developing within Africa but exports outside Africa are negligible. Imports to European countries, to meet demand from populations of West African origin, are being supplied mainly by Latin America.

Only a small proportion (approximately 15%) of plantain production is currently being processed into flour and deep-fried chips, almost entirely for local markets.

East African highland banana

In currently available production data, East African highland bananas are usually combined with other forms of cooking banana, including modern hybrids and traditional cultivars from Asia (and may erroneously include some data on dessert bananas too). However, it is clear that the main production of highland bananas is in Uganda, Rwanda, Burundi, north-west Tanzania, and highland areas of eastern DR Congo, where these bananas provide both the main staple food and the principle source of cash income, being sold to urban centres as a staple food or used as a raw material for preparing beer and spirits. Especially at higher elevations, several cultivars of highland bananas are typically grown together, under intensive management that is usually considered sustainable with local recycling of banana organic matter. Increasing

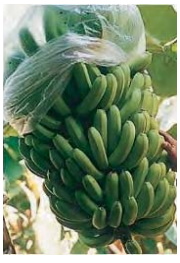
demand for bananas in urban markets, however, has led to concerns about over-intensification of production systems, leading to 'nutrient mining' and increased pressure from diseases.

At lower altitudes, highland bananas are combined with, or replaced by, Asian cooking bananas and modern hybrids. Under these conditions, problems of drought stress, black leaf streak disease, banana weevil and nematodes are of increasing importance, reducing the productivity and longevity of highland bananas. New and more acute threats are presented by Xanthomonas wilt, caused by a bacterium that spread from Ethiopia, through Uganda to DR Congo, Kenya, Rwanda and Tanzania; and banana bunchy top disease (BBTD), caused by a devastating virus that originated in Asia and is now reported in 12 countries of Central, Southern, and North Africa.

Supply chains to urban markets are characterized by numerous links that add little value and result in only a small proportion of the retail price reaching farmers, providing little incentive for investment to improve production. Furthermore, profits are affected by fluctuating fuel prices that affect transport costs. In some countries, such as Uganda, the efficiency of supply chains has been improved by efforts to organize farmers and provide current market information.

Attempts to develop a formal processing sector are at an early stage, with successful industrial brewing of beer in Tanzania and some transformation of bananas into flour and chips in Uganda. There is currently no significant international trade in cooking and brewing bananas from Africa.

Dessert banana



For many years, three countries were Africa's main producers of Cavendish dessert bananas for export: Ivory Coast, Cameroon and Somalia, the two former under humid coastal conditions typical of export banana production in the Americas and the last under dry conditions with irrigation. Dry atmospheric conditions greatly reduce the pressure of black leaf streak disease and with it the need to routinely spray fungicides. Such dryland production is now spreading along major river valleys, for instance in Mali and Sudan. The North African countries also produce significant quantities of irrigated bananas, some in tunnels ('protected cultivation'). South Africa has significant plantations, some organically certified, grown under sub-tropical conditions to supply domestic markets. Numerous countries, notably Kenya, have seen increasing smallholder production of Cavendish bananas to supply urban markets and there is a regional market for dessert bananas, with Mozambique, for instance, supplying South Africa.

Fusarium wilt (Panama disease) is widespread and devastating but usually of sporadic occurrence, while the spreading and increasingly destructive outbreak of BBTD is of great concern to dessert banana producers in DR Congo, Malawi and Zambia.

Access to the European market has been encouraged by preferential tariffs (favouring African producers over Latin American), but these are being removed. The Middle East market is growing, supplied mainly by Egypt and Sudan. Ghana is now increasingly exporting organic bananas through a grower-owned company. Some countries, such as Rwanda and Uganda, have developed limited niche export markets (by air freight) for fresh 'finger' bananas, while several countries are exporting partially dried banana 'figs'.

Banana types and origins

Bananas originate in the Asia-Pacific region, where they are derived from two wild species, *Musa acuminata* and *Musa balbisiana*. Scientists classify the cultivated forms according to the sets of genetic material that they have inherited from each wild parent. Thus plantains are denoted AAB, because they have two sets of chromosomes from *M. acuminata* (A) and one from *M. balbisiana* (B), while East African highland bananas and commercial dessert bananas also have three sets of chromosomes, all derived only from *M. acuminata*, and are therefore described as AAA. The distinction is important because AAA bananas tend to be higher yielding while cultivars with the B genome (AAB and ABB) tend to be more resistant to biotic and abiotic stresses (such as diseases and drought).

Archaeological evidence from Cameroon indicates that plantains were present there over 2,000 years ago. Although domesticated banana and plantain are seedless and are propagated vegetatively by farmers, mutations have accumulated and useful ones have been preserved over generations, with the result that lowland Central and West Africa has become a 'centre of diversity' for plantains, harbouring over 10% of the world's recognized cultivars. Bunches of plantain consist of rather small numbers of long, tapered fruit, loosely spread along the stalk; the fruit remain firm and 'starchy' even when ripe and are roasted or steamed before consumption. Plantains grow relatively slowly and yields are lower than for bananas and for root crops such as cassava; however their preferred taste and texture commands a higher price and tends to compensate for lower yield.

East African highland bananas also have a long history in Africa and numerous subtly different cultivars have been described. They form large bunches of tightly packed fruit. In the highlands of East and Central Africa the fruit are harvested green and cooked while still starchy, providing the main staple food over large areas. Some cultivars have high juice content and are mainly ripened and used for brewing beer or distilling alcohol.

Commercial dessert bananas also have large, dense bunches, providing high yields under favourable conditions. They are eaten raw. The first globally traded cultivar of dessert banana, 'Gros Michel' (which is still grown in small quantities in East Africa as 'Bagoya'), was decimated by an outbreak of Fusarium wilt and has now been almost entirely replaced in international trade by cultivars of the resistant Cavendish. Though the Cavendish cultivars have different names ('Williams', 'Valery', 'Grande Naine' etc.), they are genetically very similar and tend to be susceptible to drought and black leaf streak disease (popularly known as 'black Sigatoka') – and are now under threat from a new variant of Fusarium wilt that is spreading in Asia (known as 'tropical race 4').

Cultivars of a quite different kind of dessert banana, small 'finger' or apple bananas, with an AAB genetic make-up, have also become widely distributed in Africa. They are hard to commercialize because their yield is low, the skin is thin and easily damaged and the fruit are readily shed from the bunch; however, their characteristic flavour makes them a favourite for fresh consumption and the peeled fruit can be partially dried into banana 'figs', which are mainly exported.

A range of traditional Asian starchy cooking bananas – such as 'Bluggoe', 'Saba' and 'Pisang Awak' – have also been brought to Africa in recent decades. These plants are triploids but with a double set of B chromosomes (ABB) and tend to be resistant to disease, drought and other stresses. They are rarely preferred for traditional banana dishes but are often used for making beer, processed foods, or fried snacks in lowland or mid-altitude areas. Pisang Awak has achieved such popularity as a beer banana in East Africa, where it is known as Kayinja or Kisubi, that it is often regarded as a traditional African cultivar.

Finally, the breeding programmes of the Fundación Hondureña de Investigación Agrícola (FHIA), the International Institute of Tropical Agriculture (IITA) and the Centre Africain de Recherches sur Bananiers et Plantains (CARBAP) in collaboration with national programmes have produced a number of new hybrids, triploid and tetraploid, that are vigorous, high-yielding and variously have the characteristics of plantains, cooking bananas or dessert bananas. Though rarely preferred for traditional uses, they are now widely grown for sale in urban markets or for processing. They are adaptable to traditional mixed cropping systems and more intensive plantation production.

Production data, and limitations

Reliable data on the different types of bananas grown, and their production in terms of both area cultivated and yield per unit area, are needed for effective planning in research and economic development. However, these data are mostly lacking. Few countries in Africa have the resources to collect such data systematically, and other sources of banana production data, namely the Food and Agriculture Organization of the United Nations (FAO) and the journal FruiTrop, have their limitations. This section describes and compares current banana production data as published by these sources. It also presents the Banana Open Access Platform, a new tool for collecting, validating and using banana data, and describes its development during and after the **banana2008** conference.

FAO data

FAO presents production data by country, based on information provided by national ministries (Table 1). FAO nominally differentiates between banana and plantain (Figure 1), but circumstantial evidence indicates that the countries supplying the data do not use the same definitions. Banana seems to be produced in most of the African countries, while plantain is predominantly grown around the equator. It is not clear how highland bananas are classified. Some countries are classified as solely producing plantain (Nigeria and Rwanda), while others are classified as solely banana-producing countries (Burundi, Madagascar and Angola). Note the different legends in the two maps, indicating that plantain appears to be grown in larger volumes than banana.

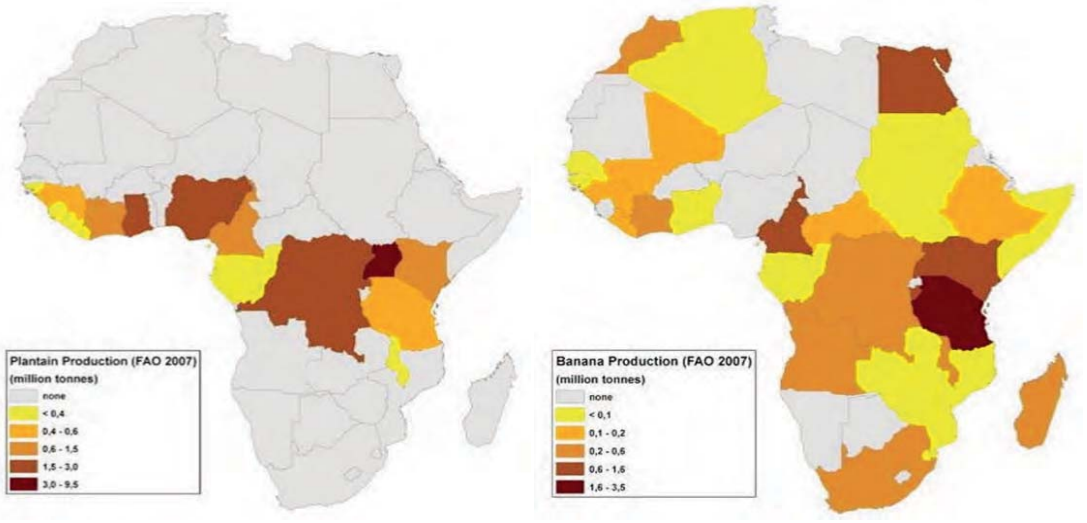


Figure 1. Maps based on FAO data, showing production of banana and plantain in 2007. Source: http://faostat.fao.org.

FruiTrop data

FruiTrop is a monthly journal containing news about trade flows of fresh and processed tropical fruits. FruiTrop presents figures on banana production by country, based on figures from the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), FAO, surveys and other sources (Table 1). FruiTrop differentiates bananas into three types: sweet (dessert) bananas, plantains and highland bananas (Figure 2). Sweet bananas seem to be produced in most countries, with the biggest producers being Cameroon and Egypt. Plantain is concentrated in West and Central Africa, with Nigeria and Ghana the major producers. Highland bananas are concentrated in East Africa although there also seems to be considerable production in West Africa. Uganda and Rwanda are the main producers. Note the different legends in the two maps, indicating that plantain appears to be grown in larger volumes than sweet and highland bananas.

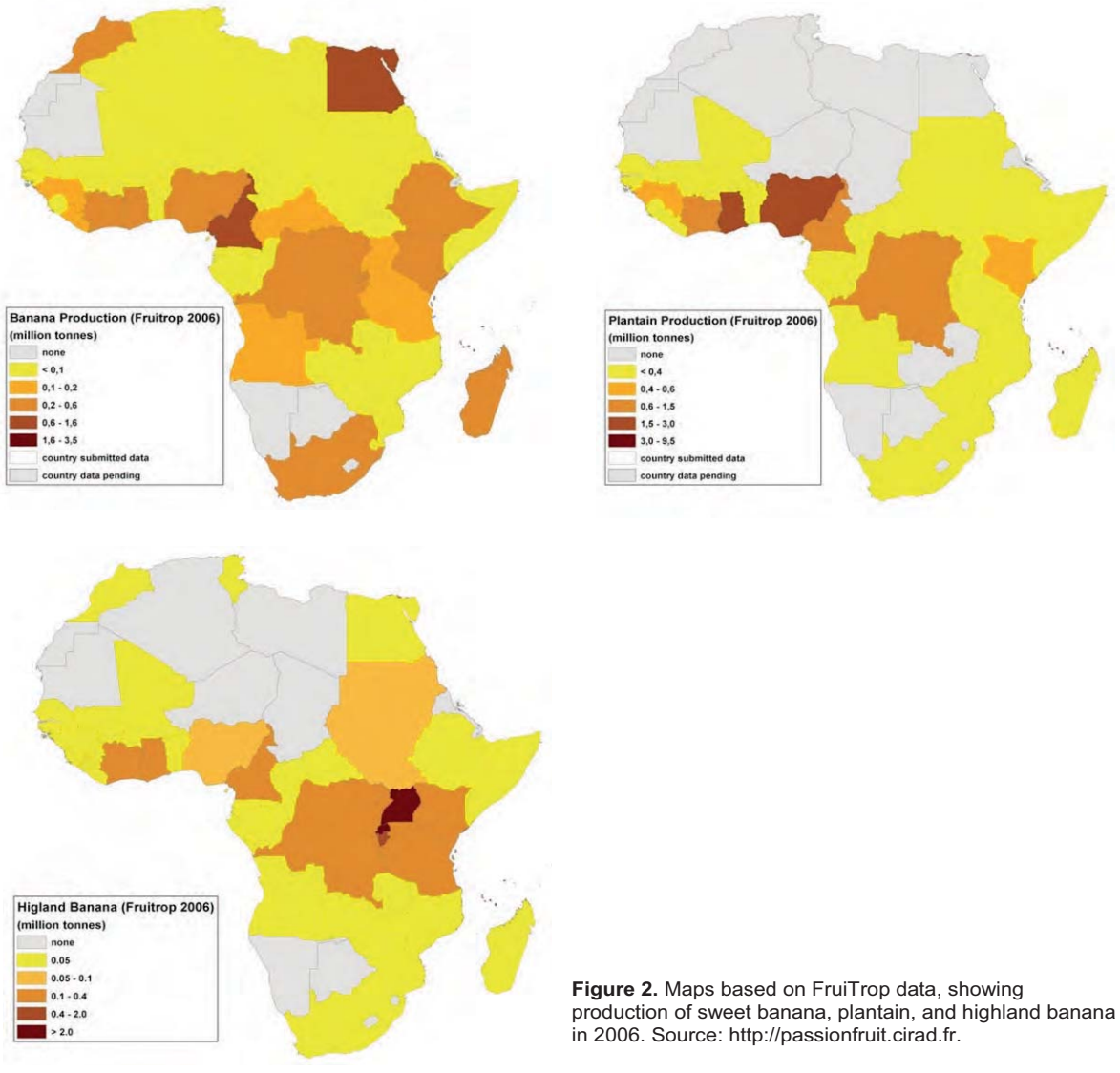


Figure 2. Maps based on FruiTrop data, showing production of sweet banana, plantain, and highland banana in 2006. Source: http://passionfruit.cirad.fr.

Comparison of FAO and FruiTrop data

For comparison, an overview of total banana production from both sources is presented in Figure 3. The map on the left sums the FAO figures for banana and plantain, and the map on the right sums the FruiTrop figures for sweet banana, plantain and highland banana. The FAO map indicates Uganda is the main producer, followed by Rwanda, Tanzania, Nigeria and Ghana. The FruiTrop data suggest that Uganda is the main producer followed by Nigeria and Ghana.

Figure 4 shows the difference between the FAO and FruiTrop data for total banana production. Countries shaded in blue have a higher production according to FAO data, while countries shaded in orange have higher production according to the FruiTrop data. Total African production according to FAO was 36.5 million tonnes in 2007, while FruiTrop has a figure of 31.5 million tonnes in 2006. The fact that the data are for different years could account for some of the discrepancy. Different interpretations of data derived from sources at the national level could be another explanation. The large producers – Uganda, Kenya, Tanzania, Rwanda, Nigeria and Ghana – all have differences of over 100,000 tonnes.

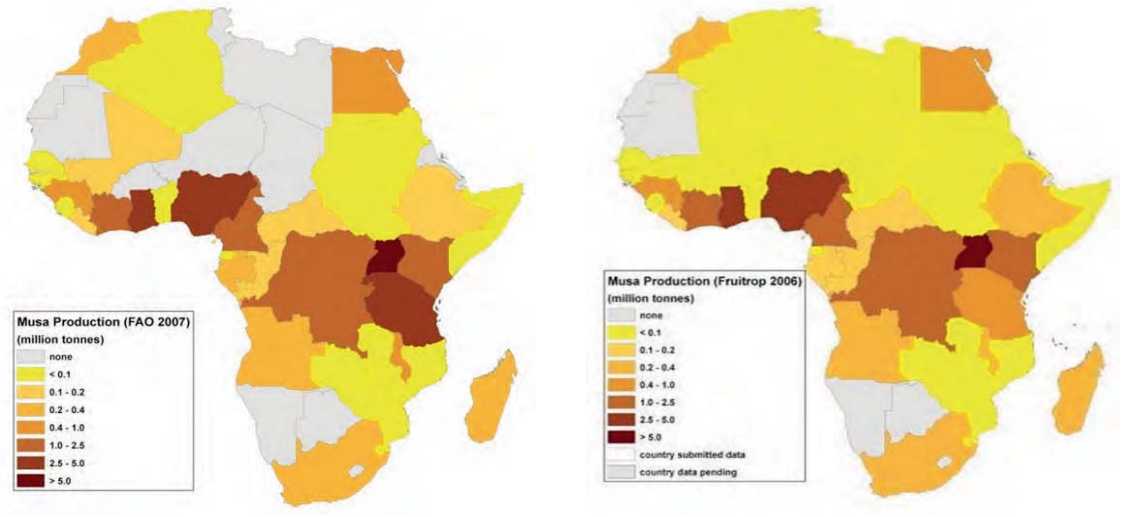


Figure 3. Total banana production as reported by FAO in 2007 (left) and FruiTrop in 2006 (right).

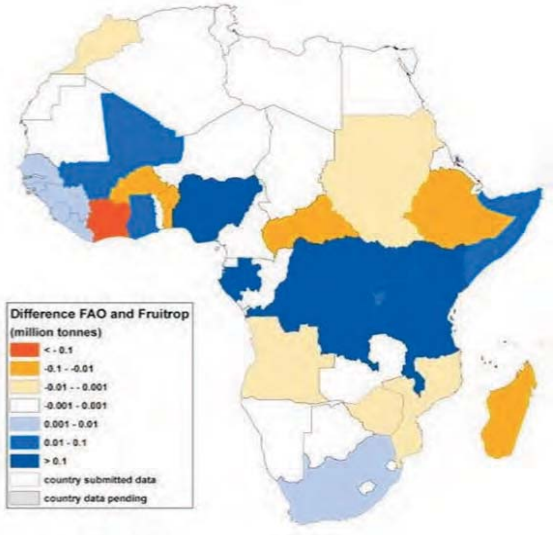


Figure 4. Difference in total banana production according to FAO and FruiTrop. The countries shaded in blue have higher production according to the FAO and the ones in orange have higher production according to FruiTrop. The countries in white have no or very little difference.

Both FAO and FruiTrop publish production data at the country level; however, a more detailed assessment of production areas is needed. The banana production areas (as determined from the Banana Open Access Platform; see Figure 7 on page 10) can be combined with the FruiTrop production data to show intensification levels (Figure 5). To do this, the area (km^2) of the main production zones, as defined by the national representatives, was calculated. The total banana production data from FruiTrop was projected to these areas and normalized by the area, resulting in a grading of intensification. The most intensive production areas are seen in Uganda and Rwanda, while the least intensive areas are in Zambia. A constraint of this procedure is that the production areas provided by national experts cannot be verified and therefore this map should be viewed as only an approximation of the situation.

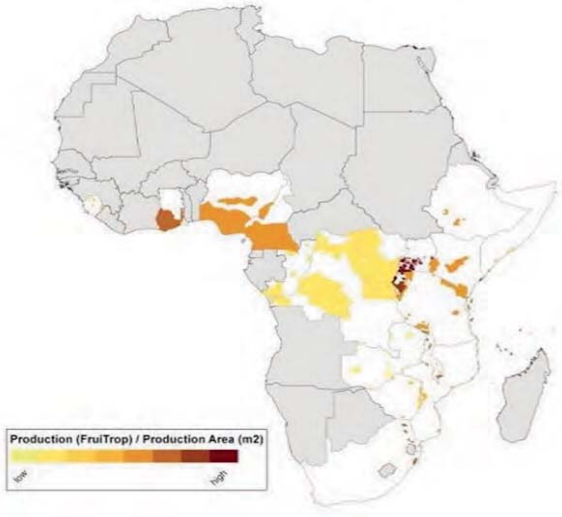


Figure 5. Level of intensification in the main banana growing areas, produced by combining FruiTrop data with banana production areas.

Banana Open Access Platform

At the **banana2008** conference, the International Food Policy Research Institute (IFPRI) presented a map of banana-growing areas in sub-Saharan Africa (Figure 6). The map was produced using IFPRI's spatial allocation model (SPAM), which allocates crop production statistics available for geopolitical units (country or state) to individual pixels. The coloring of the pixels indicates the level of banana production (green = low; red = high). Information used to prepare the map included data on land cover, farming systems, population density, irrigated areas and crop suitability, as well as national production statistics.

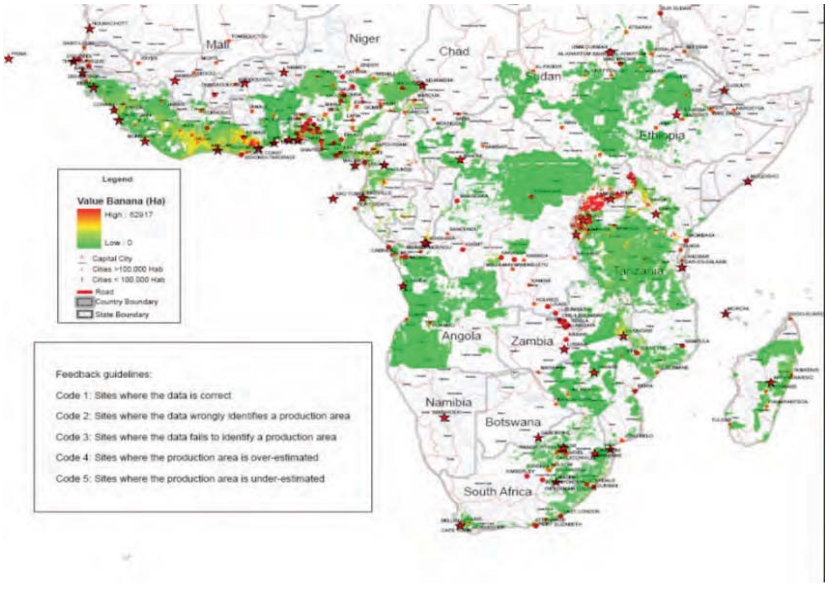


Figure 6. The original IFPRI map presented during **banana2008**. Low banana production areas are indicated in green and high production areas in red.

The map proved controversial because, according to conference participants, large areas were highlighted that are not banana-growing areas. This prompted the 'Musa mapping project', which began at the conference. The many country experts present were asked to mark on a map of their country the most important banana-growing areas. For each area identified, additional information was also requested, for example main cultivars, production systems, and pests and diseases present. By the end of the conference 10 countries had submitted data, and data submission continued after the conference by e-mail.

The need for an open access database where these data could be stored, updated, validated and used to improve knowledge of banana production became apparent, and led to the launch of the Banana Open Access Platform: http://banana.mappr.info. The database can be accessed and downloaded by anyone, either as a GIS shapefile for further analysis or as a customized map. Users can see all entered data, and any changes made by previous users, and can approve existing data, edit existing data, or enter new data.

The tool has been expanded and now includes socio-economic data as well as production data. Areas can be characterized, for example, by people's dependency on bananas, the importance of bananas in relation to other crops, presence of pests and diseases, and production technologies. Maps can also be overlaid with information from other geographic information systems, for example population densities, rainfall and altitude. The Banana Open Access Platform has also been expanded geographically to include Costa Rica.

Figure 7 shows revised banana production areas across sub-Saharan Africa from the Banana Open Access Platform, at January 2011. Figures 8 and 9 demonstrate application of the tool. Figure 8 shows detail of the areas growing the three main banana types across Central Africa, while Figure 9 shows the presence of BBTD and Xanthomonas wilt.

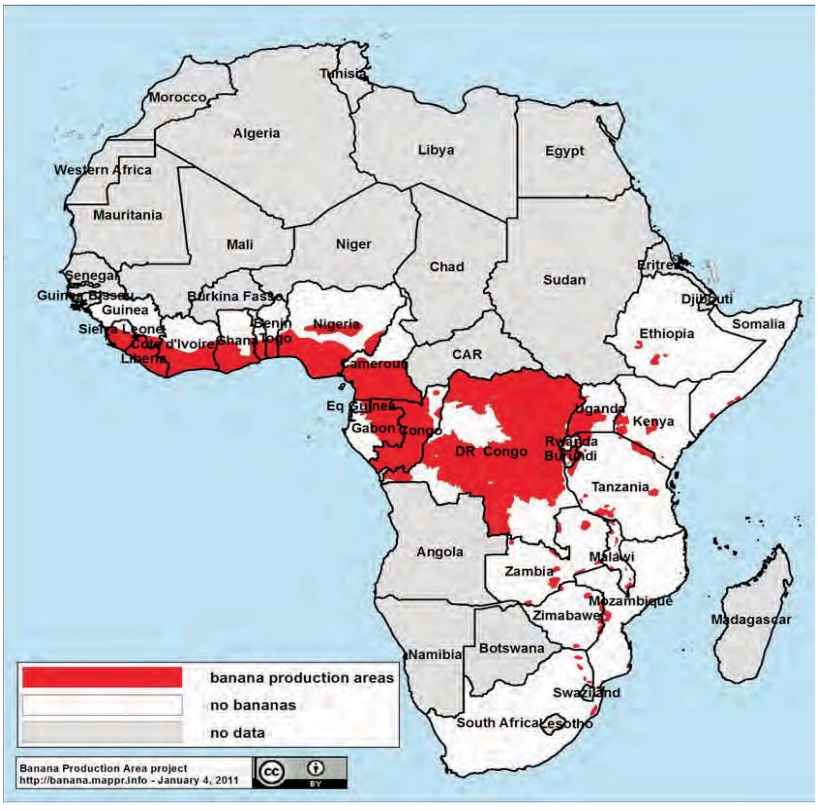


Figure 7. Map produced from the Banana Open Access Platform, showing main banana growing areas.

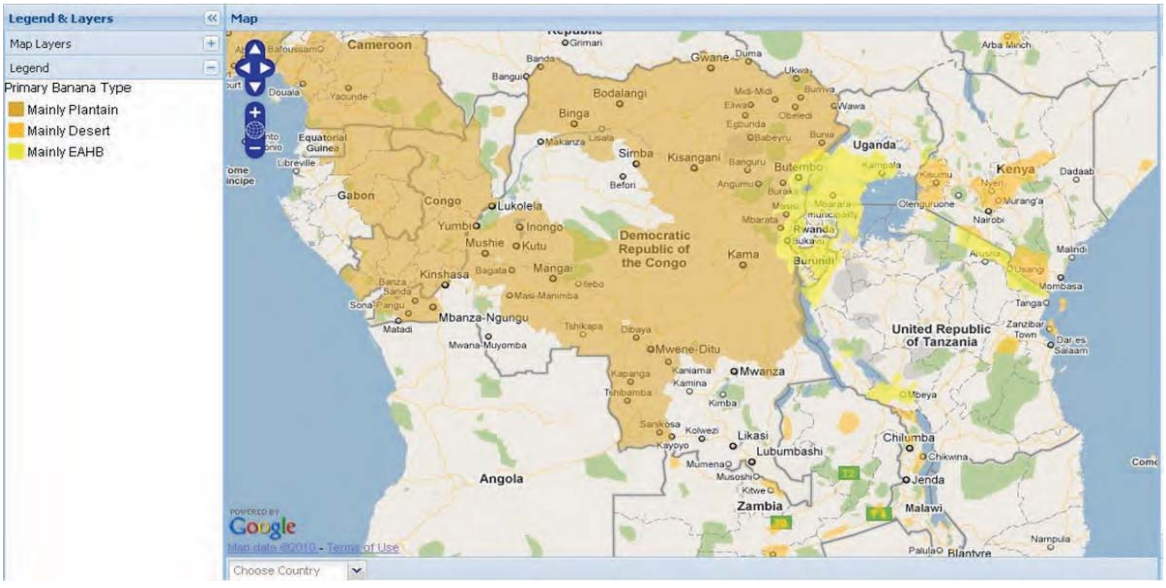


Figure 8. Map produced from the Banana Open Access Platform showing production areas for the three different banana types.

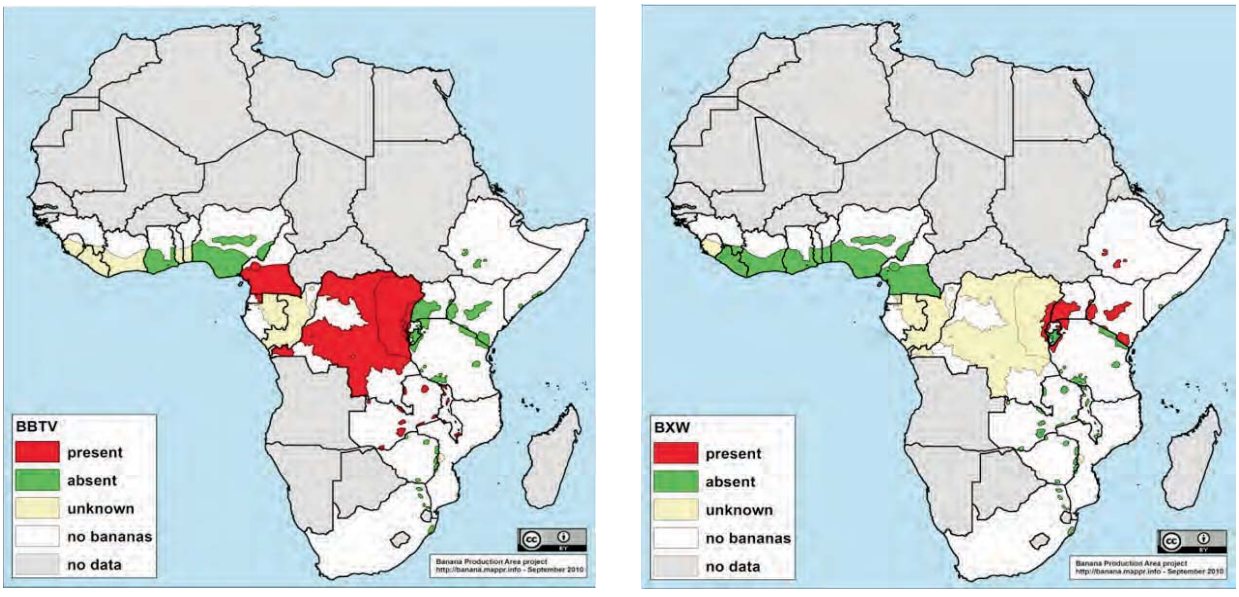


Figure 9. Map produced from the Banana Open Access Platform showing the presence of banana bunchy top disease (left) and Xanthomonas wilt (right).

Table 1. Production data for banana reported by FAO (for 2007) and FruiTrop (for 2006).

Country	FAO figures			FruiTrop figures				Difference (total FAO – FruiTrop, t)
	Banana (t)	Plantain (t)	Total (t)	Sweet banana (t)	Plantain (t)	Highland banana (t)	Total (t)	
Algeria	200	0	200	11	0	1	12	188
Angola	300,000	0	300,000	175,851	120,000	10,000	305,851	-5,851
Benin	14,000	0	14,000	22,500	45,000	100	67,600	-53,600
Botswana	0	0	0	0	0	0	0	0
Burkina Faso	0	0	0	15,010	100	10	15,120	-15,120
Burundi	1,600,000	0	1,600,000	350,000	70,000	1,118,679	1,538,679	61,321
Cameroon	860,000	1,400,000	2,260,000	860,000	1,200,000	200,000	2,260,000	0
Cape Verde	6,800	80,000	86,800	6,560	10	30	6,600	80,200
CAR	110,000	0	110,000	110,000	73,000	7,000	190,000	-80,000
Chad	0	0	0	10	0	0	10	-10
Comoros	65,000	0	65,000	52,000	2,000	11,000	65,000	0
Congo	87,000	65,000	152,000	87,000	60,000	4,000	151,000	1,000
Ivory Coast	360,000	1,204,860	1,564,860	506,000	1,300,000	200,000	2,006,000	-441,140
Djibouti	0	0	0	1	0	0	1	-1
DR Congo	314,920	1,510,778	1,825,698	314,470	1,000,000	203,030	1,517,500	308,198
Egypt	880,000	0	880,000	876,999	1	3,000	880,000	0
Eq Guinea	20,000	31,000	51,000	20,000	28,000	3,000	51,000	0
Eritrea	0	0	0	11	0	0	11	-11
Ethiopia	200,000	0	200,000	210,350	100	1,000	211,450	-11,450
Gabon	13,000	275,000	288,000	12,635	120,000	50,000	182,635	105,365
Gambia	0	0	0	11	1	1	13	-13
Ghana	57,500	2,930,000	2,987,500	385,000	2,165,000	350,000	2,900,000	87,500
Guinea	160,000	436,000	596,000	155,000	420,000	15,000	590,000	6,000
Guinea Bissau	5,200	40,000	45,200	5,000	36,000	3,000	44,000	1,200
Kenya	1,186,740	605,000	1,791,740	370,000	430,000	400,000	1,200,000	591,740
Lesotho	0	0	0	0	0	0	0	0
Liberia	120,000	43,000	163,000	115,500	39,000	3,000	157,500	5,500
Libya	0	0	0	3	0	1	4	-4
Madagascar	290,000	0	290,000	270,000	20,000	12,612	302,612	-12,612

Malawi	385,000	300,000	685,000	54,156	200,000	47,614	301,770	383,230
Mali	136,898	0	136,898	61,000	10,000	1,000	72,000	64,898
Mauritania	0	0	0	0	0	0	0	0
Morocco	201,802	0	201,802	202,500	0	500	203,000	-1,198
Mozambique	90,000	0	90,000	83,000	5,000	5,383	93,383	-3,383
Namibia	0	0	0	0	0	0	0	0
Niger	0	0	0	350	0	0	350	-350
Nigeria	0	2,991,000	2991,000	345,000	2,357,000	83,000	2,785,000	206,000
Rwanda	0	2,600,000	2,600,000	250,070	50,000	2,173,010	2,473,080	126,920
Senegal	34,000	0	34,000	29,700	200	100	30,000	4,000
Seychelles	2,000	0	2,000	1,370	100	576	2,046	-46
Sierra Leone	0	35,000	35,000	10,000	19,464	1,000	30,464	4,536
Somalia	38,000	0	38,000	17,000	4,000	1,000	22,000	16,000
South Africa	348,059	0	348,059	343,549	20	120	343,689	4,370
Sudan	74,000	0	74,000	2,000	1,000	74,791	77,791	-3,791
Swaziland	500	0	500	381	0	0	381	119
Tanzania	3,500,000	600,000	4,100,000	150,000	300,000	300,000	750,000	3,350,000
Togo	19,000	0	19,000	14,600	3,400	500	18,500	500
Tunisia	0	0	0	105	0	10	115	-115
Uganda	615,000	9,231,000	9,846,000	193,558	193,558	9,290,797	9,677,913	168,087
Western Sahara	0	0	0	0	0	0	0	0
Zambia	700	0	700	638	1	30	669	31
Zimbabwe	85,000	0	85,000	86,200	147	500	86,847	-1,847
Total	12,180,319	24,377,638	36,557,957	6,765,099	10,272,102	14,574,395	31,611,596	4,946,361

About the conference

The conference provided a unique gathering of experts who represented the different sectors of the banana chain from production to markets, including industry, government, farmer groups, nongovernmental organizations (NGOs) and entrepreneurs. In order to engage as many participants as possible, and to create an environment where everyone's experience was rated as highly as the others', the series of proverbs below was shown at the first session of the conference. This was intended to increase the confidence of those groups less familiar with a conference environment. The aim was to harness collective wisdom in order to develop robust strategies that consider all constraints and opportunities to realize the potential of banana through appropriate development of the banana sector as an economic driver for sustainable development.

A leader who does not take advice is not a leader – Kenya

One head does not contain all the wisdom – Ghana

Teamwork without coordination brings confusion – Zambia

Where two rivers meet the waters are never calm – Uganda

Even a big river is enlarged by its tributaries – Malawi

With a little seed of imagination you can grow a field of hope – Nigeria

Those who accomplish great things pay attention to little ones – Mali

If you think you are too small to make a difference, try going to sleep with a mosquito in the room – Anita Roddick, British entrepreneur

He who has not reached his destination never gets tired – Kenya

Objectives

The main objectives of the conference were to:

- Develop a strategy for the next decade to exploit banana research for African economic growth.
- Strengthen research partnerships to overcome production bottlenecks.
- Focus research on meeting the challenges of evolving production trends, and emerging markets and trade networks.

The key objective was to develop a 10-year, knowledge-based research-and-development strategy for banana in Africa that will mobilize the banana sector and lift people out of poverty, by better linking researchers with farmers and other stakeholders, farmers with markets, and researchers and farmers with private and public sector actors. The strategy is anticipated to guide a change in banana production from traditional smallholder and donor aid-supported to a system sustained by an invigorated private sector that actively seeks technological interventions.

The conference addressed the second objective by attracting relevant actors from across the globe and across disciplines. Besides the many researchers present, the organizers actively solicited input from the private sector (large and small scale), farmer groups, entrepreneurs, donors, governments, policy makers and advocacy groups. The direct results in terms of strengthened partnerships will develop with time, but the seed was sown at the conference.

To address the third objective, the conference looked to the future. Several presentations focused on climate change; the potential (and dangers) from fair-trade and organic banana production; newly emerging diseases; the potential for African farmers to engage in international markets; and the future perspectives of donors.

Structure

The full conference agenda is shown in Annex 1. The four-day conference began with three theme-focused days, and ended with the fourth day devoted to strategy development.

The three themes were: (1) markets and trade, (2) production and (3) innovation systems. Each theme was further divided into sub-themes, as shown below.

Markets and trade
- Market segments
- Policies and trade
- Supply
- Processing

Production
- Plant health
- Post-harvest
- Agronomy
- Seed systems
- Genetic improvement

Innovation systems
- Tracking adoption and impact
- Turning farmers into business people
- Innovating delivery systems
- Profiling country perspectives

For each theme, an invited keynote speaker made a presentation which was followed by a series of sub-theme presentations structured as concurrent breakout sessions. Poster presentations were divided into sections that corresponded with sub-theme titles. To harness information from all sources (presentations, posters and discussions), presenters, theme coordinators, session conveners and session chairs were given clear roles and responsibilities (Annex 2 and Table 2). Conveners played a particularly important role, summarizing key points from each session and presenting them to the theme coordinators at the end of each day. Based on these, theme coordinators prepared summary presentations for each theme of what needs to be done or to change in order to make progress in the next 10 years towards the goal of the strategy, i.e. to develop the banana sector as a driver for sustainable development. These identified priorities then fed into the 'Strategy Day'.

This fourth day began with a plenary session of keynote presentations, followed by theme coordinators presenting the priorities identified from the first three days. This was followed by a participatory session. Participants self-selected one of the three commodity groups to join, i.e. East African highland banana, dessert banana or plantain. Within each commodity group, participants chose which market orientation group to join, i.e. local, regional or international. The local market was defined as village to national, regional as trade to neighbouring countries, and international as requiring air or sea freight beyond the region. Participants were seated in groups of eight with

colleagues whom they had not previously worked with, in order to promote active discussion from different perspectives. Open discussions led to each group reaching a consensus on the three key priorities, specific to the banana type and market orientation, that need to be addressed in order to make progress in the next 10 years. Next, the same groups worked to identify how each of their priorities could be achieved, and who or which organization could take a leading role in doing so.

Outcomes from the 'Strategy Day' are described in the sections 'Strategy development during the conference' and 'A 10-year strategy for banana in Africa'.

Table 2. Summary of roles of presenters, session chairs, conveners, facilitators and strategy session chairs.

Presenters	Provide succinct overview
Session chairs	Time management and clarification of implications
Conveners	Record key messages from presentations, discussions, posters and participant input. Suggest 1–3 key recommendations of what needs to change and how this can be achieved
Facilitators and strategy session chairs	Catalyse and manage process

Conference achievements

- Publicity before, during and after the conference included numerous interviews and reports conducted at the conference and at a distance, resulting in approximately 130 announcements and interviews on various radio stations (including the BBC, Radio France, Voice of America and KBC), four magazine features (in New African, New Agriculturist and the Spectator), 17 newspaper articles and 25 online articles. At least 20 journalists from across Africa attended the conference.
- The conference was the largest gathering ever on the African continent of banana sector stakeholders. There were approximately 400 participants, with a large representation of African countries (25) as well as countries outside Africa (20).
- About 115 participants were able to attend through sponsorships. They included representatives from national programmes, students, entrepreneurs, farmers and members of small NGOs.
- The conference featured over 100 presentations and 181 posters. All had been selected and reviewed by the Scientific Committees.
- There was a parallel exhibition, with about 45 booths from 14 countries; these represented the commercial sector, farmers, international organizations, national programmes, NGOs, governmental organizations, and donors.
- The importance of the conference was highlighted by the attendance of the Honourable Janat Mukwaya, Minister of Tourism, Trade and Industry, Uganda, who delivered the opening address on behalf of President Yoweri Museveni; Anna Tibaijuka, Director-General of UN-HABITAT and Undersecretary-General of the UN; and the Honourable Agnes Abera Kalibata, State Minister for Agriculture, Rwanda.
- The conference website (www.banana2008.com) had more than 40,000 hits during the 12 months prior to the conference, and continues to be a major attraction long after the conference. All peer-reviewed publications from *Acta Horticulturae* are published and freely downloadable from the website, as well as all presentations, the abbreviated strategy document, press outputs and over 600 photos.
- Three additional symposia were tagged on to the conference: a journalist training workshop (about 25 participants); a ProMusa production workshop (about 50 participants); and the Banana21 meeting (about 30 participants).
- Towards the end of the conference participants completed an evaluation of the conference. A conclusion from their responses was that the conference was successful in bringing together stakeholders who would not normally share experiences or discuss the way forward; another was the importance of the development, distribution and deployment of a common strategy to help guide decision makers, donors, institutions and the private sector to prioritize investments to increase the impact of research.

Synopsis of presentations

This section summarizes the presentations during the first three days of the conference. The material reflects the presenters' opinions, and there were some discrepancies and conflicting views between presentations which remain in the summaries below. The full papers are available from the conference website: www.banana2008.com

Banana in Africa: an overview

Worldwide banana production amounts to about 100 million tonnes/year, of which roughly one-third is produced in Africa. Most of this is consumed within the continent. There are three major systems: (1) highland banana systems in the mid-altitude areas of East and Central Africa, (2) plantain-dominated systems in Central and West Africa, and (3) dessert banana systems in peri-urban and coastal lowlands or inland valleys.

East Africa: importance across countries

In East Africa, banana is a major food and cash crop for over 30 million people, supporting the livelihoods of over 20 million people in the Great Lakes region alone. The highland region is estimated to contribute over 70% of the total banana production in sub-Saharan Africa.

East African highland bananas are the most important type of banana grown. Of these, most are cooking types (e.g. 68% in Tanzania and Uganda) and the rest are brewing types. Some countries however focus on dessert bananas. In Malawi, for example, dessert bananas are a major source of cash for smallholder farmers, and in Kenya almost all the bananas grown are dessert bananas.

A unique and very important food crop for Ethiopia is enset (*Ensete ventricosum*), a close relative of banana, but grown for its edible corm. This crop is grown on over 180,000 ha. Besides being a staple, enset is also used for fibre production, as animal forage, in construction, as wrapping material and in medicines.

As well as an important food, banana is also a significant income generator: 4.5 million farmers earn an average of US$110/year from bananas, amounting to 20–70% of their income. However, the distinction between subsistence and cash crop is blurred in East Africa. Most often, banana is a subsistence crop with occasional cash sales, rather than an important cash crop.

In some countries, banana is a key staple. Burundi, Kenya, Rwanda, Tanzania and Uganda together account for 15% of global banana production. East African highland bananas cover approximately 25% of the arable land in much of Uganda, Rwanda, Burundi, and eastern parts of DR Congo. Daily consumption rates in these countries are the highest in the world, and can be up to 300 kg/year, representing 30% of daily calorie needs.

Uganda is the world's largest producer of cooking bananas, locally called 'matooke', which provide food for over 80% of the population. The majority of these bananas are consumed locally. South-west Uganda is a

major banana-producing area, supplying much of the East African highland bananas consumed in central Uganda. East African highland banana is also the most common weaning food for Ugandan children in banana-growing regions.

In DR Congo, banana is the second most important staple crop after cassava. The Congo basin is a secondary centre of plantain diversity. The area planted to banana has however declined from over 400,000 ha in the early 1990s to less than 150,000 ha presently, because of low yields and banana becoming too expensive for poor urban households. In eastern DR Congo, bananas occupy 40–70% of the cultivated area. Beer cultivars are the most common, followed by cooking bananas and plantains; the latter are usually cultivated at low altitudes.

In Kenya, an estimated 74,000 ha is planted with banana (approximately 2% of the total arable land). Banana cultivation, which in the past was largely for subsistence, is rapidly becoming an important economic activity among small- and medium-scale farmers who supply the urban markets. In Maragua district in central Kenya, banana provides the most significant family income and was ranked the second most important crop, with 60% of the farm land allocated to its production. Based on marketability, 'Gros Michel' is the preferred cultivar in central Kenya, although Cavendish is the most common.

In Malawi, banana is the second or third most important crop, depending on the region.

In other countries, banana production is minimal. For example, in Ethiopia in 2003 banana production amounted to 1,300 tonnes. However, in some countries that have low overall production, pockets of high production exist. In Tanzania for example, banana is by far the most grown food crop in the Kagera region, where it covers 65% of the total land under agriculture and is an important staple; in most of the rest of the country banana production is minimal.

West Africa: importance across countries

Nigeria is one of the largest plantain-producing countries in the world. The crop is produced mainly in the southern part of the country.

In Cameroon, plantain is the most important food and cash crop in the southern provinces, grown on rich forest soils. It is estimated that more than 600,000 smallholders are involved in plantain production, and almost all is consumed locally as a staple food. Besides its role as a subsistence crop, plantain is an important income-generating crop. It is also used in the processing industry and as livestock feed. Cooking bananas are also grown in Cameroon; because they can be grown on non-forest soils, they are usually grown by farmers who do not have access to forest and forest soils, or by those with insufficient labour to clear.

Besides plantain, dessert bananas are also very common in West Africa. In Ghana, 2 million t/year of plantain and dessert bananas are cultivated in the forest agro-ecological zone under rain-fed conditions, using traditional technologies. These supply mainly domestic markets. In Cameroon, dessert bananas are a staple food in the southern provinces. Dessert bananas ('Figue Sucree', AA genome; 'Grande Naine', 'Williams', AAA genome) and plantain ('Corne', 'Orishele', AAB genome) are also among the most important crops in Ivory Coast. Banana production in Ivory Coast has increased in recent years in response to reduced prices for coffee and cocoa, and banana is now an important source of revenue through local and export markets.

Markets and trade

Overseas banana trade from Africa

An overview of the current situation

The European Union (EU) is the world's largest banana importer. In 2007, 4.5 million tonnes were imported into the EU from 23 different countries. The market is supplied from three distinct sources: Latin America; the African, Caribbean and Pacific (ACP) group of countries; and domestic producers. The main supplier is Latin America (3.7 million t/year), and its share of the market is increasing (11%/year).

Africa accounted for less than 4% of international banana trade in 2007. Even from East Africa, one of the major banana-producing regions in the world, less than 1% of production is exported. Because of its proximity to Europe and tariff preferences put in place in 1993, virtually all exports from Africa go to the EU, with France and the UK being the two main destinations, where African bananas account for 11% of consumption. Virtually all imports into the EU are dessert bananas; the EU imports just 60,000 t/year of cooking bananas and plantains. Only Ghana, Uganda, Cameroon and Ivory Coast export to the EU; Ghana has been exporting only since 2006. Virtually all of Africa's export dessert bananas come from Ivory Coast and Cameroon. The entire value chain (production, export and transport) from these countries is linked to a small number of multinational fruit companies with strong links to EU importers. The decrease in price, combined with low labour costs and duty-free access, has led to more large fruit companies prospecting for new production opportunities in Africa.

Demand is increasing in the relatively closer market of the Middle East. In both Ethiopia and Sudan, efforts are under way to export certified organic banana to this emerging market. However, in Ethiopia banana export decreased from 60,000 tonnes in 1972 to 1,300 tonnes in 2003. Part of the reason for this decline is the focus of agricultural development efforts on grain production.

Somalia's main agricultural areas are located along its Shabelle and Juba rivers which provide year-round irrigation and fertile soils. The banana industry was flourishing in this area during the 1980s, and it was the largest exporter in East Africa with 12,000 ha under cultivation and employing 120,000 people. During the 1991 civil strife, banana production ceased. From 1993 to 1997, the sector was partly revived with exports to Europe and the Middle East amounting to six refrigerated ships per month leaving Mogadishu's port. Currently, bananas are cultivated on 3,000 ha, for the domestic market only.

Lessons from non-African banana-exporting countries

There may be some lessons to be learned from non-African banana-exporting countries. In many of these countries, multinational companies control the whole supply chain, and small-scale banana farmers are used by these companies to buffer fluctuations in supply and demand. As a result, farmers face permanent commercial insecurity. In Latin America, commercial banana production is also characterized by high availability of labour resulting in relatively low wages, and a high level of agrochemical inputs, causing human and environmental health hazards.

In India, banana is one of the most important fruits, and there are some exports to the Middle East, Russia, Ukraine and the EU. As in Africa, large post-harvest losses are common, and interventions are therefore targeting better supply chain management.

Challenges for African farmers

The majority of bananas in East Africa are grown by smallholder farmers. If these farmers could gain access to lucrative overseas markets, this would be a great opportunity for income generation and poverty alleviation.

African smallholder farmers face many challenges before they can reach these markets. For example they are unable to produce large volumes of bananas, they have knowledge deficits, and there is a lack of infrastructure at all points in the supply chain, at both local and national levels. Sea transport infrastructure to continental Europe is also lacking, and it will probably take private sector investors to overcome this particular challenge. Other

challenges are weak bargaining power, lack of appropriate marketing tools, absence of competitive buyers, and price information asymmetry. To overcome these challenges, some companies in Africa engage in scientific and dedicated or specialized marketing partnerships.

Empowering farmers

Empowering smallholder farmers will help them to gain access to export markets. One way to do this is for them to organize into groups. In Latin America, some farmer cooperatives have successfully managed to reach EU markets. For example, farmer cooperatives are shareholders of the banana and fresh fruit importer AgroFair, which operates under fairtrade certification and markets the fruit under its own Oké brand. Profits are returned to farmers' communities, directly improving livelihoods. However, these innovative models for farmer and supply chain organization from Latin America need to be adapted to the African context.

In Ghana, there is a fairtrade-certified plantation company that is partly co-owned by the workers, and by an experienced export house that works in partnership with the small producers; most of its bananas are also marketed in Europe through AgroFair. In DR Congo, a private company, Gourmet Gardens, runs an outgrower scheme in which over 1,000 small-scale farmers participate. Produce is processed centrally to improve product quality and reduce costs for individual farmers.

Targeting emerging niche markets

Africa may be able to take advantage of the growth of niche markets for speciality bananas and products, such as apple banana and bananas produced under certification schemes (for example fairtrade or organic).

From the French West Indies, the 'Mountain Banana' label is officially recognized in the EU and the bananas are sold at a premium based on taste superiority. Growers get higher returns, offsetting their higher production costs compared to conventional banana growers. Some companies in Africa are beginning to target these niche markets. For example, Gourmet Gardens is exporting certified organic dried bananas. Although currently in small quantities, apple banana ('Kamaramasenge', AAB genome) is exported from Uganda as dried chips, and from Rwanda as fresh fruit or processed as beverages. Limitations to increasing exports of speciality bananas and products are not a lack of demand in the EU, but production constraints in Africa, for example Fusarium wilt in Rwanda for apple banana.

Indeed, the demand for fairtrade and organic bananas is growing: an estimated one-third of the UK market, the EU's second biggest, is accounted for by fairtrade and organic banana imports. In Switzerland, this figure is over half the total market. The large fruit multinationals will aim to address these growing markets in their new operations in Africa.

Implications of EU developments for Africa's banana export industry

EU rules on imports of fresh fruits, including banana, are constantly evolving and becoming more complex. Very stringent formal steps have to be fulfilled by anyone seeking to import bananas into the EU, for example sanitary and phytosanitary (SPS) requirements. In addition, many large retailers and supermarkets have their own standards, including certification schemes. EU consumers are demanding higher and higher standards, constantly raising the bar for imports. This is largely due to environmental, health and social concerns raised over Latin American production systems. It is expected that the EU will legislate to require importers to meet certain environmental and social production standards, and in effect adopt as law many of the informal standards that are

currently required by supermarkets. It is also expected that controls will become more rigorous both in the place of production and on importation, and non-compliance will bar entry to the market.

Since 1993, banana suppliers from the ACP countries have benefitted from a free trade agreement with the EU. Economic partnership agreements (EPAs) between the EU and ACP countries, scheduled to enter into force by 1 January 2008 (although so far only a number of interim agreements have been concluded), are in effect an extension of trade preferences. The bottom line is that African exporters do not have to pay the EU import duty of €176/tonne. This duty is equivalent to 40–50% of the shipment value, and therefore gives African countries a very significant advantage over Latin American importers.

Negotiations currently taking place within the World Trade Organization will gradually phase out this advantage. In the next 10 years it is expected that the import duty on Latin American bananas will fall to €114/tonne, and to €75–95/tonne for certain countries that are seeking bilateral agreements with the EU. African exporters will therefore have to find ways to compensate for this lost advantage at the same time as building their share of the market. This will not be easy. Productivity in Latin America is relatively low and is set to increase; even a marginal productivity increase would tip the balance heavily in favour of the Latin American countries. On the other hand, Africa's proximity to the European market is a significant advantage as freight costs have increased considerably in recent years.

Some words of caution

It may not be wise to focus the African banana sector on international trade, in the short term at least. As well as the strong competition from Latin America, the important role of banana for food security and income generation within Africa must not be undermined by a reorientation towards the export market.

Value chains in East Africa

The typical farm: small with high diversity

Both the highland banana and dessert banana systems are dominated by large numbers of smallholders producing for home consumption and local markets. In central Kenya, farmers sell 25–75% of their harvest, depending on their wealth classification. Up to 84% of farmers sell their produce at the farm gate. Current lack of land tenure is one of the reasons for small farms. Another characteristic is the great diversity of cultivars, grown to provide for different market preferences: in Uganda, over 37 cultivars are grown in Bushenyi district alone.

Low use of inputs

Inputs are a major limitation to efficient banana production. In Uganda, farmers use only locally available inputs and virtually no agrochemicals. Similarly in Kenya, the cost of inputs for improvement of soil fertility and pest and disease management puts them beyond the reach of the majority of smallholder banana farmers. Irrigation is not practised. Physical availability of inputs is limited and, where they are available, the small volumes result in high prices. This becomes a vicious circle, as low productivity means weak demand for agricultural inputs and lack of stimulation for rural agro-enterprises. Stimulation of agribusinesses that supply inputs needs to go hand-in-hand with increased production. Inputs need to be introduced to farmers, who should then be encouraged to reinvest their improved profits in more inputs.

Suboptimal production

The production process itself is another limitation, because of poor on-farm practices linked to small farm sizes and lack of resources. In eastern DR Congo, the average size of banana plantations is 0.5–1.5 ha. Poor on-farm practices can be attributed to many reasons, which vary by country. In Ethiopia, there is a lack of skilled workers and extension agents. In Kenya, low adoption of new technologies, high levels of pests and diseases, poor quality planting materials, declining soil fertility, drought and inadequate information on production are the main problems. In several countries, already low production is in even further decline.

Interestingly however, in a study conducted in south-west Uganda, biophysical parameters (soil fertility, pest and disease pressure) and plant performance were not dependent on availability of land, labour and other resources, implying that resource-poor and smallholder farmers are not disadvantaged compared to resource-rich ones.

Major investments in agricultural technologies are required to improve production. Often, investments in the promotion of off-the-shelf technologies yield the best improvement. However focusing on technologies alone is not enough – technology dissemination needs to be looked at in the context of the whole value chain, including for example buyers and intermediate actors.

Resource-poor farmers will make substantial technology investments, but only when there are good output markets. In other words, a market for products is essential for new technologies to be adopted. This is clearly demonstrated with tissue culture in East Africa: lack of markets for the harvested fruit has discouraged farmers from adopting this technology.

New technologies, such as biotechnology, are expected to increase production. Their introduction should be accompanied by market development to absorb the increased production.

Lack of market access leading to market leakages

Along the value chain there may be large numbers of intermediary actors, leading to 'market leakages'. These lengthy brokerage chains (there may be up to 11 intermediaries in Uganda) add considerably to the consumer price but contribute very little value in terms of quality and consistency. As a result, in Kenya, Malawi and Uganda, farmers obtain a fraction of the consumer price while the middlemen net the lion's share of sale profits.

Improved market access is thus important for smallholder farmers, and a requisite for enhancing their income. Lack of market infrastructure and market information are the main problems that limit farmer access. These can be addressed by organizing farmers into groups, who could take over some of the roles of the middlemen. Secondly, institutional innovations (such as collective marketing and supply contracts) need to be put in place at the farm level, where they can play an essential role in improving market infrastructure and market information flow, and reducing transaction costs.

Increasing existing markets: going regional

While in some countries, such as Malawi, domestic markets for fresh produce are increasing, in many they are not. Furthermore, a history of market collapse is some countries has created aversion to risk taking. Saturated, slow, non-existent or inaccessible markets are seen as the most important barriers to a successful banana industry in East Africa. Demand and supply need to remain balanced.

The domestic market can be increased by opening up urban markets other than the capitals, by linking urban markets, and by going regional, thus expanding market ranges. The industry should focus, in the short and medium term, on supplying to local urban areas and to the large supermarket chains which are establishing themselves in Africa.

Creating new markets: processing

Apart from brewing bananas for beer, there is very little banana processing in East Africa. For example in Tanzania 95% of all produce is sold as fresh fruit, and in Uganda East African highland banana is also virtually only traded as a fresh commodity. Unprocessed banana is a highly perishable fruit and therefore needs to reach consumers quickly, so this limits farmer access to more distant markets.

Some processing does occur. In Malawi, banana products include wine, snacks, handicrafts, paper, dried bananas and flavourings. In Tanzania, bananas are mainly processed into non-alcoholic and alcoholic drinks. In Uganda, beer, juice and wine are the main products, with banana-flavoured milk products and purée also produced in small amounts.

Processing has many advantages, for example: (1) it absorbs seasonal surplus of bananas, (2) it increases shelf-life and reduces losses from spoilage, (3) it creates new markets, and (4) it can increase prices farmers get for their produce. All these result in increased farmer incomes. However, processing enterprises are limited by a number of factors such as: (1) seasonality of production, (2) price competition from the fresh fruit market, and (3) quality issues. Limitations can be overcome by investment in business services and in the management capacity of micro-, small and medium-sized businesses.

Care has to be taken that food security is not compromised. In Uganda, where banana is the main staple crop, farmers have expressed concerns for household food security and the increased work burden related to banana processing.

Creating new markets: diversification

The introduction of new cultivars might lead to new markets. However, the primary focus for introduction of new cultivars is to decrease risks related to pest and disease outbreaks.

Agro-enterprises for banana processing

There are few processing businesses, and in Tanzania for example, the majority of processing is carried out by farmers themselves. Development of small- and medium-size agro-enterprises could contribute to a successful banana industry in East Africa.

New banana processing agro-enterprises, as well as their suppliers, need a supporting environment, especially financial and technical support. The growth of an agribusiness sector would be stimulated by: (1) formation of local banana networks (e.g. farmer marketing groups), (2) stakeholder meetings (including government and private sector representatives), (3) enabling policies (e.g. with regards to obtaining local raw materials), (4) development of new processed banana products, (5) improvement and standardization of packaging and labelling, and (6) credit facilities. In Uganda, the Presidential Initiative on Banana Industrial Development (PIBID) is promoting a pilot rural banana processing industry.

Quality control mechanisms are particularly important, especially for products that target international markets or that are potentially hazardous (e.g. local brew).

Infrastructure and financial services: cross-cutting problems

Throughout the entire value chain, lack of infrastructure and lack of financial services are the main barriers. For example, in Kenya lack of microcredit is a major hurdle to using tissue culture banana plants. Household characteristics, such as size of the household and land holding size, are determinants for market participation, as they comprise productive assets that enable a household to produce a marketable surplus large enough to offset transaction costs of trading. In Uganda financial assets are often achieved through local savings, and against land or salary. Donor subsidies are only a short-term solution as they create dependence.

Farmer groups

Working in groups has many advantages for farmers. One of the most important barriers to development of the banana sector, intervention capacity, can be overcome by working in groups.

In groups, farmers can much better manage sales and marketing. For example in Uganda, when farmers organized, marketed and sold their produce as a group, they were able to bypass most of the middlemen and earn 60% of the banana sales. In Ethiopia, the formation of marketing cooperatives has increased the bargaining position of producers, especially smallholders, by allowing them access to central market price information.

Farmer group formation also has benefits through economies of scale, on both input and output sides. On the input side, agribusinesses will benefit from an increase in dedicated buyers, while farmers will be able to negotiate better prices via bulk purchases. On the output side, group formation enables product aggregation and standardization, leading to enhanced quality. In Uganda, uniform agronomic practices within farmer groups and farmer group networks resulted in better products and facilitated collective marketing which has resulted in farmers' margins rising from 20% to 50%.

Price volatility

In East Africa, prices of fresh banana change with seasonal variations in supply. For example, in Uganda farmgate prices in November–December are approximately twice those in July–August. High prices are caused by low supply and are associated with low food security. However, supply and associated price volatility can be easily buffered: simple de-suckering procedures can shift banana production towards periods of high banana prices and lower food security status. Farmers get lower bunch weights, but these are offset by higher profits.

Networks and linkages, and the role of the public sector

Two of the most important barriers to a successful banana industry in East Africa – market demand and intervention capacity – can be overcome by forming networks and linkages. In Ethiopia, when linkages were forged among farmers, traders, the public sector and nongovernmental organizations (NGOs), emerging challenges (new diseases, salinity, changes in market dynamics etc.) were more readily tackled. Regular capacity building and information sharing among the stakeholders are at the basis of improvements.

An essential role of the public sector is provision of adequate extension. Experience shows that, although a technology can spread from farmer to farmer, adoption is greatly enhanced when well-equipped extension staff work with farmers in the diffusion process. In order to function properly, institutions need to be put in place right from the farm level, where they are to play an essential role, especially for market infrastructure and market information flow.

A study in Uganda found that consumers are more knowledgeable about and have more confidence in public institutions than in private institutions. Public

institutions, both at local and national levels, could play an important role for example in raising awareness of biotechnological interventions and their biosafety.

Balancing act with other crops

Banana is grown alongside other crops, and market forces can lead to changes in focus on the different crops. In the central banana-producing region of Kenya for example, due to market failure, farmers are turning to other crops for food security. In Uganda, production of highland cooking bananas has increased in south-west Uganda and declined in the central urban region where the crop has its traditional roots. The decline in the central region was due to Xanthomonas wilt, which resulted in farmers changing to other crops which then proved to be more profitable. Also in Uganda, coffee and banana form the economic base for the majority of small-scale farmers, and are often intercropped, especially in highly populated areas. Banana–coffee intercropping is much more profitable than banana or coffee monocropping, especially for *Coffea arabica*-growing regions (Mt Elgon area).

Government policies can also steer markets and producers' responses. In Ethiopia, limited development of the banana sector can be attributed to a greater focus of agricultural development efforts on grain production. However, when the Ethiopian Government recently promoted banana in one district, productivity and marketing increased. At present, the Ethiopian Government is promoting a shift from traditional banana production to banana as an export crop.

Bringing it together: interlinked problems and vicious circles in the value chain

The characteristics of banana production systems lead to a plethora of inefficiencies in the value chain. In the sections above, critical problems within the value chain are described separately and solutions suggested. However, many of the problems are interlinked, creating vicious circles. In other words, a holistic approach needs to be taken to solving problems, and the whole value chain needs to be transformed. The biggest barriers should be tackled first, and together. For example, the NGO TechnoServe focuses simultaneously on farmer group formation, product aggregation and standardization, direct market linkages between farmer groups and urban wholesalers in the urban markets, credit access, and investment in input supply, especially irrigation technology.

Efforts to transform the banana value chain can have positive spill-over effects on other crops, for example through enhanced input use, improved productivity and better market integration.

Value chains in West Africa

Many of the characteristics of the East African banana system equally apply to the West and southern African banana systems. However there are some differences in constraints, which require different intervention strategies, as well as some unique opportunities within the dynamic West African banana systems that should be exploited.

The typical farm: small and diverse, but changing

As in the East African banana system, most plantain in West Africa is produced by small-scale farmers, with several cultivars of plantain grown. However, plantain is increasingly seen as an industrial crop, with large farms appearing in Nigeria and medium-sized farms in Ghana.

The dessert banana systems mostly target large urban and export markets. These systems are often capital-intensive and present the best opportunities for investment and further intensification.

Also, a gender division exists: in Nigeria, production is male-dominated while women essentially handle marketing. Similarly in Ghana, women and youth farmers play a particularly active role in harvesting and marketing of banana. Some of the male banana producers in Nigeria are relatively old and have poor literacy status, which has been shown to decrease their capacity to apply new technologies or improve management.

Low use of inputs

The smallholder plantain-dominated systems are characterized by relatively few external inputs. Increasing prices and markets provide some opportunities for investment in inputs (e.g. fertilizers and clean planting material), especially in peri-urban areas. In Cameroon, there are virtually no purchased inputs in banana-based systems. Labour is mainly provided by household members, and hired labour is limited to specific operations such as felling of trees, digging holes, planting and harvesting.

Suboptimal production

As in East Africa, suboptimal production is also a problem in West Africa. There are several reasons, for example inadequate knowledge of improved management practices, inefficient extension services, skewed research priorities and economic inefficiency. In Nigeria, technical efficiency (the improvement after application of new technologies) varied from 20% to 87%, allocative efficiency (the improvement after better application of available inputs) from 14% to 83%, while economic efficiency (the improvement of existing resources following better management) varied from 3% to 67%. If economic efficiency can be improved, productivity increases and costs are lowered without implementing a new technology or increasing the resource base. Improving economic efficiency is therefore an important strategy when resources are scarce and opportunities for introduction of new technologies are lacking.

Booming existing markets and an increasingly profitable income generator

In contrast to East Africa, existing markets in West Africa are growing significantly, both for dessert banana and plantain. Nigeria's banana output has doubled in the last 20 years, with increased consumption in both rural and urban households. In Ghana, the annual growth rate of dessert banana production is 7.5%, and of plantain is 5%. Unlike cassava and some other starchy staples whose demand tends to fall as incomes rise, demand for plantain increases with increase in income. Furthermore, price per unit of plantain is relatively high compared to other starchy foods. As a result, plantain farming is a profitable business, and the contribution of plantain to the income of rural households in major producing areas in Nigeria has increased tremendously in the last few years.

However, in some countries in West Africa a plateau has been reached, especially for plantain, with production becoming stagnant or even decreasing. In Cameroon, about 80% of production is consumed locally. Production is not meeting the demand of a rapidly growing population, and the consumption per capita has been dropping since the 1970s. The discrepancy between demand and production is often reflected in significant price rises in urban areas, and low-income groups in these areas then cannot afford them. In some urban areas, plantain has become an expensive luxury product.

Demand- and consumer-driven marketing

In West Africa, flavour, shelf-life and appearance of banana fruits, as determined by consumers, constitute a critical aspect of marketing. For example, when consumer preferences were investigated in a local Nigerian market, fruits of an ideal mature banana had 10–12 medium to large fingers with firm texture and medium sweetness. However, in some countries in West Africa, such as Nigeria, plantain production is plagued by seasonal shortages, and these need to be addressed.

Value addition: processing as a driver for agribusiness

Post-harvest losses are a constraining factor for banana production in Nigeria, with wholesalers incurring higher post-harvest losses than farmers. This provides a significant incentive for processing. Compared with East Africa, a relatively large market for processed banana products exists. Currently, less than 5% of dessert bananas but about 24% of plantains is processed, and industrial processing of banana is increasing. In Nigeria and Cameroon, processing of banana into chips or other dried products is the most common small banana-based agro-processing business, followed by production of alcoholic drinks (beer, gin, wine etc.). In Nigeria and Ghana there are also many other products made from banana, such as flour, soap from processed banana peels, babyfood, breakfast cereals and purée. Items made from banana fibre, such as baskets and handicrafts, are also available. In Cameroon, the NGO CHIPSA is making dough, alcoholic beverages, and soaps with reputed medical benefits from bananas.

Banana-processing businesses are predominantly family-owned and small scale. Small agro-enterprises are hampered by the same constraints as in East Africa, such as lack of raw materials, packaging equipment, skills, availability of adequate technologies, and credit. Lack of skills can be easily overcome by training sessions, while the other constraints can be addressed through creation of farmer groups and raising awareness of business support agencies.

Infrastructure and financial services: cross-cutting problems

As in East Africa, throughout the entire value chain a lack of infrastructure (e.g. bad roads) and of financial services (e.g. to buy fertilizers) are major barriers. These barriers discourage especially young people from engaging in the business of banana growing, as demonstrated in Nigeria.

Price stability

In Nigeria, seasonal price fluctuations for plantain are minimal. However, inter-market price variation is substantial, mainly due to high transport costs, resulting in a lack of movement of banana among markets.

Networks and linkages, and the role of the public sector

Technical efficiency improves with access to extension services. The Nigerian branch of Agip Oil has supported the development and transfer of banana-based technologies that are compatible with farmers' practices for several decades in the Delta region, under the Green River Project. Their efforts have focused on acquisition, development and dissemination of banana-based technologies, seed delivery, post-harvest technologies and services, and agribusiness and market-oriented advisory services.

Production

Pests and diseases

Production is threatened by several important pests and diseases. Banana has been present in Africa for thousands of years, but increased movement of plant material in the past century has introduced new pests and diseases and traditional cultivars have often proved susceptible. Africa's banana production is especially vulnerable because producers have both limited knowledge of pests and diseases, and limited resources to control them. Large areas have been forced out of banana production by different pests and diseases. In East Africa, the presence of banana pests and diseases is inversely correlated with altitude, i.e. fewer pests and diseases occur at higher altitudes.

An overview of the pests and diseases threatening African production: old foes

Root nematodes, especially the burrowing nematode *Radopholus similis*, are one of the major causes of yield loss in banana and plantain. In Kenya, the major nematode pests are *Pratylenchus goodeyi* and *Helicotylenchus multicinctus*. Control of *R. similis* has been a challenge in most banana-growing areas around the world because of its cryptic nature. In Rwanda, nematodes are not a major problem.

The banana weevil *Cosmopolites sordidus* damages both cooking and dessert bananas, but several ratoon cycles are required to achieve a sufficient population build-up to cause substantial reduction in yield and plant growth. In Rwanda, banana weevil damage is low.

Mycosphaerella leaf spots (Sigatoka disease complex), which are caused by three main fungal species – *Mycosphaerella fijiensis* (black leaf streak or black Sigatoka), *Mycosphaerella musicola* (Sigatoka leaf spot) and *Mycosphaerella eumusae* (eumusae leaf spot) – are a major constraint and can reduce yield by up to 75%. Since their introduction onto the continent, Mycosphaerella leaf spots, and especially black leaf streak, have spread to all banana production areas, causing extensive damage especially to plantains and dessert bananas but also to East African highland bananas. In Kenya however, most farmers consider Mycosphaerella leaf spots to be mild, especially if the banana crop is adequately fertilized.

Fusarium wilt, caused by *Fusarium oxysporum* f.sp. *cubense*, is an important disease, especially on dessert banana. It is also a major disease on apple banana in East Africa, and limits productivity of this and other exotic cultivars. There are several races – races 1 and 2 occur in Africa. Viable control options are lacking, although there are some resistant cultivars of East African highland banana and Cavendish.

There are six viruses that affect banana worldwide: banana bract mosaic virus (BBrMV), banana virus X (BVX), banana bunchy top virus (BBTV), banana streak virus (BSV), banana mild mosaic virus (BanMMV) and cucumber mosaic virus (CMV). In West and Central Africa, banana dieback disease (BDD), one of the major diseases of banana and plantain, has an inconclusive aetiology, although an isometric virus, named banana dieback virus (probably a Nepovirus) has been possibly associated with this disease. In East Africa, of the six banana viruses only BBrMV and BVX have not been detected. These could be devastating if introduced. A key intervention to reduce infection is planting virus-free material, however currently no virus indexing of planting material is performed. BSV is widespread in Uganda and possibly other East African countries, and constitutes a major threat to banana production. Persistence and spread of BSV is mainly through banana planting material. Development of an efficient polymerase chain reaction (PCR) protocol for detection of specific BSV isolates infecting East African

highland cultivars is underway. BanMMV is likely to be present in East Africa causing small losses. CMV is the primary virus affecting commercial banana plantations in Ivory Coast, whereas in East Africa it causes only small losses.

Several fungal diseases affect banana fruits. Wound anthracnose, caused by *Colletotrichum musae*, is among the major problems affecting the quality of export bananas from a lot of countries in the world, especially where bananas are grown in lowland plantations during the rainy season. Stressful growing conditions, especially soil flooding, was shown to slow fruit growth but had no direct effect on fruit susceptibility to *C. musae*. However, temperature is a critical factor affecting the susceptibility of banana to the pathogen. Banana fruit spot or speckle, caused by *Deightoniella torulosa*, and Cladosporium speckle, caused by *Cladosporium musae*, are a problem in Ivory Coast, and are seen on all cultivars. 'Figue Sucree' is particularly susceptible. Cigar end rot, caused by *Verticillium theobromae* or *Trachysphaera fructigena*, is another important fruit disease, to which 'Dwarf Cavendish' is particularly susceptible. In DR Congo, *C. musae* is only present at higher elevations (>1,700 masl) where it is a major causal agent of fruit peel disease or 'Cibojo'. The disease has been in the region for over 50 years, especially on beer banana 'Nakasimbu'. The symptoms start on the fruit peel as tiny black spots, which enlarge to diamond-shaped black lesions which eventually cover the whole fruit. The disease progresses rapidly during the rainy season and fruits of severely affected bunches become unsuitable for human consumption. Farmers do not practise any control measures. It is postulated that insects make the initial damage to the fruit peel and secondary fungal infections colonize these wounds.

The enset root mealybug *Cataenococcus ensete* was first recorded as a pest of enset in southern Ethiopia in 1988. Since then, its biology has been elucidated. Infestation is severe only between 1,400 and 2,200 masl. More than 30% of farms surveyed in Ethiopia were infested.

New kids on the block

New diseases are constantly emerging, and several (BBTV, Fusarium wilt tropical race 4 and Xanthomonas wilt) pose a significant threat that requires a greater research focus. Xanthomonas wilt, caused by *Xanthomonas campestris* pv. *musacearum*, was first observed in eastern DR Congo and Uganda in 2001, after decades of being confined to enset and then banana in Ethiopia. It has since devastated bananas in these countries, with production losses of up to 100%, threatening food security and income generation. The pathogen kills plants quickly and spreads rapidly over a large area in a short time, making the disease one of the most dreaded. The disease has spread to several other countries in East and Central Africa, such as Burundi, Kenya, Rwanda and Tanzania, mainly through (1) contaminated farm tools, (2) infected planting materials, and (3) insect vector transmission (Drosophilidae, honeybees (*Apis melifera*), wasps and stingless bees (*Plebeina denoiti*)). Particularly affected are certain sites in central Uganda, western Rwanda and eastern DR Congo. In DR Congo, returning refugees have contributed to the spread of this disease as infected banana suckers are often used to establish new banana plantations. In eastern DR Congo, extension efforts to contain the spread of Xanthomonas wilt have been hampered by security issues and inaccessibility.

BBTV is the most devastating virus disease affecting banana around the world. The pathogen is spread by banana aphids (*Pentalonia nigronervosa*), which are common throughout Africa, or through infected planting materials. Although reported from numerous countries, the virus has been positively identified only in Angola, Burundi, DR Congo, Egypt and Malawi, and recently in Rwanda, Congo, CAR, South Africa and Gabon. The strain is similar to that in the South Pacific. The status of the disease is unclear, but it seems to be well established in Malawi, where it causes up to 40% yield loss. In Burundi, BBTV is present in the Rusizi valley. Because of limited geographic spread, the disease currently has a relatively limited impact on banana production, but regions under significant threat include countries of the Great Lakes region of Central Africa (DR Congo, Rwanda and Burundi) which face major losses if the disease spreads. Recent changes in farming systems (cultivars, practices and even climatic factors) might have led to the surge in incidence and severity of the BBTV virus.

Some differences between West and East Africa

Pests and diseases are major production constraints in the dessert banana- and plantain-based lowland systems of West Africa. Soil-borne pests and pathogens in particular have a major impact on production in intensive

monocultures. In the East African highland banana systems, pest and disease pressure is relatively less, and abiotic stresses (such as water shortage and nutrient deficiencies) are the more significant production constraints. However, based on farmer assessments, pests and diseases are still among the top three constraints to banana production in the highlands in Kenya.

Lack of knowledge

Lack of knowledge about pest and disease symptoms and appropriate control practices is one of the major factors limiting banana production. Some farmers attribute severe damage by pests and diseases to lack of water and low soil fertility. For example, faced with nematode damage, farmers often simply resort to replanting toppled plants. In West and Central Africa, farmers practise virtually no pest or disease control, partly because they are unaware of the pests and diseases which often reside in the roots or corms. Farmers are unaware of infection pathways of nematodes such as *Radopholus similis*. There is a critical need to raise awareness of the major pests and diseases, and introduce simple measures to reduce or eliminate them.

A strong focus on cultural control

Radopholus similis and other banana nematodes can be readily managed using synthetic pesticides, although some of these are being discontinued because of environmental side effects. In theory at least, antibiotics might also be used for control of Xanthomonas wilt infestations, and would be preferred to uprooting, which is labour-intensive and expensive. However, chemical control is not practised by smallholder farmers in Africa because of lack of availability or high cost. If pests and diseases are controlled by smallholder farmers, they are primarily managed through cultural control options.

In Cameroon, farmers often use suckers infested with pests and diseases as their planting material, and this is one of the main constraints to the intensification of banana. In Ghana, bananas are also traditionally propagated by means of suckers, although use of clean planting material, derived from micropropagation techniques, is gaining in popularity. The ideal situation involves disease-resistant cultivars established with clean seed.

There are some low-input cultural management options for nematodes, as well as other pests and diseases. For example, submerging pared suckers in boiling water for a short time (30 s) is a simple, inexpensive and effective treatment against nematodes, and also several other pests and diseases. However, disseminating this technology poses a problem in countries like Cameroon, which have no extension system in place, dispersed farmers and poor road infrastructure.

Cultural methods such as trapping, mulching and application of ash are the most common control measures used against the banana weevil. While insecticides (e.g. chlorpyriphos) reduce banana weevil populations, they are not necessarily more effective than mulching, and must be applied more often.

Disease management of Xanthomonas wilt focuses on eliminating the three infection pathways, by male bud removal, use of non-infected tools, and use of clean planting material. The disease is mainly transmitted through infected tools, so rigorous tool disinfection is essential, and de-suckering and de-leafing in highly infected fields should be avoided. De-budding should be carried out with a forked

stick. When symptoms are seen, infected plants should be entirely removed and destroyed using herbicides (glyphosate), followed by a fallow period of at least 6 months or crop rotation with non-host crops.

Against Fusarium wilt, soil solarization holds some limited promise for smallholder farmers. To tackle black leaf streak, introduced hybrids resistant to the disease can be grown in mixtures with landraces to reduce the spread of the disease between susceptible plants.

The growing interest in biological control

Biologically based management options are increasingly being sought. Nematode-antagonistic plants and plant products, such as *Tithonia diversifolia* (shrub sunflower), *Tagetes* spp. (African marigold), *Crassocephalum crepidioides* and *Azadirachta indica* (neem) seed cakes, when applied to the base of planted suckers, often as mulch, improve plant growth by decreasing *R. similis* populations and damage. These methods can be combined with cultural-based systems, for example a 15-min dip in *Acalypha* sp. extract and hot water treatment, or a combination of *T. diversifolia* leaf mulch and hot water treatment, has synergistic pest-controlling effects.

The entomopathogenic fungus *Beauveria bassiana* offers great potential for the biological control of the banana weevil *Cosmopolites sordidus*. However, cumbersome formulations and lack of an effective and economically viable delivery system remain limiting factors to use of this fungus. In Kenya, research is ongoing on entomopathogenic nematodes to control banana weevil and other pests.

Efforts are moving towards the integration of multiple control methods for Fusarium wilt, for example a combination of biological and cultural control methods. Application of biological control agents (endophytic *Fusarium oxysporum* or the rhizosphere inhabitant *Trichoderma harzianum*), combined with silicon and mulching, improves plant health and is an effective control option.

There is huge potential in Africa for harnessing rhizosphere or endophytic biodiversity for improved crop productivity and pest and disease management. Crop plant association with arbuscular mycorrhizal fungi (AMF) is often beneficial to crop productivity and growth through a number of mechanisms, such as improved access to nutrients and water, and pest and disease suppression. Banana and plantain are both highly dependent on AMF, with a total of 20 species associated with them in East Africa. Some species appear to be superior in their effects on plant productivity and growth. Natural spore abundance of AMF, which determines colonization, is largely influenced by management practices. In Kenya, spore abundances of AMF were significantly different among farms, related to differences in exchangeable phosphorus, and among cultivars. Root damage showed significant negative correlation with spore abundance. Twenty-two AMF species were distinguished with spores of *Acaulospora* spp. most abundant. AMF can also be applied to the field. In a field experiment in Nigeria, the application of a mixture of AMF isolates (*Glomus* spp.), recovered locally from plantain rhizosphere to plantain suckers enhanced crop growth, improved bunch yield, increased sucker production and reduced the plant cycle. Growth and yield improvements were comparable to those seen with nematicide application. In another experiment in Nigeria, on 'Eparanta', inoculation of plants with mycorrhizal fungi, in combination with organic mulches, reduced nematode damage and increased growth.

Trichoderma asperellum is mass produced in Kenya by the RealIPM Company and is currently undergoing registration as a biopesticide for control of root knot nematode (*Meloidogyne* spp.) in vegetable and flower crops. Isolate RIPM03 has also proved effective against *Fusarium oxysporum* in pea crops by competitive exclusion. Its combined efficacy against nematodes and Fusarium wilt makes it a potentially useful biopesticide in bananas, and its effect in controlling Fusarium wilt has already been shown in 'Gros Michel' in the field in Kenya. The low-cost production systems used to mass produce RIPM03 (using organic substrates) and its high rhizophere competence enhances its cost-effectiveness and economic viability as a potentially important crop protection agent for both small-scale farmers and large-scale plantations.

In the field, 'suppressiveness' is based on unique interrelationships between the microbial community and plants, which result in a healthy root system. However, research into commercial biological enhancement of banana planting material has often been based on using a single antagonist against a single pest; this 'one antagonist–one pest' concept has been reasonably successful and has been used effectively for the biological enhancement of banana planting material with endophytic microorganisms. Good control has been attained regardless of the control organism involved: mutualistic endophytic fungi or bacteria, AMF, plant health-promoting rhizobacteria

or entomopathogenic fungi. However, to increase long-term and broad-spectrum control, a mixture of agents might be needed.

Inoculation of tissue culture plantlets

Biological control using rhizosphere or endophytic microorganisms can be especially useful for tissue culture banana plants. Tissue culture plants are disease-free, but are also free of beneficial microbes such as AMF and endophytes, leaving them open to attack by pathogens when they are planted out in the field. Inoculation of these plantlets with such beneficial microbes can enhance growth and pest and disease resistance. Inoculation can be carried out in newly deflasked tissue culture plants or in nurseries before plants are sold to farmers. Inoculating tissue culture plantlets with AMF has been shown to contribute to nutrient use efficiency in several species, as well as suppressing plant-parasitic nematode populations. Inoculation of tissue culture 'Giant Cavendish' with exotic *Glomus* spp. in the rooting substrate enhanced plant growth. The effect was specific to *Glomus* species and substrate type.

The survival and establishment of tissue culture banana plantlets could be enhanced by root endophytes. In Kenya, *Fusarium oxysporum* was the most prevalent endophytic fungus isolated from banana roots and corm, comprising almost 50%. Dual inoculation of two *F. oxysporum* isolates, V5w2 and Emb2.4o, resulted in a synergistic effect in both plant colonization and pest control. In Kenya, in on-station experiments, three *F. oxysporum* endophyte isolates inoculated into tissue culture bananas reduced nematode damage by 20% and population density by 40% compared to control treatments.

Applied as an artifical endophyte, *B. bassiana* offers a promising protection strategy against *C. sordidus* because it directly targets the damaging larvae growing inside the rhizome. Furthermore, endophytic *B. bassiana* requires little inoculum and since the fungus, when applied inside the plant, is protected from abiotic and biotic factors that would otherwise reduce its efficacy in the field, this provides an economically feasible management strategy for the weevil. *B. bassiana*-inoculated plants showed reduced banana weevil larvae damage in the screenhouse. *Trichoderma* also enhanced the growth of plants and increased the root volume compared to untreated tissue culture control plants.

Resistance breeding: new cultivars

Breeding for host plant resistance is the most economical and sustainable means of managing many pests and diseases, such as plant-parasitic nematodes, banana weevils, black leaf streak and Xanthomonas wilt. It is particularly appropriate for smallholder farmers in sub-Saharan Africa who cannot afford pesticides.

In recent decades, progress has been made in identifying sources of host plant resistance, identifying germplasm in other countries most like the original progenitors of African landraces, and developing genomic tools to increase the efficiency of developing resistant lines. Good progress has been made in introgressing resistance to black leaf streak disease, burrowing nematodes, banana weevils and Fusarium wilt in elite selections.

In Cameroon, three triploid hybrids ('PITA 21', 'PITA 23' and 'FHIA 25') and four tetraploid hybrids ('PITA 14', 'PITA 17', 'BITA 3' and 'FHIA 23') were selected with the help of farmers, exhibiting higher levels of resistance to black leaf streak, shorter growth cycle and higher bunch yield relative to landraces. In Ghana, three tetraploid cultivars ('BITA 3', 'FHIA 21' and 'CRBP 39') with resistance to black leaf streak and good yields were found acceptable by farmers, compared to the local cultivars 'Apantu' and 'Apem'.

Resistance management: shifting cultivars

Pest and disease management through exploitation of genetic sources of resistance is widely encouraged, especially in resource-poor countries. Banana cultivar groups differ in their resistance/tolerance to nematodes. For example, East African highland bananas are less resistant to nematodes than the hybrids, but also resistance/tolerance varies within cultivar groups. 'Nfuuka', 'Entukura', 'Tereza', 'Kazirakwe', Cavendish, 'Yangambi Km-5' (AAA group), 'Sukali Ndizi' (AAB group), 'FHIA-21' (AAAB group), and '2409K-3' and '9494S-10' (diploids) were all found to be

uninfected by nematodes. The roots of 'FHIA-21' and 'Yangambi Km-5' contain chemical substances which reduce populations of *R. similis* and *Pratylenchus* spp.

In Rwanda, Fusarium wilt strongly affects exotic banana production (AB and ABB genome beer and dessert bananas). In the absence of an effective control method for Fusarium wilt, farmers avoid the disease by planting alternative resistant cultivars. In Rwanda, high-yielding 'FHIA 17' and 'FHIA 25' are replacing susceptible apple banana, and 'Kayinja' (ABB group) is replacing AAA-EA genome beer bananas, while across the continent 'Gros Michel' is being replaced by Cavendish. However, 'FHIA' are inferior in taste to apple banana. Consequently, development of new cultivars of apple banana with both resistance and the desired taste is necessary to exploit the potential of the fresh fruit export market and the banana beverage industry. Since the 1980s, when Fusarium wilt first appeared, most farmers in Rwanda have replaced apple banana with more resistant East African highland cooking or brewing cultivars, abandoning a potentially lucrative export market. Processed chips from other dessert bananas such as 'Gros Michel' and Cavendish are inferior, but there is potential to exploit the dried dessert banana export market using Fusarium wilt-resistant exotic cultivars.

Resistant/tolerant cultivars provide one of the management tools used against banana weevils. Plantain seems to be more susceptible to banana weevils than dessert banana. East African highland banana is very susceptible, but in Uganda some introduced cultivars ('Yangambi Km-5', 'Saba', 'Pisang Mas', 'Pisang Ceylan' and several 'FHIA') are highly to moderately resistant/tolerant. Since there is no oviposition discrimation among these cultivars, resistance/tolerance is determined by reduced larval fitness (especially prolongation of the larval development period). The genetic basis for resistance is being elucidated, with the Bowman-Birk serine protease inhibitor (BBI) gene of the resistant 'Calcutta 4' fully sequenced. These can be used in breeding programmes or for rapid screening: the BBI gene is present in many banana weevil-resistant East African highland banana cultivars.

'FHIA 21' is a plantain hybrid with good tolerance to pests and diseases, excellent palatability and a high level of acceptance by farmers.

In Nigeria, improved hybrid cultivars are less susceptible to black leaf streak disease than the local cultivars, but farmers often cannot afford to buy them. In Bas Congo province of DR Congo, most introduced cultivars showed good tolerance to black leaf streak disease, except 'Orishele'.

Xanthomonas wilt affects almost all commonly grown banana cultivars but there are differences in susceptibility. The beer banana 'Pisang Awak' (syn. 'Kayinja', ABB group) and Cavendish are most susceptible, followed by East African highland bananas. Within cultivar groups, there also seem to be differences in susceptibility to Xanthomonas wilt. Within the East African highland cultivars, 'Nakitembe' (AAA-EA group) is moderately resistant due to flower morphology (persistent bracts). However, the diploid parent *Musa balbisiana* (BB group) is resistant, and a few enset clones also show partial resistance/tolerance to the pathogen. Due to lack of resistance traits in existing breeding lines, genetic transformation appears the most feasible way of introducing this trait into banana germplasm. For example, some banana cultivars have been *Agrobacterium*-mediated transformed with the amphipathic protein gene, which confers resistance against bacterial diseases in many other crops.

Although BBTV attacks all cultivars, the highland beer banana 'Nakasimbu' is least affected. In DR Congo in recent years, farmers have resorted to replanting their infected fields with 'Nakasimbu'. Control of the disease is based on promoting the use of non-infected planting materials.

In Ethiopia, 'Poyo' is a relatively pest- and disease-resistant cultivar compared with 'Dwarf Cavendish', but with equally favourable export qualities.

Genetically modified bananas to combat pests and diseases

The development of disease-resistant banana cultivars remains a high priority against Xanthomonas wilt since farmers are reluctant to employ labour-intensive disease control measures. Prospects of developing cultivars with resistance to Xanthomonas wilt through conventional breeding are limited, as no source of germplasm exhibiting resistance has been identified. Genetic transformation of banana with the pflp gene against Xanthomoas wilt is in progress at IITA in collaboration with Uganda's NARO. Several transgenic lines have been generated and are currently under screening for disease resistance in laboratory conditions.

A number of hybrids have been developed for nematode resistance/tolerance through conventional breeding, but genetic engineering is increasingly being deployed: nematode resistance in Cavendish was acquired by applying RNAi technology against the nematode collagen gene (col-5) needed for nematode reproduction. The same technology is being applied to confer nematode resistance to 'Sukali Ndizi' and East African highland bananas.

The expression of mammalian anti-apoptosis genes in plants such as tobacco has been shown to provide varying levels of resistance against several necrotrophic fungi and abiotic stresses. At the University of Queensland, a large number of transgenic banana plants (Cavendish and 'Lady Finger') expressing different mammalian anti-apoptosis genes have been generated by *Agrobacterium*-mediated transformation. Greenhouse trials are underway to challenge a selection of transgenic bananas lines with the fungal pathogens causing Mycosphaerella leaf spot and Fusarium wilt.

A rice chitinase gene (RCC2) was introduced into buds of 'Rastali' (AAB group). Assay of protein extract from the transgenic plantlets showed an increase in chitinase enzyme activity compared with the untransformed plantlets.

The important link to nutrient management

Improvement of plant nutrition is another primary, indirect strategy for management of *R. similis*. Nitrogen-deficient plants are associated with a significant increase in root densities of *R. similis*. Potassium nitrate and chicken manure improve plant growth and nematode control. For Xanthomonas wilt, increasing the availability of potassium can decrease virulence/pathogenicity.

Clean planting material

Even without substantial financial resources, the effect of pests and diseases in Africa can be substantially reduced by promoting the use of clean, healthy planting material. The use of tissue culture is explained in a subsequent section.

Hot water-treated conventional suckers and plants produced from corm fragments are two techniques used to provide planting material free of nematodes and other pests and diseases. In trials using both types of planting material in Nigeria, bunch weight was highest in corm fragment-derived material, yet due to the higher plant losses in the early stages of growth, bunch yield of the plant crop was lower than after hot water treatment of conventional suckers and not different from traditionally prepared suckers. None of these advantages was carried over to the first ratoon crop.

Macropropagation is a technique that involves manipulation of the buds on a corm to increase number and rate of sucker production. It involves uprooting and paring a maiden sucker, followed by removal of sheaths to expose buds. Apical and lateral buds are then cut (to suppress apical dominance and increase shoot number) and the corm is placed in a sterilized medium in the propagation chamber. Up to 35 plantlets can be

produced from a single corm over a period of 10–18 weeks. On emergence, plantlets are detached from mother corms and planted in soil in potting bags and kept in the shade, where they develop roots and are hardened prior to field planting. Currently, organizations such as IITA are promoting this technique as an efficient means of propagating healthy and robust planting material, with relatively uniform growth characteristics. The technique is simple, inexpensive, and suitable for on-farm adoption.

Diagnostics

Accurate and rapid diagnostics are a prerequisite for quarantine schemes, as explained further below. At the farm level misdiagnosis is a problem, especially for nematodes. In Kenya, farmers mistakenly rate banana weevils as the most important pest because they fail to associate banana toppling with nematode damage.

Accurate diagnostic tools are necessary for early detection and timely intervention. Knowledge of the distribution, identity, genetic structure and pathogen–host interactions will help in optimizing diagnostic and disease management protocols. Sometimes molecular markers are essential. In Nigeria, molecular markers of single nucleotide polymorphism (SNP) types revealed the presence of two species of *Mycosphaerella* (*M. fijiensis* and *M. eumusae)* and distinguished different strains within each species. This will also help unravel the population dynamics of the pathogens for better management of the diseases. Finding different strains and assessing their respective level of pathogenicity and virulence will help in challenging breeding materials with the appropriate pathogen diversity for durable resistance.

Molecular-based diagnostic tools are also required for nematodes. PCR-based systems can be used to quickly detect and quantify populations of *R. similis*. Robust diagnostic tests for viruses, and a region-wide strategy for implementation of routine testing, particularly for distribution of tissue culture planting material, is being developed. Banana materials are easily sampled for BBTV presence by the PhytoPASS kit followed by molecular diagnostics. The PhytoPASS system could be used to collect samples to then assess prevailing BBTV isolates in countries where outbreaks have been reported.

Pathogenesis

An intricate knowledge of pathogenesis is needed to develop effective pest and disease management practices. The pathogenesis of Fusarium wilt is elucidated as follows. Six days after infection, microconidia and chlamydospores enter the roots followed by cortical distortion. Even though the roots are heavily infected, no external symptoms are evident. The external visible symptoms of yellowing and leaf wilting start appearing with the entry of the fungus into the rhizome. By this time the infection is at an advanced stage and no curative control measures are possible. Control measures during the early stages of infection of the roots may help to prevent the disease from progressing.

For Xanthomonas wilt, diagnosis is difficult as plants carrying the pathogen can be asymptotic, or symptoms can be confused with those of Fusarium wilt. The pathogenesis of Xanthomonas wilt, which is similar to other banana bacterial wilts such as Moko bacterial wilt and blood bacterial wilt, is elucidated as follows. The presence of distant and isolated outbreaks suggests transmission by long distance agents, such as birds and bats, as well as movement of planting material and garden tools. Research is also investigating the insect infection pathway. While transmission through the banana male bud is well documented, disease transmission through female inflorescence is also possible, and even de-budded plants with ooze on the rachis are sources of infection. In principle, biological control might be used to interrupt the transmission pathway but no plausible control mechanism is currently available. The bacterium cannot survive in the soil away from host tissue for long, and probably survives in decaying debris from the rhizomes and roots. The duration of an appropriate fallow or crop rotation period is not known.

Combinations of pests and diseases, requiring a multifaceted approach

Scientists working in entomology or plant pathology often target their research to a single pest or disease, because of the need for a practical technology for application at the farm level, the economics of production, the cost of registration of control products, and the lack of knowledge of the impact of complex inoculants on control efficacy and environmental health. However, pests and diseases attack in combination. This calls for a multifaceted approach in the search for strategies to arrest the decline in banana production. Disease management should also be targeted to banana type.

Cooperation and lessons across countries

The impact of pests and diseases in Africa can be substantially reduced by promoting quarantine regulations to prevent dissemination of existing pathogens and pests and the introduction of new pathogens. In some African countries, scientists have the capacity to accurately identify and map the distribution of important pests and diseases, and the means to determine their dissemination in-country and across borders. However, the basis for effective quarantine regulations, diagnostic capacity, is lacking in much of Africa. Regional diagnostic, communication and data networks, such as the International Plant Diagnostic Network (IPDN) and the East Africa Phytosanitary Information Committee (EAPIC), are being established as a solution. These initiatives can serve as a foundation from which to develop harmonized diagnostic and quarantine protocols.

Geographic information systems (GIS) can be a cost-effective and efficient tool for monitoring, predicting and managing the spread of crop diseases and pests. For example, GIS allows for the interpolation of different data sets that can be used to identify where critical interventions are needed to control diseases i.e. in areas where disease coincides with high dependency on bananas and where food security is at risk.

Cooperation is also beneficial on other fronts. In Uganda, the national programme, NARO, carried out research to study Xanthomonas wilt and generate technologies for its control. Proven technologies were formulated into a prophylactic and curative control package, mostly focusing on cultural control options. Farmers' capacity to diagnose and control the disease was developed using participatory approaches, and resulted in 60–90% control. These disease management technologies are now being applied in Kenya.

Breeding

Methods

Banana breeding is slow and uses a lot of land, so increasing breeding efficiency is an objective. The most important constraint to breeding cultivated bananas is triploidy, which contributes to sterility and limits the use of hybridization in banana improvement. Conventionally, improvement of triploid species has been achieved through crossing triploid landraces with wild or improved diploids to produce tetraploids that are generally more fertile. Selected tetraploids are then crossed with improved diploids to produce sterile secondary triploids, which are targeted for release. Both wild and cultivated diploid bananas are used as male parents in banana breeding programmes. In Uganda, where male fertility is a major limitation in the genetic improvement of bananas, synthetic diploid hybrids derived from East African highland bananas have been bred and provide an opportunity for germplasm enhancement at the diploid level, as quantity and quality of pollen grains are sufficient for banana breeding.

The need to conserve organoleptic attributes

The development of disease-resistant banana hybrids with consumer characteristics that match traditional cultivars is still the major challenge for banana breeders. East African highland bananas are unique in their utilization, taste and cultural attachment for people in East Africa. As such, farmers and consumers are very critical of the sensory attributes of any new banana cultivar. Texture and colour of the cooked product are the most important parameters determining acceptability of new cultivars. Using synthetic diploid hybrids derived from East African highland bananas, the characteristics of the East African highland bananas are conserved in new cultivars. In Uganda, tetraploid bananas from 3x × 2x crosses were developed and used to generate new hybrids in 4x × 4x crosses. One of the striking features of the progeny obtained from the 4x × 4x crosses compared to progeny obtained from other breeding strategies (3x × 2x, 4x × 2x) is their marked resemblance in morphology, bunch characteristics and palatability to their female grandparents. The tetraploid hybrids inherit 75% of their genes from the triploid landrace gene pool and 25% from the diploid parent sources. Tetraploid hybrids are therefore expected to have more traits in common with landraces.

Breeding efforts in sub-Saharan Africa

There are major banana breeding programmes in Nigeria (IITA), Cameroon (CARBAP) and Uganda (NARO and partners). In East Africa, research efforts by NARO and IITA have focused on improving East African highland bananas for disease and pest resistance and higher yields, while keeping their unique taste and other culinary qualities. In an on-farm participatory evaluation of 18 conventionally bred hybrids selected from an early evaluation trial at NARO, four ('M2', 'M9', 'M14' and 'M17') were selected as the highest yielding and most acceptable, and also having resistance to black leaf streak disease and banana weevils. Some secondary triploids, such as 'e2821k-10' and 'e12572s-28', have satisfactory pest and disease resistance and sensory attributes similar to the locally available cultivars. Four hybrids ('TMH3 x9750S-13', 'TMH3 x7798S-2', 'TMH3 x9187S-8' and 'TMH3 x8386S-19'), developed by IITA in collaboration with NARO, were selected in on-station trials according to their black leaf streak resistance, maturity period, high yield and pulp colour. When planted in farmers' fields, most of these hybrids produced higher yields than conventional cultivars, with acceptable organoleptic characteristics. However, a multiple pest- and disease-resistant, high-yielding cultivar with superior consumer acceptability is yet to be achieved, and remains a key objective. In West Africa, CARBAP has developed several triploid plantain hybrids with dwarf stature and resistance to black leaf streak. Although the performance and acceptability of the first generation is good, their cooking features have to be improved in order to broaden their use and increase their market value. Superior plantain-like diploid parental lines are used to produce superior dwarf hybrids, which have already been tested with farmers.

Markers

The present day edible bananas mostly originate from the diploid species *M. acuminata* and *M. balbisiana*. The diploid or polyploid cultivated banana varieties are sterile intra- or inter-specific hybrids of these two species and have been fixed through hundreds of years of human selection. Through the use of cytoplasmic and nuclear DNA-based markers, the phylogenetic relationship between *M. acuminata* and *M. balbisiana* is being elucidated. This information will be beneficial for breeding programmes.

Genetic variability in existing banana cultivars is rich and needs characterization prior to use in breeding. Although characterization based on morphological and agronomic traits or isozymes has been used to distinguish and classify accessions, it is now known that these traits can be subject to environmental influences. Considerable efforts have been made to characterize banana genetic material using molecular markers such as RAPD, AFLP, SSR, rDNA and IRAP. For example, simple sequence repeat (SSR) DNA markers were used to assess the genetic diversity and relationships in the East African 'Apple' (AAB) and 'Muraru' (AA) dessert banana cultivars. From the analysis, major clusters of banana cultivars closely corresponded with the genome composition and were able to separate the subjectively classified groups, based on utilization – namely cooking and dessert. SSR markers could also distinguish between individuals at the sub-group level.

Chimerism and mutagenesis

In vitro culture methods and induced mutations combined with conventional breeding is a strategy for creating genetic variability in banana. Chimerism has also been exploited for selection of favourable traits both for consumption and commercial purposes. The current diversity of East African highland banana is believed to have evolved through chimerism. However, farmers play an important role in initiating and adjusting the proportions of cultivars on-farm, based on different traits. Bunch and fruit characteristics are the traits most associated with chimerism, and are used as selection criteria by farmers. This indicates a possible role of chimerism in the conservation of banana diversity on-farm.

Genetically modified bananas

Rationale

Conventional improvement through cross-breeding is difficult in bananas because of their high levels of sterility, as well as their parthenocarpy and polyploidy. Few diploid banana clones produce viable pollen. Banana also has a slow propagation rate. Finally, the fact that they have been vegetatively propagated since domestication has resulted in a narrow genetic base with useful genes generally lacking in the gene pool. Modern biotechnology offers great potential to overcome these obstacles.

Over the last few years, the largest growth in the adoption of genetically engineered crops has been in developing countries and this trend is expected to continue. The multinational life sciences companies have been leading the way in crop genetic engineering, but they are focusing primarily on a few crop/trait combinations that have high commercial value. Many crops and traits of importance to subsistence and resource-poor farmers around the world are being ignored. However, through consortia involving public-private partnerships, these shortcomings can be addressed.

A push for genetically modified bananas

NARO in Uganda and partners are focusing genetic engineering efforts on two major targets: disease resistance and biofortification. Other areas include improvement of traits such as early maturity and delayed ripening. Cavendish and 'Lady Finger' have been transformed with a range of anti-apoptosis genes for resistance to black leaf streak and Fusarium wilt. The two major micronutrient targets are pro-vitamin A and iron. NARO has acquired infrastructure and personnel capacity to develop transformation systems. They have also been able to identify, acquire, clone and evaluate novel genes as sources of resistance to biotic and abiotic constraints, as well as other productivity and nutritive traits for banana improvement. A consortium of local, regional and international institutions for research, technology transfer and training has been successfully nurtured. Since 2005, NARO has been working with various advanced research institutes to establish safe and cost-effective programmes for the development and commercialization of East African highland bananas genetically engineered for resistance to black leaf streak and nematodes.

Genetically modified (GM) bananas and associated technologies are at various proof-of-concept stages and not yet developed into commercial products. The most advanced products are bananas containing two rice chitinase genes (cht-2 and cht-3) for the control of black leaf streak, which are currently under field evaluation in the first confined field trial of transgenic bananas in Africa.

Somatic embryogenesis

Genetic engineering for disease resistance has been reported in plantain and dessert banana. Somatic embryogenic cell suspensions are highly suitable for mutation induction and genetic transformation. However, due to recalcitrance of East African highland banana to somatic embryogenesis, their genetic transformation remains complicated. A high-quality embryogenic cell suspension was developed for a few East African highland cultivars, with protocols for *Agrobacterium*-based gene transfer and stable expression of a foreign gene optimized. Protoplasts would be an ideal system for developing asymmetric and symmetric somatic hybrids, especially for partial genome transfer. However, development of banana protoplasts and doubled haploids is very slow.

Biofortification

Many important staple food crops, including banana, are low in essential nutrients such as vitamin A, vitamin E and iron. Biofortification of staple crops is regarded as one of the most effective strategies for reducing micronutrient deficiencies. The key to improvement in nutrient levels is the combination of appropriate promoters with highly active genes at the correct developmental stage. A number of genes are available for the improvement of pro-vitamin A, vitamin E and iron levels; however, there is limited information about promoters which will drive transgene expression in banana fruit. The Queensland University of Technology has identified a number of constitutive promoters, as well as fruit-specific/preferentially expressed promoters, and is currently investigating expression of these genes in whole plants.

The molecular basis for variation in pro-vitamin A is being elucidated. Variations in the gene encoding phytoene synthase, which catalyses an important rate-limiting step in the biosynthesis of carotenoids, plays an important role in mediating differences in pro-vitamin A levels, and provides an entry point for genetic modification. Phytoene synthase genes from high pro-vitamin A banana cultivars and maize have been isolated and inserted into Cavendish in Australia and into East African highland banana in Uganda under the control of both fruit-specific and constitutive promoters. Potential genes to drive accumulation of iron in banana fruit are being isolated and characterized.

Growth traits

East African highland bananas can grow as high as 5–8 m, which increases susceptibility to pseudostem breakage and is associated with a long vegetative phase of the plants. Genetic engineering to shorten the vegetative phase through over-expressing flowering genes that induce early flowering is being sought. 'Sukali ndiizi' (AAB group) has been transformed with the gene AP1, which is reported to reduce plant height in several plant species. Plants are currently being evaluated in the greenhouse. Using another strategy, over-expressing Cylin D type genes that

are responsible for shortening the cell cycle duration with eventual increased growth rates is also being investigated.

Consumer attitudes, scientific concerns and ownership

GM bananas are still in the early stages of development and are not without controversy, which has implications for marketing the product. In developing countries, acceptance of GM crops is relatively high, but this decreases with an increase in education and income. For example, in a study in Uganda, rural consumers were more likely than urban consumers to accept GM bananas, because of their higher trust in local community leaders and public organizations to control and regulate food safety. If GM crops are to be introduced, governments have an important role in sensitizing the population, and especially urban consumers, about their benefits. Strict regulations to ensure biosafety will be important for GM crops, but they are currently lacking in many developing countries.

The use of genetic engineering has raised several biosafety concerns, for example those related to geneflow. Of interest is geneflow to rhizosphere and phyllosphere microorganisms. In a study in Uganda, microorganisms such as the endophyte *Fusarium oxysporum* did not take up the transgenes from several transgenic plants.

Ownership of novel genes is another issue. For example, the ferredoxin-like amphipathic protein (pflp), isolated from *Capsicum annuum*, is a novel protein that can intensify the hypersensitive response. IITA has negotiated a royalty-free licence for this gene from Academia Sinica, the patent holder, through the African Agricultural Technology Foundation (AATF).

Abiotic constraints and management

The importance of abiotic constraints

In Rwanda, in all banana-growing areas the majority of farmers report drought stress and poor soil fertility as the main constraints to banana productivity. A minority of farmers mentioned pests and diseases as major constraints, which is in line with scientific assessments. Yield losses associated with drought stress are estimated at 38–72% under average rainfall conditions. However, only a minority of farmers adopt technologies to overcome these yield-limiting factors (e.g. application of mulch, manure and compost). Constraints to technology adoption need to be investigated. For example, in northern Tanzania and southern Uganda, most farmers were not practising soil and water conservation because it is too labour-intensive.

Water

Paring suckers before planting enhances plant establishment and resilience to dry conditions. In a study on a typical sandy clay loam in Nigeria, plantain extracted soil moisture throughout the shallow soil profile (up to 50 cm deep). In northern Tanzania, in a region with low rainfall but with hills and valleys, bananas were planted in the dry season in waterways that would otherwise not be used due to the large volumes of water flowing during the rainy season. Besides producing a good crop in the dry season, erosion in the valley was also reduced.

Nutrients and nutrient management

In central Kenya, virtually all farmers apply cattle manure at planting. Also in central Kenya, in an on-farm study, high banana yield variability within farms was noted: bunch weight and yields were higher closer to the homesteads, where plants receive more nutrients in the form of household waste. In Rwanda, while most farmers own some cattle or small ruminants, only a minority of them apply manure. Also in Rwanda, banana yield is positively correlated with the amount of mulch applied, although few farmers apply external mulch. None of the farmers in Rwanda apply mineral fertilizers.

With limited market opportunities and limited resources (e.g. land and capital), farmers need to improve production by optimizing nutrient cycling within the farm, through improved management of organic nutrient

sources (household residues, crop residues, mulch and manure). This is however labour-intensive. Banana is a crop with a high demand for nutrients, especially potassium and magnesium. The continuous planting of bananas on the same land without the use of external inputs exacerbates the problem.

There is a lack of basic knowledge on the amount of nutrients a banana plant requires, the potential production under well-fertilized conditions, the most limiting nutrient to plant growth in different areas, and the optimum amount of fertilizer needed to achieve target yields. In a nutrient omission trial in Cavendish in Kenya, lack of application of fertilizer or fertilizer application that was not specific to actual nutrient imbalances reduced growth, delayed flowering and reduced bunch weight. Nutrient omission trials can help identify essential minerals under different conditions. Measuring both soil and foliar nutrient levels, fertilizer recommendations to enhance yields can then be formulated.

In Uganda, farmers perceived fertilizer price as the most important constraint for adoption, despite limited knowledge of actual prices. Other constraints perceived were poor availability, large/costly fertilizer pack sizes, lack of know-how of application methods, and a belief that fertilizer negatively affects soil and fruit quality. Fertilizer use was highly profitable at sites close to the market, but not at distant sites (>250 km). Fertilizer use can become more profitable when targeting site-specific plant nutrient deficiencies.

Plantain mulched with oil palm refuse had higher yields and shorter cycles, but also appeared to have increased incidence of Fusarium wilt, more plant-parasitic nematodes and banana weevils, and more frequent pseudostem breakage.

In banana, different plant organs accumulate different levels of silicon. As silicon fertilizer levels were increased, silicon accumulated preferentially in the roots, with levels soon exceeding those in the leaves. This shows that silicon uptake and accumulation is not just a passive process driven by the transpiration stream. Silicon was mainly deposited in the epidermal layer of roots and leaves. High levels of silicon in the epidermal layer of roots and high levels of soluble silicon in the root cytoplasm have been shown to be related to reduction of biotic stresses, including soil-borne pathogens such as Fusarium wilt, and abiotic stresses such as cold damage.

Cropping systems

Sustainable intensification

How to increase banana's low productivity is hotly debated between those who favour a high-input, biotechnology-based 'green revolution' approach, and those who advocate various forms of low-input 'sustainable farming' options. The debate has assumed that there can be very little co-existence between the two. However, because of the complicated nature of Africa's agronomic, climatic, food security and economic challenges, a mix depending on local conditions might be warranted.

High-input approaches may have negative impacts on the environment, and on the health of workers and nearby communities, and may also have high financial costs. However, smallholder farmers in sub-Saharan Africa do not practise high-input agriculture in any systems. One approach being promoted is 'agro-ecological intensification'. This is a practical, knowledge-based approach with potential to respond both to the needs of smallholders who are trying to increase production through more efficient use of local resources, and to the demands placed on the high-input export sector for more environmental sustainability. While this approach does not exclude the use of external inputs, the focus is on biological mechanisms

for suppressing pests and diseases, strategies for increasing total crop photosynthesis and conversion to yield, and management of soil nutrient cycles and crop nutrition. Management of functional biodiversity is also part of the approach, and serves to reduce losses, optimize crop residue breakdown and symbiotic nitrogen fixation, and promote crop health.

The current situation: high variety of cropping systems, but all with suboptimal yields

Africa's bananas are produced across a wide variety of cropping systems, involving diverse management practices and soil and climate conditions. Production ranges from homestead gardens in densely populated areas to slash-and-burn in the sparsely populated humid forest zone of Central Africa. Biotic and abiotic constraints vary considerably, and often interact. Plantain cropping systems of southern Cameroon can be separated into those based on forest clearing (slash-and-burn), where plantain is the major crop starting the forest clearing cycle, and those where land is already used for cropping. Because forest clearing is labour- and cost-intensive, large trees and tree species with hard wood and/or of commercial value are often retained, as well as forest trees bordering directly on the plantain field.

Banana yields are far below potential yields in all production systems. Overcoming the soil biotic and abiotic stresses in the diverse cropping systems, while avoiding large nutrient losses in the long term, is a formidable challenge to sustainable banana production.

Intercropping

In Ghana, bananas are sometimes intercropped with trees. In Nigeria, small-scale farmers have over the years ingeniously integrated banana into various cropping systems. In Kenya, banana is intercropped with annual crops. Intercropping reduces the need for inputs and results in more sustainable systems that more effectively use and even potentially replenish natural resources for long-term management of farmland. Some benefits of intercropping to the grower are risk minimization, effective use of available resources, efficient use of labour, increased production per unit area of land, erosion control and food security. In Cameroon, double cropping of groundnut, maize and cassava promoted plantain growth and yield, with about twice as many plants reaching flowering and producing edible bunches. Crop density and inclusion of trees had no effect on flowering, bunch production and yield. Combining plantain with food crops on forest land is an option to generate income but is, however, compromised by the low plantain plant densities.

Some additional comments about cropping systems

In East Africa, highest banana productivity is observed near the Albertine rift, where soils are relatively young, rainfall is high, and plant densities are high. This is in contrast to much of central and south-west Uganda, eastern and central Rwanda and Burundi, which have weathered soils, low rainfall, and low plant densities.

In eastern DR Congo, banana planting densities are lower at low altitude than at high altitude, but bigger bunches are produced. Yield reduces with plantation age, although some plantations of up to 70 years are still producing at high altitudes.

Compared to other crops, growing banana is relatively labour-intensive because plants require individual care.

Many banana systems could be improved by simple agronomic measures, such as regular planting distances to increase densities and separation of cultivars into early producing versus late producing types to reduce weeding labour.

Fallow duration can have a large effect on yield. In an experiment in Cameroon, yield and performance of plantain on land cleared from forest was significantly better than on bush fallow land. Ratoon production was also higher in the older fallows than in young bush. Root health parameters were positively affected by age of fallow, and these effects persisted in the ratoon crops. Soil chemical properties could not explain the yield difference between forest and bush fallow land.

Plantain may be shaded to various degrees. The hybrid 'FHIA 21' is less suitable for planting in systems with high levels of shading. In a field trial in Cameroon, for example, canopy cover by the tree *Inga edulis* was negatively correlated with growth parameters of 'FHIA 21' and the proportion of plants that produced a bunch and bunch weight were higher under low canopy cover than in high canopy areas. 'FHIA 21' also developed more severe black leaf streak after phases of low water supply when shaded by *Inga edulis*.

Nutrition

Micronutrients

Vitamin A deficiency causes approximately 8 million deaths per year in developing countries, but is preventable. Many staple foods, including bananas, have low pro-vitamin A levels, and many people have limited access to alternative pro-vitamin A-containing foods. Some banana cultivars endemic to the Asia-Pacific region are high in pro-vitamin A. For example, pro-vitamin A content of cooking, dessert, juice, roasting and FHIA cultivars was found to be seven times less than that in bananas from Papua New Guinea.

There is increasing interest in combating vitamin A deficiency by promoting consumption of vitamin A-rich bananas among the banana-consuming communities of East and Central Africa. Orange pulp colour, and colour intensity, reflects pro-vitamin A content and so can be used to evaluate the nutritional benefits of banana cultivars.

Anaemia due to iron deficiency is a major health issue in East Africa. Like vitamin A deficiency, iron deficiency is intensified by overdependence on banana that contains insignificant quantities of iron. This is clearly demonstrated by higher rates of vitamin A deficiency and anaemia in banana-growing areas of western and south-western Uganda.

In Cameroon, bioavailability of iron and zinc is low in banana and plantain, and women and children get less than 5% of their daily needs of these micronutrients from banana and plantain.

Phenolic compounds

Phenolic compounds are antioxidants that have medicinal benefits, such as reducing cancer and cardiovascular diseases. They also contribute to the organoleptic qualities of banana. Phenolic compound content changes significantly during maturation, and this change is different across cultivars. For example, among a wide range of dessert bananas, cooking bananas and plantains, 'Kelong Mekintu' (plantain) and 'Popoulou' (cooking banana) have the highest phenolic compound content during early stages of maturation.

Sugar content

Diploid dessert banana and diploid cooking banana (AA genome) were both observed to have the same pattern of total soluble sugar accumulation. However, diploid dessert cultivars accumulated more sucrose during ripening on the plant than did diploid cooking cultivars. Acid invertase activity is a key step that controls the sucrose level during ripening of diploid banana fruit, therefore genes coding for acid invertase constitute a target for the

identification of molecular markers usable in breeding, and marker-assisted selection to improve quality traits of banana fruit.

Natural fruit drink from 'FHIA 1' has a higher sugar content (20%) than that from Cavendish or 'FHIA 25' (10–12%). Fruit juice from 'FHIA 1' also contains less residues and is superior in flavour. In Ghana, consumers rate aroma and taste above sweetness and colour for banana fruit juice.

Shifting use of cultivars

Introduction of new cultivars not only helps to decrease risks related to pest and disease outbreaks, but also leads to diversification and an increase in markets. In Uganda, Kenya and Rwanda, consumer acceptability and willingness to pay for introduced dessert bananas was assessed. All the three introduced dessert bananas were acceptable to consumers in local and regional markets, although rated inferior to 'Gros Michel'. Consumers in the local market would only buy the introduced bananas if they cost less than 'Gros Michel', while in the regional market, consumers would pay the same for the introduced bananas as they did for 'Gros Michel'. This indicates a market potential for the introduced dessert bananas in regional markets. Such introductions need to go hand in hand with (1) awareness campaigns, (2) market development activities, (3) training of farmers to grow and handle post-harvest the introduced banana cultivars, and (4) promotion of the introduced bananas to urban consumers in particular.

In Tanzania, introduction of new banana cultivars into banana-based farming systems is one of the strategies to revive declining banana production due to pest and disease infestations and low soil fertility. Introduction of new banana cultivars has a direct positive impact on productivity, and thus indirectly increases socio-economic parameters (social status, group formation, credit access, etc.). Adoption rates of new cultivars increase when constraint pressure increases, and are higher when households are resource-rich.

In Kenya, immigrating farmers in Nakuru district in Rift Valley Province have introduced banana cultivars and technologies from their original home areas. However, this district lacks good banana production conditions, having low and erratic rainfall and depleted soils. Different cultivars and production techniques can be adopted to counter these negative effects, for example 'Kisii' was more successful than 'Dwarf Cavendish'. The performance of cultivars depended on method of establishment: cultivars showed more tolerance to drought conditions when planted in trenches as opposed to holes.

In Uganda, 'Sukari Ndizi' (apple banana, AAB group) has good physiological adaptation to drought; 'Pisang Awak' (ABB group) can withstand abiotic stresses (drought, poor soil); while 'Mpologoma' has a high yield potential and harvest index, but is considered (by farmers) to be sensitive to abiotic stresses (drought, soil fertility) and is one of the most drought-sensitive cultivars within the highland banana group.

In Bas Congo province of DR Congo, organoleptic evaluation revealed that the local plantains 'Bubi' and 'Diyimba' and the dessert type 'Gros Michel' are most appreciated. However, 'FHIA-01', 'FHIA 21', 'SH 3640' and 'Bita 3' were most preferred by farmers. 'FHIA 25'was not liked despite its large bunch size and large pseudostem, because of the presence of seeds in fingers of the first hand.

Climate change

Africa is expected to be the continent most vulnerable to climate change, due to a combination of the greatest changes in climate combined with a lack of adaptive strategies due to poor technical infrastructure. The predicted impacts are both positive and negative. Increasing temperatures may allow expansion of current banana cultivation areas to higher altitudes, but may also be associated with increased pest and disease pressure. Predictions vary but, based on averaged predictions, banana cultivation areas in West Africa may expect reduced rainfall while banana-growing areas in the Great Lakes region of Central and East Africa could experience higher rainfall. In Uganda, shifting patterns of rainy and dry seasons, resulting in unexpected droughts and floods in Eastern region, have already been ascribed to climate change.

Plant physiology

Across cultivars, different types of suckers (peepers, sword suckers, maiden suckers and water suckers) have changing leaf shape, from lanceolate to a broader leaf lamina. This progressive leaf lamina broadening is an indication of the increased independence of the suckers from the mother plant. There is a reduction in sucker vigour during the ratoon crop cycle, which may be attributed to the taller mat and possible soil degradation, affecting plant anchorage and stability. This limits possibilities for perennial production of banana under monocropping conditions on degraded ultisols. Across most cultivars, but not all, a positive correlation exists between mother crop and sucker growth characteristics, with fast-growing mother plants having better developed suckers. It is still unclear whether cultivars with a larger root system have better suckering, which would have implications for breeding programmes.

A reduction in leaf area, corm weight and root system occurs during the reproductive stage of both the plant crop and the first ratoon cycle. First ratoon plants are slightly taller than the parent crop and have a bigger corm and a higher number of cord roots, but of shorter length.

Ripening is the main physiological process that affects fruit quality. The progress of this process is different for bananas that ripen on the plant and those that ripen after harvest, and according to the treatment applied to the fruit after harvest. The level of ethylene, although not the sole factor that controls the speed of ripening on the plant, is important. It is regulated at a downstream step of aminocyclopropane-1-carboxylic-acid (ACC) biosynthesis mediated by the MA-ACS1 gene and, in pulp tissue, the product of MaACO2 might be involved in this regulation.

Harvest, post-harvest ripening and shipping: maintaining quality

Harvest

Increased efficiency of harvest practices and better post-harvest management are needed to raise qualitative standards of the product while lowering production costs. Banana is harvested at various stages of maturity, depending upon the purpose for which it is cultivated and the distance to market. Banana bunches generally are harvested using a curved knife when the fruits are fully developed (75% mature). In large-scale commercial dessert banana production systems, harvest efficiency is increased by using an electric single-man picking platform, and banana bunches are hung on tramways for efficient transport out of the plantation. Hands are cut into units of 4–10 fingers, graded for both length and width, and carefully placed in poly-lined boxes.

The most suitable maturity indices of tissue culture bananas 'Williams' and 'Grande Naine' may be a combination of bunch age and grade, as these correlate well with post-harvest characteristics such as pulp-to-peel ratio and total soluble solids.

Mechanical damage is one of the major causes of post-harvest deterioration of banana. It affects the product's appearance, and increases potential for pest and disease infection, ultimately resulting in lower market quality and price. Damage can occur at any time from the point of harvest to the point of consumption.

The size and structure of bananas, together with plantation layout, often constitute an obstacle for automation of the main cropping operations, especially harvesting and spraying. Mechanization of agricultural operations in banana fields is one of the main ways of increasing productivity and reducing costs, especially where labour is scarce or expensive. Efforts to develop effective equipment are ongoing, but are often based on attempted adjustment of existing machinery, such as tractors equipped with an extensible arm, pincer and sickle for harvesting of bunches.

Post-harvest ripening

Early ripening is among the major problems affecting the quality of export bananas from many countries in the world, especially for bananas grown in lowland plantations during the rainy season. Ethylene is a very important factor in ripening speed. Ethylene absorbers are used to extend the post-harvest life of dessert banana, and various commercial ethylene absorbers are available. However, alternatives can be home-made. For example, a 2:1 (w/w) ratio of marl:water mixed with 3% potassium permanganate ($KMnO_4$) solution had an absorption rate close to that of the two commercial ethylene absorbers. When packed in paper and placed in a perforated polypropylene pouch, the storage life of 'Gros Michel' was 15 days compared with 18 days with the commercial ethylene absorbers. Other chemicals can also be manipulated to decrease the rate of ripening and to reduce the incidence of senescent spotting, a physiological condition of banana during ripening. Senescent spotting develops during the latter phase of ripening, but only in some cultivars. It does not affect eating quality of fruit but it reduces attractiveness to the consumer. The development of senescent spotting depends on many factors such as ripening stage, cultivar, atmosphere, temperature and relative humidity. It can be effectively controlled by atmosphere and temperature management. In 'Sucrier', short-term nitrogen gas treatment (24 h) delays senescent spotting and rapidly decreases the concentration of dopamine, which slows ripening and increases shelf-life.

In the Morogoro district of Tanzania, 'Grand Naine' (syn. 'Mtwike', AAA group) is the major dessert banana. Due to the absence of ripening rooms, the banana is harvested when mature and smoked in special pits on the day of harvest by middlemen traders, before being transported to urban markets two days later. Smoking of ripened fruits does not change the organoleptic fruit quality, but induces rapid ripening, so that fruits have shorter shelf-life.

Post-harvest ripening of fruits involves different physiological processes from pre-harvest ripening. Pulp-to-peel ratio, total soluble extract, total acid and peel dry matter content increased considerably during post-harvest ripening, while pulp firmness, pH and pulp dry matter content decreased. These changes are dependent upon cultivar.

Assessment of fruit susceptibility to mechanical damage is an important post-harvest selection criterion to provide information on the handling and storage potential of the fruit, and the design of packaging material for the product.

Shipping and cargo out-turn

Fruit are usually shipped by boat when green, and ripened by exposure to ethylene gas at their destination, in sealed banana ripening rooms. In case of 'cargo out-turn' (discrepancies in the form of over, short, or damaged cargo) in the UK, shipment information is obtained during surveys at destination (on behalf of cargo receivers, underwriters, ship owners or charterers) or during the study of claims submitted by lawyers acting for one or other of the above parties. There may also be occasion to visit the producer country. Pre-shipment factors influencing cargo quality include the weather, crop husbandry (especially in relation to diseases), harvesting and handling techniques, post-harvest treatments, method of packaging, schedule of loading, and carriage instructions written by the shipper/exporter. Shipboard factors include design and function of the refrigeration and ventilation equipment, method of stowage, interpretation of carriage instructions, and duration of voyage. For container shipments it is the shipper's responsibility to stuff the container in an appropriate manner; the container operator accepts the closed box and undertakes to supply refrigeration/ventilation in accordance with the shipper's carriage instructions. Deterioration (such as premature ripening) is often the result of a combination of adverse factors. Particular problems include the difficulty of achieving uniform air circulation through a palletized stow, and the challenge of shipping additional commodities (such as melons or citrus) in the same vessel.

Post-harvest banana processing

Due to its high bulk/low nutrient content and low protein efficiency ratio (PER), unprocessed banana presents a major nutritional drawback, resulting in high levels of child malnutrition in areas where banana is the most important weaning food, such as Uganda. Processing can help overcome these disadvantages.

Starches obtained from banana have industrial potential for value addition and food processing. Plantains commonly grown in Nigeria have a starch yield between 14% and 22% and amylose content between 23% and 25%. Banana starches form a gel rather than a viscous paste and can retrograde during cooling. They have reasonable freeze–thaw stability.

In Uganda, processing of East African highland banana into flour is being researched as a value-adding activity, especially for use in the baking industry. Banana flour can also be used to make soups and porridges. Banana flour has a higher ash and starch content than wheat flour, but a lower protein, fat and reducing sugar content. Efforts to develop banana/wheat composite bread have been hampered by the lack of gluten in banana. Studies are in progress to improve the use of banana flour, and a mixture of banana flour, gluten and water has been optimized for best baking results. Studies have also investigated the most economical dehydration methods (e.g. conventional versus freeze drying) that yield the highest quality flour. Pre-dehydration techniques, such as cooking, have been developed to reduce the bulk of the flour. Also, the addition of soy flour has been researched to further enhance the quality of banana flour.

Data collection and modelling

In East Africa, much of the current research is based on assumptions derived from insufficient, inaccurate or otherwise flawed datasets. For example water stress, which has previously been overlooked, is an important production constraint, while some banana pests and diseases may not be as important as has been assumed.

Despite the importance of banana for smallholder farmers, reliable quantitative data on production and the relative importance of major biotic and abiotic constraints are scarce in East Africa. From a large multi-year survey across the region, banana productivity averaged 11–26, 25–53 and 35–63 t/ha/cycle for Uganda, Rwanda and South Kivu in DR Congo, respectively, much higher than levels reported by FAO (6–15 t/ha/year).

Banana research suffers from a lack of standard and consistent methods to determine yields. The following are needed: (1) uniform yield calculation methods, (2) universally comparable units of banana and plantain yield, and (3) procedures to compare banana and plantain yields with those of other major staple crops. Some considerations include: a standardized cut-off point of the peduncle should be defined to increase comparability and reduce bias; fresh bunch yield should be averaged over the large but variable proportion of plants that do not produce bunches; comparison with other major staples requires conversion to dry matter yields; and yields need to be expressed per time unit.

A crop growth simulation model based on the light use efficiency approach has been developed to better understand and estimate how potential yield is attained, and to quantify water- and nutrient-limited yield in East African highland bananas. The overall aim is to identify opportunities to increase actual yields through improved crop management and to assist breeders with optimum phenotype recommendations.

Research is required to determine fertilizer response curves, response of different plantain cultivars to planting density, response to weeding frequency, and other agronomic measures to increase yields and profitability.

Tissue culture

Benefits

Kenya has seen a decline in banana production during the last two decades, mainly due to an increase in pests and diseases, combined with a lack of disease-free planting material. Since there is no formal system and standards to regulate planting material, farmers frequently use untreated sword suckers for planting, aggravating the problem. The introduction into Kenya of tissue culture has made significant strides in addressing these constraints.

The use of tissue culture technology to propagate banana plants has several advantages over conventionally propagated material. Tissue culture banana are: (1) pest- and disease-free, (2) rejuvenated, resulting in more vigorous growth with higher and faster yields, and better quality fruits, (3) more uniform, and (4) easier and less expensive to transport. In Kenya, use of tissue culture banana was positively related to off-farm livelihood activities and contact with extension agents.

Virus indexing and virus indexing schemes

Since the tissue culture process does not eliminate viruses, a major limitation of tissue culture systems is the lack of virus indexing services, especially for commercial production, which hampers cross-border trade. Workable and practical models for the distribution of certified virus-free tissue culture material within and between countries in Africa are required. This is becoming an urgent need in view of increased regional movement and expansion of the private sector. Such a system would require: (1) cooperation of policy makers, who set detection protocols, (2) capacity, (3) robust diagnostic procedures, and (4) establishment of virus-free plots from which to source material. Detection protocols need to be rapid and inexpensive, facilitating quick decision-making. Such systems are not yet present in East Africa. Agrobiotec, for example, certifies its starting material in Belgium.

The role of the private sector

Private tissue culture companies are emerging in East Africa, such as Agrobiotec in Burundi (250,000 plants/year) and Agro-Genetic Technologies in Uganda. Both laboratories use country-wide nurseries to disseminate their material to farmers. The nurseries also serve as training sites. The following constraints are faced by the private tissue culture sector: (1) inadequate laboratory infrastructure, (2) unskilled personnel, (3) lack of locally available laboratory inputs, (4) lack of locally available virus indexing mechanisms, and, depending on the country, (5) an unfavourable policy towards private investment. Many of these constraints lead to increased production costs, resulting in suboptimal adoption of the technology. As a result, NGOs and governmental organizations are the major clients for these enterprises, and not the farmers directly. Some of these constraints can be solved by better government support and improved networking of tissue culture producers.

In South Africa, Du Roi Laboratory is a major company specializing in the production and international export of tissue culture banana plants. Du Roi Laboratory is actively researching new Cavendish cultivars with superior morphology and yield characteristics and/or disease tolerance. At least nine cultivars have been tested in the field in Cameroon in collaboration with CARBAP. Some cultivars showed a shorter growth cycle duration and better yield.

Performance

Surprisingly, data on performance of tissue culture plants compared with conventional planting material are ambiguous. In a well-managed field in Ghana, 'FHIA-1' propagated from tissue culture grew faster and more vigorously (taller, bigger leaves etc.) than from conventional suckers. The tissue culture plants however produced smaller numbers of fingers than the conventional sucker-derived plants. No differences were observed in bunch weight. In Kenya, some studies report that tissue culture bananas yield 20% more than conventionally propagated plants; however in an on-farm study in Kenya, tissue culture plants did not have better growth than sucker-derived plants. Another comparative study between tissue culture- and sucker-derived plants concluded that few growth parameters differed between the two types during the vegetative phase, and plants originating from different propagules behave similarly at flower emergence. However, during the mid-vegetative phase, sucker-derived plants produced a larger root system, possibly due to the larger corm which bears the root initiation zone. Therefore, the major advantage to growing tissue culture-derived plants would be their more homogeneous growth, which is particularly important for timing of field practices. In Sri Lanka, tissue culture-derived plants of 'Ambon' and 'Rathambala' (AAA genome), two cultivars with great commercial potential, showed greater vigour (taller, and more leaves and suckers) but did not have greater yield compared with conventional planting material.

Adoption constraints

In spite of the advantages of tissue culture, the technology remains little known and underexploited in Africa due to a number of constraints or limitations. In East and Central provinces of Kenya, many farmers reverted to planting their own suckers despite having been introduced to tissue culture bananas.

In East and Central Africa, farmers reported that when establishing new banana orchards, 60% of them obtained suckers from their own fields while 30% got them from their neighbours. Knowledge of and access to clean planting material was identified as a major constraint in this region.

The technology is also poorly adopted because of lack of credit facilities for farmers to purchase both the planting material and the high level of inputs required to realize optimum yields, and lack of knowledge on the agronomic practices required for dealing with the tissue culture plants. Information on agronomic practices needs to be better documented and disseminated. In Kenya, adoption of tissue culture banana was found to be related to financial, physical or natural capital.

Increasing production efficacy and reducing costs

The cost of production of tissue culture plants is a major limitation to adoption. Establishment of a low-cost and/or more efficient in vitro regeneration system will therefore increase adoption. Several technical innovations related to the media in which plantlets are produced are being researched. Higher concentration of sugar increased the regenerative frequency of several banana cultivars. The use of local sugar instead of sucrose reduced the cost of tissue culture. Initiating bananas in liquid media with a reusable solid support matrix, such as glass beads or marbles, would help reduce the cost of banana tissue culture. In Bangladesh, addition of kinetin, indole-3-acetic acid and coconut water to the Murashige and Skoog medium increased the rate of shoot proliferation, increased shoot elongation and stimulated shoot growth of the popular sweet banana 'BARI-1'. Rooting percentage and root growth were much better in liquid media compared with semisolid media. Elimination of agar from root induction media also drastically reduced the cost of production.

Somatic embryogenesis of banana has progressed but is not yet commercially exploited because success is highly dependent on genotype.

Dwarf off-types among the somaclonal population are a major problem affecting micropropagation of banana, and their detection at an early stage of growth assumes significance. Research is ongoing to detect somaclonal variants at an early age using molecular markers.

Compared to the use of culture tubes where normally one shoot-tip cube is used, shoot proliferation in Petri dishes in the dark requires less media per explant, and more explants can be stacked per unit area. Culturing in the dark also saves electricity.

Value chain approach

A 'whole value chain' approach needs to be taken for tissue culture technology to be successful. Of paramount importance are: (1) awareness creation, (2) development of appropriate marketing and distribution systems, and (3) empowerment of farmers through promotion of banana growers' associations. Improvement of enabling policies and availability of microcredit are also essential. A whole value chain approach is being used by several organizations in Kenya to promote tissue culture banana, which includes providing seedlings, training on good agronomic practices, and providing market information to banana growers. Hardening nurseries were established to facilitate accessibility to tissue culture banana plantlets. Through public–private partnerships involving, among others, KARI, Jomo Kenyatta University of Agriculture and Technology (JKUAT), the International Service for the Acquisition of Agribiotech Applications (ISAAA), Africa Harvest and commercial laboratories, banana tissue culture technology has been successfully introduced in the major banana-growing areas of Kenya. As a result, in central Kenya up to 32% of planting material is tissue culture-derived. Tissue culture banana technology helped increase banana production from 46,426 ha in 1996 to about 82,000 ha in 2006.

In India, tissue culture propagation of banana has been gaining wide acceptance, with Reliance Life Sciences (RLS) implementing a whole value chain approach. The plant tissue culture division of RLS has established a state-of-the-art plant tissue culture facility and hardening centres across the country. Apart from producing and supplying high quality, virus-free tissue culture plants, RLS is also offering training and management packages. Finally, RLS buys back banana fruits from growers, which are being distributed to retailers and consumers through a chain of retail stores.

Networks among research bodies

National versus regional research centres

Addressing regional issues traditionally leans on the support and direction of regional institutions. However, some national programmes have become centres of excellence and are increasingly able to provide expertise at a regional level, offering new opportunities for augmenting regional efforts. For instance, the national programmes of Kenya provide excellence in sanitary and phytosanitary regulations, while Uganda has proven expertise in diagnostics, deployment of control interventions and biotechnology. The current operational frameworks for addressing regional problems need to increasingly consider such national centres for enhanced effectiveness. These centres could champion processes where national institutions initiate R&D strategies to enhance ownership, as opposed to current arrangements where regional organizations lead the formulation of strategies, resulting in reduced national ownership and support. The New Partnership for Africa's Development (NEPAD) has recognized this and has, through the Biosciences eastern and central Africa (BecA), organized the national banana R&D programmes in the region into a consortium, the Banana Consortium for Central, Eastern and Southern Africa (BACCESA). This should facilitate pooling of expertise to tackle regional issues, such as safe cross border trade and movement of planting material, under one umbrella, but with elevated input and responsibility at the national level. The consortium has recently formulated a strategy and is in the process of mobilizing resources to implement it.

The role of NGOs

While NGOs have been lauded for their ability to respond quickly to crises and to work with a variety of actors to address problems in a coordinated manner, they have also been criticized for their lack of technical capacity and the limited sustainability and short-term nature of their actions. The NGO mandate differs significantly from that of national and international research programmes. NGOs also follow a multi-sectoral approach and as a result are less inclined to view sector-specific technical capacity as an in-house requirement. Whereas research excellence is critical for national and international research centres, management and partnership capacity drive NGO success. The current operational framework for addressing regional banana problems needs to increasingly appreciate the core competencies of NGOs, specifically their capacity to foster and sustain effective networks and partnerships at multiple levels, to administer programmes in complex operating environments, and to leverage technical capacity at both the regional and national level in order to address problems at scale in a timely and cost-effective manner.

South–South cooperation beyond Africa

Production and marketing issues in Africa have some similarity to those in Latin America, where in recent decades banana production has increased in response to increased demand. Lessons can be drawn from such experiences to help address problems in Africa. Plantain in Latin America has benefited from technical advances in the export banana sector, more demanding supply chains organized by supermarkets, and the proximity of growing export markets in North America. This has resulted in more uniform and healthier planting material, agronomic and cultural practices directed to higher yields and better quality fruits (such as increased use of irrigation and fertilizers), and short marketing chains which pay growers based on weight and quality. South–South cooperation between Latin America and Africa could have a stimulating effect on the marketing chain, intensification process, and innovation management as a whole in Africa.

Other networks

In order to boost banana production, in 2001 six countries in Central Africa created the Centre Africain de Recherches sur Bananiers et Plantains (CARBAP). CARBAP contributes to increasing plantain and banana productivity through research, training, sector development and partnership activities at national and regional levels. CARBAP particularly targets improvement of organoleptic and post-harvest qualities of plantain.

The Banana Research Network for Eastern and Southern Africa (BARNESA) was created in 1994 to strengthen national agricultural research and extension systems to improve the productivity of banana-based cropping systems, and to provide a framework for enhancing collaboration, exploiting synergies, avoiding duplication and raising the critical mass for technical research capacity. BARNESA's research and development priorities have shifted in emphasis, from pests and diseases (1994), to post-harvest processing and marketing (2003), to diversity conservation with commercialization of diverse products (2007).

Redima, the documentation and information network for banana in Africa created in 2004 and coordinated by Bioversity International, aims to encourage and facilitate the gathering, generation, management and sharing of knowledge and information among stakeholders; improve access to scientific and technical information produced worldwide; and provide a framework that facilitates technology transfer and capacity building. Redima's members include most national and many regional banana programmes. Redima has put in place many tools and services such as a library, a question and answer service, a regional bibliographic database and a list server.

Farmers Organization Network in Ghana (FONG) was established in 2003. It formally shares information and experiences, aiming to enhance the capacity of member organizations to analyse and communicate to farmers relevant government policies and provide feedback to government on issues that affect farmers, and to act as an intermediary between development partners and members.

Innovation systems

The disconnect between science and application

There is a surprising disconnect between research and application, with a system for technology and knowledge diffusion lacking, resulting in relatively little innovation in the agricultural sector. For example, in East Africa rigorous scientific banana breeding over several decades has not produced much farm-level impact (i.e. widespread diffusion of an improved cultivar), yet East African farmers have reportedly identified over 80 cultivars themselves, without scientific input, in a relatively short timespan. In another example, tissue culture is being heralded as a well-researched application that is transforming agriculture in Kenya with numerous spill-over effects, but other research suggests that only 5% of Kenya's banana farmers seem to have adopted tissue culture bananas.

The definition of innovation, and why it is important

Originally used to mean a new technology, the word 'innovation' is increasingly used for the process of scaling-up through technical and institutional change at farm and higher levels, resulting in impacts on productivity, sustainability and poverty reduction. The key challenge is not so much to transfer technology to users, but to enhance the innovative capacity of key stakeholders, which can only happen through the synergistic interaction of such stakeholders.

In the conventional model of innovation, the emphasis has been placed on the adoption of specific technologies, with impact being assessed on the basis of the number of adopters and the area over which the technology is applied. There are several problems with this narrow perception of innovation: patterns of adoption and potential lessons may be missed, and the risks of negative consequences – such as damaging agro-ecological impacts or widening of socio-economic gaps through preferential adoption of technologies by wealthy farmers - may be ignored. The development community needs to move from this one-step concept of technology introduction to seeing innovation as a process that proceeds from problem definition to technology targeting, testing, monitoring and trouble-shooting - leading to further dissemination or discontinuation depending on the feedback received.

The target group in Africa

Smallholder farmers

Smallholder farmers are by far the majority of the African population, and are the principal target group. Persistent poverty is especially rural, and thus the most promising way to ensure food security and reduce rural poverty is to work with these smallholder farmers and their currently unproductive resources. Smallholder farming presents significant challenges with regard to access to markets by the farmers. Farmers are often remote, mostly work alone, and their production and marketing methods are incompatible with the needs of the larger players in the value chain, for example they are unable to assure quantity and quality of products. All of these limit farmers' access to certain market sectors. Farmgate prices are low yet consumer prices may be very high, meaning that farmers are losing out. An intrinsic characteristic of smallholder farmers is that they have very few opportunities to access improved technology. Appropriate technologies can only be effective within these very small windows of opportunity. The challenge, therefore, is to stretch those opportunities.

Social capitalism, not market capitalism

Turning African farmers into businessmen and connecting them to markets is seen as a goal in addressing rural poverty. However, this is a 'market capitalism' approach, and may not be appropriate to sub-Saharan Africa where farmers operate in a 'social economy'. Under market capitalism, profit maximization is premised on marginal revenue equalling marginal cost. However, in a social economy, profit maximization is premised on marginal social costs equalling marginal social revenues. To achieve the desired outcomes, it is important to understand the institutional context, and the economic system within which the institutional framework is embedded.

Sub-Saharan Africa's social economy is characterized by social capital, social labour, social insurance, traditional knowledge systems and other social institutions. African farmers are already businessmen, but are operating under this different type of capitalism. Attempting to impose market capitalism in African agribusiness is unlikely to work; what is needed is a different kind of capitalism appropriate to the needs and capabilities of the farmers.

The logical conclusion: innovation systems needed

Innovation pathways, along with the technologies themselves, should be the focus of agricultural scientists and research organizations. Conceptualizations of pathways of research-for-development need to be thoroughly understood. Research-for-development needs to work at the interface of technical and institutional change. Several pathways exist, each of which has its merits and shortcomings.

The pathways

Pathway 1: Technology transfer model

The technology transfer model (also known as the supply-push or linear model or pipeline model) emphasizes agricultural research and technology development and looks at innovation as the delivery of science-based technologies to ultimate users, assuming almost spontaneous diffusion among them. From a perspective of reaching and creating impact with smallholders, this model has not been very effective. On the other hand, one of the biggest agricultural success stories, the Green Revolution, has been heralded as a vindication of this model. Closer scrutiny however reveals that this success was achieved only because of the conditions that Asian governments created.

Pathway 2: Farmer-driven innovation

The farmer-driven innovation model is based on the premise that farmers are the best experimenters and will find technological solutions to their problems, appropriate to their circumstances, through trial and error and without knowing the underlying science. This pathway can be harnessed, e.g. by creating farmer experimental groups to carry out systematic experiments in collaboration with researchers.

To improve the identification of farmers' needs and the dissemination of new banana and plantain cultivars in West and Central Africa on a regional scale, CARBAP and partners have used a mother/baby approach for participatory cultivar evaluation. This includes a local network of platforms for dialogue and exchange between all the stakeholders. Each platform includes: (1) a common reference plot with 10 cultivars, (2) a network of 20 farmers, each testing on their individual plots four cultivars chosen from the 10, (3) a steering committee in charge of the management of the platform, and (4) a committee of local experts and users. At key steps of the banana growth cycle, all stakeholders are brought together by a steering committee for joint evaluation.

Pathway 3: Participatory development

The participatory development model focuses on the importance of indigenous knowledge, and assumes that only farmers can provide and steer areas of and conditions for scientific research. This pathway is similar to consumer analysis in marketing research. In practical terms, this pathway focuses on the active involvement of farmers in technology development. In its ultimate form, this is achieved through farmer groups and cooperatives.

In Kenya for example, on-farm trials for introduction of new banana cultivars were conducted using a participatory development approach, whereby farmers used their own criteria to select cultivars which they considered suitable for their areas. Field days helped improve on the research–extension–farmer linkage.

One major criticism of this pathway is that, to be successful, farmers need to have full political and institutional control of, and participate in, a transparent agricultural sector, including the policy environment. Unfortunately, this is not usually the situation in Africa. For example, immigrant settlers engaged in destructive soil fertility management practices do so because of the insecurity of land tenure.

Pathway 4: Market-propelled or -induced innovation/the agricultural treadmill

After the technology supply push pathway, the market-propelled pathway is the model most followed by economists, based on experiences in industrial countries. The model views farms as small business entities and price-takers in a free market. Introduction of a technology allows early adopters to capture a profit because overall prices are still dictated by the prevailing state of the technology. Diffusion leads to over-production and a resulting price reduction. Ultimately, adoption becomes a necessary condition for staying in the marketplace, but now it is no longer profitable. Unproductive farmers are pushed out and their resources are absorbed by the survivors who increase their business by capturing economies of scale. Scale enlargement increases efficiency and competition, leading to higher rates of return to investment in research and extension, and reducing dependency on agriculture (e.g. by freeing labour) in economies.

This neo-liberal economic model, which is the basis for the working of the World Trade Organization, is promoted by the business-oriented NGO TechnoServe. SNV in Zimbabwe has also used this model to enhance the success of market linkage programmes. This entailed developing a market (demand and supply) for both extension services and business development services, and developing the capacity of local service providers to work as a more market-driven support to farmers. As a result, services were better customized to farmers' needs and environment, and more accessible and affordable.

A lack of understanding of this pathway is revealed when scientists believe that the high incomes that early innovators make in the windfall profit phase is something that will happen to all farmers, or when project success is calculated as the rate of return. A shortcoming of this model is that it requires a very specific institutional context – functional research institutes and extension services – that are not generally present in Africa. A second shortcoming is that this pathway externalizes social and environmental costs for farmers, which need to be internalized by well-functioning governments. Thirdly, it promotes formation of large companies, which can then cream off wealth from farmers for the interests of their shareholders, as is seen in commercial banana plantations in Latin America; this is dangerous in environments where few good governance institutions exist to ensure accountability.

In 2003, IITA initiated an outreach programme with NGOs and farmer associations aiming to foster a fast-track cultivar testing and dissemination scheme. The dissemination of new cultivars was coupled with hands-on training in healthy sucker production and post-harvest processing options to overcome scarcity of planting material and to cater for the anticipated excesses.

Pathway 5: Innovation systems

Markets are embedded in institutional contexts that allow them to function, and this newest model is based on the premise that appropriate institutional

conditions, in a broad sense, are required for smallholder development. It has a strong focus on partnerships, networks, coalitions, collaboration and linkages.

Sometimes, a necessary condition for smallholder development is institutional change in a broad sense, addressing issues such as gender relations, patrimonialism, corrective regulatory frameworks, quality controls, price stabilization, access to inputs, and the development of value chains. These are embedded in highly diverse historical contexts and, as such, one cannot treat them as if they were technologies.

Because this pathway looks at innovation as the emergent property not of science or of markets, but of interactions between these, there is a strong focus on engaging all stakeholders. This includes aspects such as negotiations, conflicts, agreements and the ability to undertake concerted synergistic action.

Because institutions emerge from human interaction and agreement, this pathway, unlike the others, cannot be designed, tested and replicated or scaled up like a technology. It needs to be flexible and dynamic.

Institutions

Institutions in Africa

Institutions in the broad sense need to be stimulated and promoted, with emphasis on principles such as fairness, equity, sustainability and opportunity – and driven by development and sustainability goals.

In Africa, with its hugely diverse social and economic systems, one cannot simply design uniform institutional development. Aspects of greatest relevance to farmers need to be incorporated, which, due to the intrinsic fabric of African agriculture, means local adaptation.

Very strong institutions already exist, including patriarchy and patrimonialism. For example, due to the prevailing illiteracy in Uganda, interpersonal channels were found to be the most efficient in informing and changing attitudes of farmers towards new cultivars and practices.

In a study of introduced banana cultivars in Tanzania, farmers made modifications to the technologies to fit the existing farming systems. The pattern of spill-over was very much related to existing social networks in the community. Kin (nuclear and extended family) accounted for half of the spill-over of improved banana germplasm and non-kin (friends and neighbours) for the other half. The introduced bananas were found as far as Dar Es Salaam, more than 300 km away.

Gender as part of the institutional framework

In a study of introduced banana cultivars in Tanzania, the observed gender imbalances in technology spill-over points to the need for new approaches to gender inclusiveness and equity in the target community. This can be addressed through negotiation of rules for equitable technology access.

In Kenya, banana is a 'women's crop', especially when grown for subsistence. Rural women play a central role in food production, processing and marketing. Their contribution is essential to both food security and rural development. However, existing agricultural policies have not adequately considered gender. Also, women do not generally make decisions involving intra-household resource management.

The role of governments and the policy environment: examples

Historically, extension within Nigerian agriculture has been largely a function of the government, and focused on technology transfer within an advisory system, following either a top-down or bottom–top approach. These models have not however successfully achieved agricultural innovation, especially related to dissemination of cultivars. Studies on the adoption level of cultivars in selected states of southern Nigeria show that farmers have adopted less than 50% of IITA-based technologies. Therefore, both public and extension personnel need to be involved in the initial survey to identify different categories of plantain and banana farmers in Nigeria, as groups need to be formed based on the intensity of production, resources and economics while technological information needs to be promoted to farmers.

In Ghana, the policy environment is fairly supportive of the plantain subsector. Although there is no specific plantain policy, the food and agriculture sector and other subsector policies specify strategies that directly or indirectly serve as an incentive framework for plantain development. Hence, there have been several plantain projects related to technology improvement, dissemination and adoption since the 1980s, which have yielded positive results in the 1990s and 2000s. There is significant growth in plantain acreage, output and yield, and producer price. Positive changes in habits, practices and competencies of key actors are clear. Some smallholder farmers have adopted research findings in micropropagation of new cultivars and integrated pest management. The private sector has invested in plantain flour and small-scale processors have commercialized plantain chips as a snack. Many of the actors believe that the government should increase budgetary support to statutory agencies and that NGOs should intervene more strongly in credit provision, transportation services and support for farmer-based organizations.

Generally, Tanzania has well-established agricultural and science and technology policies. However, implementation has been hampered by low investment that did not match government commitments. In Tanzania, most banana producers operate on an individual basis with collaboration amongst themselves rather than with other actors. Growers lack specialized training and operate within traditional systems with very low use of innovations.

The International Livestock Research Institute (ILRI) and Ethiopia's Ministry of Agriculture and Rural Development (MoARD) initiated a five-year project with financial assistance from Canada, called Improving Productivity and Market Success (IPMS) of Ethiopian farmers. IPMS follows participatory value chain and innovation systems perspectives and focuses on knowledge-based development of identified agricultural commodities with market potential. In Metema, the project introduced banana production.

In Uganda, the government has played a critical role in management of Xanthomonas wilt. Because politicians (either heads of key government institutions or locally elected leaders) are trusted by their electors, and have superior mobilization skills, they have been effective in convincing their constituents to participate in Xanthomonas wilt management. Regions with more active leaders have achieved >90% control, compared to <60% where leaders are less active. Also in Rwanda and Tanzania, the disease has been contained following enthusiastic engagement of local district leadership. The government of Uganda has also played a key role by giving high priority to the disease in annual development plans, leading to increases in local budget allocations, as well as lobbying for increased donor support to management activities. In comparison, disease prevalence has almost quadrupled in eastern DR Congo where local leaders have not been effectively involved, largely due to civil instability.

The need for dynamic stakeholder identification

The highly diverse conditions in African farming make a uniform or blanket approach impossible. This has two very important implications for the methodology for developing science-for-impact: (1) an exploratory process is needed to zoom in on crucial opportunities and constraints, and on actors who can make a difference, and (2) we need facilitators or coaches who can foment concerted action among the stakeholders who make innovation happen.

In Cameroon, the lack of synergy among stakeholders is a serious constraint. In the absence of a coordinating body, partners tend to work independently, resulting in a lot of discrepancies in technology transfer. The government has however committed itself to developing the banana sector. There is a key need to establish a stakeholder platform to coordinate efforts, enable interaction, and harmonize technology transfer methods.

Besides the policy framework, other important aspects of stakeholder identification are knowledge infrastructure and the strength of linkages among system actors. For example, those that exist between national research organizations, universities and farmers determine the strengths and weaknesses in the innovation system and the innovative capacity of the actors.

The process of introduction and diffusion of innovations in Nigeria follows the research–extension–farmer linkage system, however poor production has been attributed to weak linkages in the system. Major innovations in the last six years have brought dynamic changes in this classical system. Several technological innovations, such as

macropropagation, introduction of new cultivars and disease control, were subjected to on-farm adaptive research, small plot adoption techniques and then demonstrations to encourage farmers to adopt.

In Kenya, to establish a self-sustaining system of production, distribution and utilization of farmer preferred cultivars of tissue culture banana, a microcredit scheme was implemented by four institutions (KARI, ISAAA, Ministry of Agriculture (MoA) and K-Rep Development Agency). ISAAA acquired the tissue culture plantlets, K-Rep administered and managed the credit facilities, while KARI and MoA provided technical backstopping and extension services, and linked farmers to markets using farmer field schools. In one study, the technologies were found to have been adopted by 90% of the farmers and production increased from 15 to 30 t/ha. Farmers realized incomes 300% higher and several jobs were created in the nursery industry. The provision of credit to farmers significantly increased adoption of the new technologies.

What needs to change among scientists

It has been assumed that the agricultural scientist has expertise in pathways of science, but this is often not the case. Scientists need to learn approaches such as opportunity scoping, diagnostic studies and multi-stakeholder processes, which can help minimize pre-conditional choices by researchers, such as a focus of research on yield/ha. In the innovation systems pathway, the acronym ASTI (agricultural science, technology and innovation) is used, promoting the idea that scientists need to have innovation embedded in their research. There is also a disconnect between the science and technology community on the one side, and policy/decision makers on the other. Also, monitoring of the diffusion and adoption of new technologies is crucial and must not be overlooked.

Capacity building is vital, through creation of an enabling environment for learning, networking, and information and knowledge sharing. We need adapted university curricula, training of scientists and reading materials, as well as recognition of this issue in agricultural science journals. A good example is the training course on ASTI systems based on the innovation system pathway for ACP countries that was recently conducted by the Technical Centre for Agricultural and Rural Cooperation (CTA).

The problem of value chains collapsing immediately after the project timeframe, when the development organization withdraws, is often seen. The main factor is that smallholder farmers are the weakest link in the chain, with insufficient business and agronomic skills to guarantee the success of the new chains as well as sustaining the new business relationships.

What needs to change among extension services

Exposure of farmers though exchange visits has been shown to have a very large positive impact on adoption. In Uganda, the National Agricultural Advisory Services (NAADS) is the decentralized government body responsible for extension. Extension agents deliver agricultural extension services to farmers, however the agent:farmer ratio is very low (1:2,000) resulting in low impact.

Local, community-based organizations are increasingly acting as an alternative to the traditional model of agriculture extension in many sub-Saharan African countries. These organizations are important in the diffusion and adoption of agricultural technologies, but the spill-over effects tend to be more important among participants than non-participants. These organizations are also often formed within villages, and they may have limited impact beyond the village.

The Global Plant Clinic is a good example of strengthening the link between research and farmers, and includes a feedback loop, characteristic of innovation systems. The Global Plant Clinic started in 2003, and grew out of a longstanding if poorly known service for diagnosing plant diseases in developing countries. It is now comprised of over 60 clinics in Asia, Africa and Latin America. Plant health clinics are run by NGOs, farmer cooperatives and others on a weekly basis, consisting of direct and practical question-and-answer sessions with farmers based on concrete problems they are facing (e.g. a diseased plant, and how to deal with it). Often, it is the first time farmers are able to seek answers directly about plant health problems, and find solutions. The Global Plant Clinic also includes extension material, which undergoes farmer peer review. The goal of the Global Plant Clinic is to provide a platform for both gathering demand directly from the farmer, and responding directly to the farmer. In doing this, the Clinic also helps to identify research needs, and strengthens extension–research links. However, there are more complex problems that go beyond the Clinic's capabilities.

The training needs of extension workers involved in banana and plantain technology transfer need to be identified. In a study conducted in Nigeria, these training needs were investigated. Site selection and preparation, harvesting techniques, orchard establishment and orchard management were the most common technology dissemination activities for extension workers. Also, extension workers currently involved in technology dissemination in banana and plantain are not knowledgeable of improved technologies, which calls for a focus on training of extension workers.

Privatization of extension services has been shown to improve their quality in some instances. Although a lot of public funds have been injected into extension, outputs are lacking because of the many challenges facing the public sector such as fund embezzlement, low capacity of extension staff and low extension agent:farmer ratio.

Factors determining adoption: examples

Technology adoption is influenced by the appropriateness of the technology and the dissemination method. In Uganda, to promote fertilizer use, a demonstration plot approach simultaneously allowed participative evaluation, fine-tuning, adoption and adaptation of fertilizer recommendations. This approach can shorten and strengthen the adoption pathway, provided it is supported by proper agronomic and economic evaluation of the technologies tested.

Several studies have been conducted on the drivers of adoption of new banana cultivars. In a study in central Ghana, the use of introduced cultivars was widespread among project and non-project participants, especially in villages where community farmer organizations were active. Knowledge of the new cultivars had spread to non-participant farmers up to a distance of over 30 km. The strengthening of farmer organizations and use of social networks can be effective in better dissemination of improved technologies. Community farmer organizations secured processing machines and credit from the government. Constraints to the further adoption of new plantain technologies include problems with land tenure and access to credit.

In Cameroon, several projects aimed at distributing improved hybrids using macropropagation on a large scale. The adoption of both complementary technologies by farmers depended on the financial support for training by organizations, access to planting material, availability of inputs for farmers, and technical support from the research institution.

Proper scaling up is equally important. In Cameroon, efforts by the various stakeholders to develop the plantain sector have yielded significant results, but have failed to have a significant impact on production, since only a few projects have been implemented and a few areas covered.

In Nigeria, farmers' capacity to choose and use

planting materials and related production techniques was significantly improved by long-term training programmes (four years), but also with field days, demonstration plots, farmer exchange visits, and a platform for sharing information on improved cultivars and associated techniques. Farmers adopted hybrid cultivars because of their direct participation and contact with breeders and other projects partners.

Unlike disseminating new germplasm, new pest and disease control technologies need to be taught and demonstrated to farmers, in order for them to appreciate their positive effects. Farmers then need to make changes in labour allocation in order to adopt them. For example, boiling water treatment of suckers is a seemingly lethal technology that is counterintuitive to farmers, especially when administered to a commodity in short supply such as plantain. However, technology adoption can be facilitated through farmer-participatory hands-on demonstrations. In Cameroon, with no extension system in place, poor road infrastructure, and farmers dispersed in forested territory, disseminating the technology poses a problem. The approach chosen was a combination of workshops and demonstrations. As a positive side effect, many farmers adopting the technology expanded their field size. A negative consequence of the introduction of boiling water treatment was social conflicts arising between adopters and non-adopters.

In Kenya, the government extension service is faced with challenges in providing appropriate technology for HIV/AIDS-affected households. Although HIV/AIDS status of the household had no influence on the initial adoption of tissue culture banana, a higher proportion of HIV/AIDS-affected households was shown to use less inputs and inferior management practices in banana plots, while some households abandoned their plots due to lack of labour, time, cash, skills and knowledge on de-suckering and pruning. The death of an adult household member negatively influenced continued use of tissue culture banana.

In the case of macropropagation, in Uganda several training sites were developed in the four districts. When perceptions of stakeholders were gauged, the majority of respondents preferred that macropropagation services be provided by farmer groups. A reasonable price for plantlets was indicated in the price range US$0.29–0.58. In districts where older plantations are common, the level of adoption was much lower than in those where new fields are being established due to recent losses caused by Xanthomonas wilt.

In DR Congo, because of the numerous political, economic, social and technological constraints to increase banana production and generate income, innovative approaches are identifying best-guess bottlenecks and opportunities, and developing initial priorities. Simple and low-cost strategies to estimate production and planted areas and the extent of serious pest and disease threats are needed to guide investment for greatest impact. This can be done by mapping production potential based on soils, climate, water sources and ease of market access.

In Uganda, since Xanthomonas wilt was first reported in 2001, an aggressive awareness campaign based on cultural control measures has been effective in controlling the disease. Currently, over 85% of banana farming communities know about Xanthomonas wilt identification, spread and control. However, only 30% of the farmers have implemented control methods. With farmer field schools and other participatory approaches, more farmer communities effected cultural control.

A framework possible, and required

Although some pathways, such as the innovation systems pathway, are intrinsically dynamic, a standardized methodological framework for analysing the ASTI systems can still be applied. Formal surveys, farmer records and focus group discussions can be used to establish the path taken and distance covered by the technology, barriers encountered and modifications made by farmers. There is a need to further enhance understanding and conceptualization of innovation processes, the innovation system approach and its relevance to agriculture.

Message 1: Focus on key driver innovations

Apparent financial benefits associated with introduced innovation are related to success of adoption. Cash-generating crops like banana may therefore tend to move faster than soil conservation technologies, for example. To ensure a reasonable rate of adoption of the latter, researchers might link technologies that move slowly with those that move quickly.

'Entry points' refers to interventions that address priority farmer needs, while 'linked technologies' are integrated complementary technologies. Focus group discussions and key informant interviews established that improved tomato, cabbage and banana germplasm were the three most preferred technologies in northern Tanzania, and hence were considered important entry points. Improved banana technology was then linked to soil and water conservation technologies through better fodder species and increased manure from well-fed livestock. The use of innovative scaling-out approaches such as this increases the adoption of technologies that appear expensive and that are less attractive to farmers.

Message 2: Balance the early adopters with the laggards

Coupling technology dissemination activities with credit schemes, or facilitating negotiations among early and late innovators prior to technology introduction, can both help address technology access and uptake by different groups of farmers.

Message 3: Internalize externalities

Negative agro-ecological impacts of innovations can be addressed through complementary technologies that help to minimize negative effects, or by further research (breeding or on-farm experimentation) to improve upon the technology itself.

Feedback loops and local adaptation: an essential part of innovation systems

An in-depth understanding of the factors promoting the spread of technology enables research to capitalize on those factors in the modification of the technology, and allows development agents to focus on the most efficient pathways. For example, in a study of introduced banana cultivars in Tanzania, farmers mentioned the lack of familiarity with the new banana germplasm and limited technical backup as constraining factors. These can be addressed through awareness raising and capacity building. Similarly, concern by farmers that the recommended spacing for banana takes up too much land and increases labour investments during planting and mulching can be addressed through concurrent introduction of crops that can be integrated with banana. The benefits of mulching banana orchards can be capitalized on to explain and promote soil fertility and weed suppression. The identification of the slow rate of propagation of banana suckers as a key adoption constraint prompted the establishment of collective multiplication plots involving schools and community-based organizations, and speeded up the spread of the technology.

In South Africa, banana cultivars grown in the rural areas are 'Pisang Awak' and Cavendish, while in the commercial banana-growing areas only Cavendish is grown. 'Pisang Awak' is a hardy banana cultivar that is currently grown in small plots or along fence-lines. Although 'Pisang Awak' is a lower yielding cultivar, it is a very good juice banana. The establishment of a juice processing facility and fruit collection system has opened the way for farmers to derive significant income. Efforts are underway to introduce higher yielding cultivars, increase the area of production and establish cooperatives, as a means to ensure the viability juice processing and the livelihoods derived from it.

Strategy development during the conference

Synopsis of presentations from the strategy plenary

Some of the strategic needs for reinvigorating the banana sector in Africa are well known. For example, it is known that the private sector has a key role to play, to ensure commercial viability and sustainability. Adding value to banana products through processing is also a key strategy. And much better transport linkages and infrastructure, especially between rural and urban areas, are a requirement that African governments need to urgently address. For banana systems to be productive, research needs to identify sustainable solutions that provide:

- Pest/disease-resistant cultivars
- Integrated pest and disease management methods
- Ways to improve yields under intensified and diversified systems
- Ways to improve quality for export markets (reduce contaminants and increase nutritional value)
- Ways to minimize post-harvest losses
- Ways of adding value, for example through processing.

It is also recognized that there is a need for better linkages, coordination and networking for the impact of results generated from research to be maximized. Too often results are not shared beyond project partners or the region where studies were undertaken. A reorientation of research is needed, towards an integrated system that promotes development and innovation, along with appropriate policy, institutions and technologies.

The Forum for Agricultural Research in Africa (FARA) has a pivotal role to play in this reorientation. The overarching framework of FARA is the Comprehensive Africa Agriculture Development Programme (CAADP), which has four pillars. Pillar IV aims to enhance agricultural research, technology dissemination and adoption, and its implementation is governed by the Framework for African Agricultural Productivity (FAAP). Key goals are to integrate natural resource management, to encourage adoption of appropriate germplasm, to develop sustainable market chains and to stimulate policies for sustainable agriculture. The implementation strategy is built around an informed knowledge base that is organized around innovation platforms that engage stakeholders and engender ownership. In terms of levels of institutional arrangement, national agricultural research systems feed into sub-regional organizations (SROs) which feed into FARA. Technical backstopping is provided by advanced research institutes (ARIs) such as the CGIAR and its partner network, FAO and AATF.

To implement the strategy, the following is envisaged. Each innovation platform will be populated with researchers, extension agents, policy makers, farmers and farmer organizations, private sector, agricultural business staff and developmental partners. Technology dissemination will be market oriented and participatory, and happen through farmer-collective action, farmer-to-farmer learning, market-led technology adoption, a mutual learning market chain approach, demonstration plots and contract farming/out-growers. The strategy would test, validate and promote an innovation systems approach as opposed to the traditional linear research–extension–farmer approach.

Donors present at the conference expressed a keen interest for the strategy to be embedded in the strategy of an African organization such as FARA rather than an international organization such as IITA or Bioversity International. Donors considered that this would result in a greater sense of ownership by Africans. They also expressed their interest in supporting further development of the banana strategy through provision of funds for pilot studies and workshops to refine recommendations and increase awareness.

The sub-regional research and trade organizations, such as the West and Central African Council for Agricultural Research and Development (WECARD), the Southern African Development Community (SADC), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Economic Community of West African States (ECOWAS) and the Common Market for Eastern and Southern Africa (COMESA) also have important roles to play. A presentation on behalf of ASARECA explained how CAADP could be the natural

overarching programme for the banana strategy as this was understood at continental, regional (African Union and NEPAD), sub-regional and national levels.

ASARECA recognizes the potential of banana, as follows. Some 70% of East and Central Africa is of medium to high agricultural potential, with extended annual growing periods and medium market access. Advantages of bananas are that they are perennial and able to grow throughout the year. The economy of East and Central Africa is dominated by agriculture, and to achieve the Millennium Development Goal of halving poverty by 2015, more than 6% growth rate is required in this sector from 2003 onwards. The greatest agriculture-led growth opportunities are in commodities for which there is already a large production base established, such as banana. There exists a large and growing demand in the region, which is assured for fresh banana but so far untested for processed banana products. Clearly, growth is also required in non-agricultural sectors that generate market demand for bananas and in market conditions, such as transport and infrastructure, electricity, and sectors that generate wealth among consumers. Models predicting growth up to 2015, which consider GDP generation per commodity group, estimate that the bulk of growth will come from staple crops such as banana (followed by livestock, fruits and vegetables, oilseeds, hot drinks and pulses).

ASARECA, SADC and WECARD can harmonize national efforts into a synergized regional framework, to share knowledge and experience, training and education. ASARECA, on behalf of the 10 countries it represents, can ensure consultative priority setting, strengthen capacity, enhance partnerships, and support the development and harmonization of information exchange and policies to support banana across the region.

Priorities identified during the first three days of the conference

The priorities identified during the first three days of the conference – what needs to change or be done, for each of the themes (1) markets and trade, (2) production and (3) innovation systems – were summarized by the theme coordinators and presented to the conference (Tables 3–5). These served as the starting point for the participatory session, which aimed to further prioritize needs for the banana sector, as well as how to address them.

Table 3. What needs to change/be done, based on presentations during the first three days of the conference, as summarized by conveners and coordinators for the theme 'markets and trade'.

Market segments • Establish needs and preferences of consumers, and integrate the needs of consumers in technology development and dissemination ('Consumer needs and preferences' in following tables) • Establish major and lasting benefits of involvement in markets (domestic/international/niche) for smallholder farmers ('Benefits of market involvement' in following tables) • Match supply and demand ('Supply and demand' in following tables)
Policies and trade • Decide where to concentrate: on local, regional or global markets ('Focus on local/regional/global markets' in following tables) • Determine export requirements and adjust production and marketing ('Match exports with production and marketing' in following tables) • Liberalize trade
Processing • Stabilize raw material inputs for processing ('Stabilize raw materials for processing' in following tables) • Establish the ethical and food security issues of processing • Develop business support policies and models • Tailor technologies to scale and level of industry ('Tailor technologies to industry needs' in following tables)
Supply • Improve input supply systems ('Improve supply systems' in following tables) • Increase market outlets • Develop scaling-out models for success stories

Table 4. What needs to change/be done, based on presentations during the first three days of the conference, as summarized by conveners and coordinators for the theme 'production'.

Overarching themes • Nutrient cycling • Biotechnology tools • New models for collaboration (multi-sector, maximize local expertise, core competency) • Planting material (clean, indexed, enhanced)
Plant health • Rapid and reliable diagnostics • Clean seed (disinfestations, tissue culture, indexed) • Control mechanisms – options available (awareness, local suitable/practical/appropriate, 'simple', 'basket' of options)
Agronomy • Ecological durability (intensified systems need to be sustainable, nutrient use efficiency/knowledge) • Plantain (expanded opportunities) • Climate change (use of new tools – GIS, modelling, relation to rainfall, temperature, effect on soil, drought, change in wind patterns, implications for pests/diseases and vectors)
Seed systems • Phytosanitary standards (awareness, durable, indexing mechanism, certification, sanitary and phytosanitary capacity) • Linkages (strengthened distribution chain, investments in dessert banana, commercial interests) • Tissue culture enhancement (beneficial microorganisms/micronutrients (e.g. silicon), more viable plants, agronomic packages)
Genetic improvement • Consistent genetic improvement for production (GM and classical breeding in tandem) • Better classification (greater understanding of genetic resources, use of molecular markers) • Greater diversity in genetic resources (knowledge and information, continued collection and characterization)
Post-harvest • Ripening • Production chain improvement (from farm to market) • Storability and shelf life

Table 5. What needs to change/be done, based on presentations during the first three days of the conference, as summarized by conveners and coordinators for the theme 'innovation systems'.

Overall • Commercialization of banana production, benefitting rural communities and smallholders and without compromising food security, through increased research impact and institutional change
Building a better understanding of our clients – social marketing • Improve characterization of where bananas are grown, who produces them, and their major constraints and opportunities as a basis for improving prioritization of research and development funding, for targeting technology generation to specific farm household constraints and opportunities, and for evaluating impact
Making innovation systems more accountable to small farm sector ('Accountable to small farm sector' in following tables) • Strengthen mechanisms for farmers and their organizations to influence the use of applied research and development resources, for farmer feedback to scientists and for farmer policy advocacy
Strengthen agricultural science, technology and innovation linkages ('ASTI linkages' in following tables) • Improve mechanisms to bring together stakeholders for concerted action, to strengthen innovative capacity and to learn continuously from feedback and impact evaluation
Farmers and farmer marketing organizations more effective ('Effective organization' in following tables) • Improve base of methods and experiences for building business capacity among farm households and their organizations, including capacity to identify potential and realistic markets and more effective farmer-oriented marketing structures
Better information and services for different types of farmer households ('Information services' in following tables) • Broaden and innovate approaches directed to different subgroups of farm households to improve their access to useful, quality information, tools, services and support institutions with feedback to scientists on effectiveness of results
Orienting R&D organizations on pathways of science for impact ('R&D organizations – impact' in following tables) • Strengthen rewards system, training and capacity development for research and development organizations and their professionals for more effective pathways of science for impact

Identification of organizations and partnerships

Following presentations from the theme coordinators, an open forum discussion was held to identify types of organizations and partnerships required to implement or operationalize a banana strategy for Africa. The results are given in Table 6.

Table 6. Types of organizations/stakeholder groups identified by participants during open forum discussions on Strategy Day. Some examples are given in brackets.

Principal actors in the banana market chain		
• Smallholder farmers	• Regional traders	• Arts and crafts producers
• Private commercial farmers	• International traders	• Industrial fibre and fuel producers
• National and multi-national banana companies	• Airlines, shipping lines and freight companies	• Small- and medium-scale retailers
• Farmer organizations	• Individual and community-level food processors	• Supermarkets
• Local traders and middlemen	• Industrial food processors	• Consumers
Supporting actors providing technical and other services		
• National extension services	• Consultants	• Private investors
• Local, regional and international development NGOs	• Input suppliers (planting material, fertilizer, pesticides, irrigation equipment etc.)	• Credit and financial institutions
• Community-based organizations	• Microfinance providers	
Other actual or potential stakeholders/actors		
• Social and healthcare workers	• Local religious and cultural leaders	• Local, national, regional and international media
Sources of new technology and innovation		
• University agricultural faculties, agricultural schools and colleges	• Regional banana networks (BARNESA, MUSACO)	• Advanced research institutes (CIRAD)
• National agricultural research organizations (KARI, NARO, NIHORT)	• International agricultural research centres (IITA, Bioversity, CIAT, CTA)	• Other international agricultural R&D and information organizations (FAO, CTA, AATF)
• Regional research organizations (CARBAP, IRAZ)		
Actors determining and affecting policy and the operating environment		
• Government ministries (agriculture, finance, infrastructure, education and technology etc.)	• Chambers of commerce	• Regional policy organizations (FARA)
• National, regional and international phytosanitary regulators	• Local authorities	• Sub-regional research organizations (ASARECA, BecA, CORAF/WECARD)
• Other regulatory agencies (food safety etc.)	• Port and airport authorities	• Donors (to agricultural R&D, infrastructure etc.)
• Certification organizations (fair trade, organic etc.)	• Regional economic and development organizations (NEPAD, CAADP, COMESA)	

Participatory strategy development

During the afternoon, a participatory approach was followed. Participants worked in their chosen commodity/market orientation groups with eight per group. The aim for each group was to select the three most important priorities for their commodity and market orientation. Groups used the lists presented by the theme coordinators (Tables 3, 4 and 5) but were also able to add priorities that had not already been identified. Results are presented collectively in Tables 7, 11 and 15, for East African highland banana, plantain and dessert banana, respectively.

Next, the same groups focused on how the selected priorities might be achieved. They were also asked to identify, if possible, which type of organization should facilitate or coordinate the activities, and which ones should also collaborate. Results are given in Tables 8, 9 and 10 for East African highland banana in local, regional and international markets, respectively; in Tables 12, 13 and 14 for plantain in the same markets; and for dessert banana, under a slightly different format, in Table 16. The dessert banana group focused on a value chain approach, and developed four models: (1) strengthen existing value chains, (2) ensure value adding for each chain actor, (3) replicating the value chain of producer-based market integration model and (4) change people to become entrepreneurs.

Table 7. Prioritization of what is required to make progress in the next 10 years for East African highland banana for local, regional and international market development, as harnessed from participatory sessions during Strategy Day. Numbers in parentheses indicate the number of groups that identified the priority where this was more than one; all other priorities were identified by a single group.

Theme	Market level		
	Local	Regional	International
Markets and trade	• Supply and demand (3) • Benefits of market involvement • Consumer needs and preferences • Focus on local/regional/global markets	• Supply and demand (3) • Benefits of market involvement • Consumer needs and preferences • Focus on local/regional/global markets	• Supply and demand (3) • Benefits of market involvement • Consumer needs and preferences • Focus on local/regional/global markets
Production	• Planting material (2) • Rapid and reliable diagnostics • Clean seed • Control mechanisms • Ecological durability • Production chain improvement	• Planting material (2) • Rapid and reliable diagnostics • Clean seed • Control mechanisms • Ecological durability	• Planting material • Rapid and reliable diagnostics • Control mechanisms • Consistent genetic improvement
Innovation systems	• ASTI linkages (2) • Information services • Effective organizations	• ASTI linkages (2) • Information services	• ASTI linkages (2)
Priorities not listed by theme coordinators	• Farming systems (2) • Water management • Technical information service to link outreach/sensitization/extension/ information dissemination	• Technical information service to link outreach/sensitization/extension/ information dissemination	• Technical information service to link outreach/sensitization/extension/ information dissemination

Priorities recognized as important but not selected in top three: nutrient replenishment; breeding with wild populations; studies to understand physiology of banana; improvement of traditional seed systems/macropropagation; better links between production, research and extension; packaging and transportation; foster formation of farmer groups for their empowerment to reduce reliance on middlemen to maximize farmer profit; studies on potential of banana to improve human nutrition and health.

See Tables 3, 4 and 5 for priority titles in full.

Table 8. How to achieve the identified priorities for East African highland banana for local market development. '–' signifies that no group tackled the priority due to time constraints. Where two different groups addressed the same priority, the two sets of responses are given.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Markets and trade			
Supply and demand	• Farmer campaigns for increased production • Sensitization, training and workshops • Processing for value addition • Identify new market opportunities • Market information systems	• NARES • NGO • Extension	• Farmer groups • Community-based organizations • Media • Technology developers
Benefits of market involvement	• NGOs advise farmer group leaders • Production centres • Strategy to sustain farmer groups • Strategy for sustainable production/sustainable marketing • Organizational transparency and sustainability • Production schedules • Market price announcements • Regular meetings • Identify new market opportunities	• NGO • Farmer group leaders	• Farmer group members • Farmers
Consumer needs and preferences	• Market information • Participatory technology development • Marketing	• Agri-business • NARES • East African Community	• NGO • Donors • Farmer organizations • NARES
Focus on local/regional/global markets	–	–	–
Production			
Planting material	–	–	–
Rapid and reliable diagnostics	• Institutionalizing services • Training and networking • Cost-effective tools • Surveillance and monitoring • Certification schemes	• NARES • Phytosanitary bodies • Regional research organizations • CGIAR	• NGOs • Government agencies • Farmers • Community-based organizations • Private sector
Clean seed	• Improve quality and supply of seed • Establish mother gardens • Increase indexing capacity • Improved efficiency of tissue culture production • Upscale macropropagation • Surveillance and monitoring • Policy and quarantine	• NARES • CGIAR • Regional organizations • East African Community	• Farmer groups • Community-based organizations • NGO • Donors • Private sector • Phytosanitary services
Clean seed	• SPS regulations and enforcement • Somoclonal variation reduced • Verify true to type tissue culture plants • Virus indexing • Farmer-orientated production package • Low price of tissue culture plantlets	• Farmer • Research • Government	• Research • Extension • Farmer associations • NGO • Input suppliers

Control mechanisms	–	–	–
Ecological durability	• Capacity building • Policy and quarantine • Demonstration plots • Increased extension with more visits • Collate existing experiences • Design cropping systems • Clean seed • Conducive policies including subsidies • Fair taxation system • Premiums offered for increased quality • Farmer groups more cohesive • Better use of new and existing funds • Greater transparency and accountability	• Research • Farmer organizations	• Research • Extension • Farmer organizations • NGO • Input suppliers
Ecological durability	• Land stewardship • Appropriate field size • Ensure ecological balance first • Soil conservation • Tree planting • Water management • Underplanting/intercropping • Policy development • Livestock integration	• Ministries of Agriculture • Ministries of Environment	• Environmental management agency • Extension • Research • NGO • Donors • Private sector • Universities • Communities • Local governments
Production chain improvement	–	–	–
Innovation systems			
ASTI linkages	–	–	–
Information services	–	–	–
Effective organizations	–	–	–
Priorities not listed by theme coordinators			
Farming systems			
Water management	• Combined with nutrient management • Conservation technologies • Studies on erosion, mulching • Studies on manure and crop associations • Irrigation • Fertilizer efficiency • Cultivar selection • Site soil studies • Weed management • Tillage studies	• Ministries of Agriculture	• NGO • Extension • Communities • Donors • Research • Private sector • Universities • Local government
Technical information service to link outreach/sensitization/ extension/information dissemination	–	–	–

See Tables 3, 4 and 5 for priority titles in full.

Table 9. How to achieve the identified priorities for East African highland banana for regional market development. '–' signifies that no group tackled the priority due to time constraints. Where two different groups addressed the same priority, the two sets of responses are given.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Markets and trade			
Supply and demand	• Knowledge of market needs • Control supply with demand • Fresh produce system • Processed product system	• Regional organizations	• Governmental agencies (e.g. PIBID) • Private sector
Benefits of market involvement	–	–	–
Consumer needs and preferences	• Conduct surveys • Prioritize research • Prioritize technology development	• Regional organizations: ASARECA, CORAF	• NARES • CGIAR • MUSACO • CARBAP • Private sector
Focus on local/regional/global markets	• Develop policy • Develop transport infrastructure • Market information • Postharvest handling, certification and packaging • Tariff barriers harmonized • Phytosanitary measures • Product promotion	• Governments • Regional organizations • Private sector	• Donors • Farmer groups • Schools
Production			
Planting material	• Create germplasm repository • Conserve germplasm diversity • Prospect for germplasm • Characterize germplasm diversity	• Regional organizations (CARBAP, ASARECA)	• NARES • CGIAR
Planting material	• International training in best practices • Training in macropropagation (PIF)	• Regional organizations (CARBAP, CORAF)	–
Rapid and reliable diagnostics	• Link to control practices • Quicker diagnoses • Localization and training of plant doctors • Increase coordination between NARES • Establish centres of excellence • Commercialize diagnostic tests, user validation of control methods	• Regional organizations (ASARECA)	• Private sector
Clean seed	• Increase capacity for virus indexing • Develop regional standards • Harmonize regional standards • Catalogue pest and disease lists • Training • Prepare policy briefs • Harmonize legal frameworks	• Regional organizations (ASARECA) • EAC for regulation	• NARES • Bureau of standards • Private sector

Control mechanisms	–	–	–
Ecological durability	–	–	–
Innovation systems			
ASTI linkages	–	–	–
Information services	–	–	–
Priority not listed by theme coordinators			
Technical information service to link outreach/sensitization/ extension/information dissemination	• Establish knowledge resource centre • Bottom up as well as top down • Package information for clients • Pre-testing • System for dissemination • Translation resources • Monitoring and evaluation system • Communication specialists • Equipment, training, develop national nodes	• Regional organizations	• NARES • Regional NGOs • Private sector, e.g. media, printers

See Tables 3, 4 and 5 for priority titles in full.

Table 10. How to achieve the identified priorities for East African highland banana for international market development. '–' signifies that no group tackled the priority due to time constraints. Where two different groups addressed the same priority, the two sets of responses are given.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Markets and trade			
Supply and demand	–	–	–
Benefits of market involvement	–	–	–
Consumer needs and preferences	–	–	–
Focus on local/regional/global markets	–	–	–
Production			
Planting material	• Virus indexing • Quarantine policies • Provide affordable planting material • Develop internationally accepted certification • Develop internationally acceptable screening	• CGIAR	• Universities • NARES • National laboratories • International Laboratories • Donors
Rapid and reliable diagnostics	• Increased coordination • Standardized protocols • Supply chains for reagents, etc. • Reduce costs • Improve technologies • Surveillance systems	• CGIAR	• ARIs • Local governments • NARES • Universities • Donors
Control mechanisms	–	–	–
Consistent genetic improvement	• Focus on landraces for breeding programmes • Look for new sources of resistance • Diversify parent materials • Clarify intellectual property rights • Test GM banana technologies	• CGIAR	• NARES • Donors • National genebanks
Innovation systems			
ASTI linkages	–	–	–
Priority not listed by theme coordinators			
Technical information service to link outreach/sensitization/ extension/information dissemination	–	–	–

See Tables 3, 4 and 5 for priority titles in full.

Table 11. Prioritization of what is required to make progress in the next 10 years for plantain for local, regional and international market development, as harnessed from participatory sessions during Strategy Day.

Theme	Market level		
	Local	Regional	International
Markets and trade	• Consumer needs and preferences • Stabilize raw materials for processing • Tailor technologies to industry needs • Improve supply systems	• Consumer needs and preferences • Stabilize raw materials – processing • Match exports with production and marketing • Tailor technologies to industry needs • Improve supply systems	• Consumer needs and preferences • Stabilize raw materials – processing • Match exports with production and marketing • Tailor technologies to industry needs • Improve supply systems • Liberalize trade
Production	• Rapid and reliable diagnostics • Clean seed • Control mechanisms • Ecological durability • Phytosanitary standards	• Rapid and reliable diagnostics • Clean seed • Ecological durability • Phytosanitary standards • Consistent genetic improvement	• Clean seed • Ecological durability • Phytosanitary standards • Consistent genetic improvement
Innovation systems	• ASTI linkages • Information services • R&D organizations – impact	• ASTI linkages • Accountable to small farm sector • R&D organizations – impact	• ASTI linkages • Accountable to small farm sector • R&D organizations – impact

Priorities recognized as important but not selected in top three: regular supply of raw materials; soil biology: presence/absence of beneficial organisms; facilitate integration of farmers into marketing system; maintain/conserve banana diversity for future generations and their food security; promote production and advocate consumption of yellow-flesh (high-carotene) plantain for child and maternal health; standardize diagnostic tools (for production research and impact assessment); promote intensive monocrop plantain to increase supply and meet demand (especially urban); stabilize mixed cropping system for rural food security; education and training to increase communication between community, farmers, extension; establish demonstration plots to encourage adoption of new technologies.

See Tables 3, 4 and 5 for priority titles in full.

Table 12. How to achieve the identified priorities for plantain for local market development. '–' signifies that no group tackled the priority due to time constraints.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Markets and trade			
Consumer needs and preferences	–	–	–
Stabilize raw materials – processing	• Organized committees representing farmer' interests	• Farmer-selected committees	• Private sector • Wholesalers • NGOs • Brokers
Tailor technologies to industry needs	–	–	–
Improve supply systems	• Standardization and negotiation for supply inputs	• Farmer-selected committees	• Local governments
Production			
Rapid and reliable diagnostics	–	–	–
Clean seed	–	–	–
Control mechanisms	–	–	–
Ecological durability	–	–	–
Phytosanitary standards	–	–	–
Consistent genetic improvement	–	–	–
Innovation systems			
ASTI linkages	–	–	–
Information services	–	–	–
R&D organizations – impact	–	–	–
Priorities not listed by theme coordinators			
Maintain/conserve banana diversity for future generations and their food security	• Enlighten farmers on role of diversity • Select and conserve cultivars with good traits • Maintain culture of consuming local cultivars • Establish collections in schools and universities	• Farmers	• Extension agents • Women organizations NGO • Research • Local governments

See Tables 3, 4 and 5 for priority titles in full.

Table 13. How to achieve the identified priorities for plantain for regional market development. '–' signifies that no group tackled the priority due to time constraints.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Markets and trade			
Consumer needs and preferences	–	–	–
Stabilize raw materials – processing	–	–	–
Match exports with production and marketing	–	–	–
Tailor technologies to industry needs	–	–	–
Improve supply systems	• De-emphasize use of fertilizers, pesticides and other costly inputs in favour of IPM and soil fertility management	• CGIAR • ARIs • Universities • IFAD	• Farmer groups • NARES • NGOs • Private sector
Production			
Rapid and reliable diagnostics	–	–	–
Clean seed	–	–	–
Ecological durability	–	–	–
Phytosanitary standards	–	–	–
Consistent genetic improvement	• Target all pests and diseases • Enlarge programmes	• Regional organizations	• CGIAR • ARIs • AATF
Innovation systems			
ASTI linkages	• Infrastructure • Education/awareness • Access agronomic planting calendar	• Farmers	• Wholesalers • NGOs • Brokers
Accountable to small farm sector	• Accountability of technology innovations to farmers	• Farmer-selected committees	• Private sector
R&D organizations – impact	–	–	–

See Tables 3, 4 and 5 for priority titles in full.

Table 14. How to achieve the identified priorities for plantain for international market development. '–' signifies that no group tackled the priority due to time constraints.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Markets and trade			
Consumer needs and preferences	–	–	–
Stabilize raw materials – processing	–	–	–
Match exports with production and monitoring	–	–	–
Tailor technologies to industry needs	–	–	–
Improve supply systems	–	–	–
Liberalize trade	–	–	–
Production			
Clean seed	–	–	–
Ecological durability	–	–	–
Phytosanitary standards	–	–	–
Consistent genetic improvement	• Improve the quantity and quality of planting material	• FARA	• Regional organizations
Innovation systems			
ASTI linkages	–	–	–
Accountable to small farm sector	• Feedback and distribution of funds to support appropriate production methods • Development of protocols	• NGOs • Private sector	• NARES • Farmers • Universities • CGIAR • ARIs • UN • Credit providers
R&D organizations – impact	• Improve the supply of improved planting material		• Farmer organizations • CGIAR

See Tables 3, 4 and 5 for priority titles in full.

Table 15. Prioritization of what is required to make progress in the next 10 years for dessert banana for local, regional and international market development, as harnessed from participatory sessions during Strategy Day. Numbers in parentheses indicate the number of groups that identified the priority where this was more than one; all other priorities were identified by a single group.

Theme	Market level		
	Local	Regional	International
Markets and trade	• Supply and demand (3) • Develop business support policies and models (2) • Tailor technologies to industry needs • Focus on local/regional/global markets • Liberalize trade	• Develop business support policies and models (3) • Supply and demand • Tailor technologies to industry needs • Liberalize trade	• Develop business support policies and models (2)
Production	• Control mechanisms (3) • Production chain (3) • Rapid and reliable diagnostics • Nutrient cycling • Ripening	• Control mechanisms (2) • Production chain (2) • Rapid and reliable diagnostics (2) • Nutrient cycling • Ripening	
Innovation systems	• Information services (4) • Accountable to small farm sector (2) • Effective organizations	• Information services (2)	• Information services (2)
Priorities not listed by theme coordinators	• Value chain analysed and strengthened by identifying committed leaders (4) • Water management • Farming systems • Assessment of advantage of banana • Product quality grading • Capacity building for farming to become a business	• Value chain analysed and strengthened by identifying committed leaders (4) • Institutional building	• Value chain analysed and strengthened by identifying committed leaders (3) • Institutional building • Capacity building for farming to become a business

See Tables 3, 4 and 5 for priority titles in full.

Table 16. How to achieve the identified priorities for dessert banana.

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Model 1. Strengthen existing value chains			
Integration of partners (horizontal and vertical)	• Empowering farmers to know the value of their crops and to access market information • Empowering farmers to make decisions	• Governments • NGOs	• NGO • Local governments • Farmer groups
Input supply systems: timely fertilizer supply, quality seed	• Empower suppliers and traders to increase service • Increase use of media	• Private sector • Media • Governments	
Improve production	• Enhance soil fertility • Increase crop protection deployment • Train farmers in crop protection methods • Develop appropriate crop protection methods • Monitor adoption and impact	• NGOs • FAO • Governments • Extension	• Community-based organizations • Private sector • NGO • Research
Postharvest	• Handling • Ripening • Harvesting • Transportation • Cultivar selection • Quality, regularity, quantity • Establish standards that comply with international standards • Market-focused grading • Crop protection	• Governments	• NGOs • Farmers • Research
Processing	• At cottage level • Respect international standards	• National regulatory bodies • Extension agencies • Private sector	• Researchers • Farmers • Consumers • Regulatory bodies
Model 2. Ensure value adding for each chain actor			
Export investment chain leader driven	• Feasibility study • Share results • Organize logistic chain • Legal framework • Market integration and price	• Importers • Exporters • Local industry	• Government • Banks • Shippers • Insurance companies
Production	• Introduction of new/improved cultivars • Use expert consultants • Mobilize farmers • Develop farmer interest groups • Integrate with market information	• Importers • Exporters • Farmers	• Retailers • Importers • Exporters • Consultants • Government
Measure of progress of above	• Share of banana market for African banana increased by 25% • Business success increased from 80% failure to 60% failure • Income generated used to sustain production • Local/regional/international		

	cooperation increased through inter-country collaboration • Chain efficiency improved as each role player adds value		
Model 3. Replicating the value chain of producer-based market integration model			
Producer-based market integration model	• Regional focus • Consultation process across region • Build partnership consensus • Pilot testing of producer-based market integration model • Policy environment to support a competitive value chain • Analysis for advocacy • Policy regional dialogue • Policy change	• Regional organizations • University-based think tanks	• Farmer groups • Private sector • Transporters • Research • Governments • Donors • Processors
Future performance indicators: (1) Production/economic impact	• Farmer and group income • Percentage of retail price • Farm cost and investment in production • Jobs created		
Future performance indicators: (2) Process of change	• Project cost to establish functioning units	• NGOs	
Future performance indicators: (3) Institutionalization	• Number of operational hubs • Sustained presence of input supplies • Growing level of input supplies		
Model 4. Change people to become entrepreneurs			
Site selection for pilot trials	• Region • Country • Measure of success shown by number of platforms to drive sustainable system	• Regional organizations	• NARES • Farmer groups • Donors
Selection of strong leaders	• Amongst farmers: how to choose; how to empower; farmer-selected? • Amongst other partners: how to chose them and link to markets? • Measure of success assessed by number of farmer associations	• Farmers • NGOs	• Extension
Farmer associations	• Legal framework • Measure of success based on establishment of framework	• NGOs • NARES • Regional organizations	• Ministries of agriculture
Accountable partner interactions	• Quality chain accountability • Input supplies • Encourage entrepreneurs • Minimize risks (though improved practices and information dissemination) • Formularization of value chain • Measure of success: determined by country task force / steering committee	• Private sector • Research • NARES	• Extension • Private sector

Priority (what needs to change/be done)	How can this be achieved?	Who will facilitate?	Who will collaborate?
Training	• Information and knowledge management • Regional platforms • Create sustainable value chain with increased number uantitative and uantitative • Measure of success based on number of workshops and number of people trained	• Research • NARES	• Extension • Private sector • Governments • armers
Increase market opportunities	• Increase consumption • Higher productivity • More consistent production • Increase awareness through promotion • Measure of success determined by consumption figures	• AO • Ministries of health • I AVA (Institute of ruit and Vegetable Alliance)	

Interpretation of results from participatory sessions

The participatory approach used cannot produce true quantifiable data, but it makes the most of the diversity of experiences and expertise of participants to set priorities for the future. The priorities identified, and the proposed ways to address them, can be used to guide the next steps of strategy development for the different banana types and the different markets.

Table 17 summarizes the priorities under the three themes for the three banana types, and shows which priorities are perceived to be shared across banana types and which are relevant to just one type. This can help to guide interventions for the banana sector based on banana type.

Table 17. Identified priorities under the three themes for the three banana types.

Priorities shared by banana types	Priorities relevant to one banana type
Markets and trade	
• Supply and demand (dessert banana + East African highland banana) • Tailor technologies to industry needs (dessert banana + plantain) • Focus on local/regional/global markets (dessert banana + East African highland banana) • Consumer needs and preferences (plantain + East African highland banana) • Liberalize trade (dessert banana + plantain)	Dessert banana • Develop business support policies and models Plantain • Stabilize raw materials – processing • Match exports with production and monitoring • Improve supply systems East African highland banana • Benefit of market involvement
Production	
• Control mechanisms (all three types) • Production chain (dessert banana + East African highland banana) • Rapid and reliable diagnostics (all three types) • Clean seed (plantain + East African highland banana) • Ecological durability (plantain + East African highland banana) • Consistent genetic improvement (plantain + East African highland banana)	Dessert banana • Nutrient cycling • Ripening Plantain • Phytosanitary standards East African highland banana • Planting material
Innovation systems	
• Information services (all three types) • ASTI linkages (plantain + East African highland banana) • Accountable to small farm sector (dessert banana + plantain) • Effective organizations (dessert banana + East African highland banana)	Plantain • R&D organizations – impact
Priorities not listed by theme coordinators	
• Water management (dessert banana + East African highland banana) • Farming systems (dessert banana + East African highland banana)	Dessert banana • Value chain analysed and strengthened by identifying committed leaders • Institutional building • Assessment of advantage of banana • Product quality grading • Capacity building for farming to become a business East African highland banana • Technical information service to link outreach/sensitization/extension/information dissemination

A 10-year strategy for banana in Africa

Priorities

The priorities identified through participation of the diverse stakeholders gathered at the conference are summarized in Table 18, under the different banana types and market levels. Based on the range of expertise and experience of the participants, this informed and authoritative summary can be used to guide investments, policies and activities to energize the banana sector in Africa.

Table 18. Priorities for the banana sector in Africa, by banana type and market level. Where every group (of 8 people) selected an issue as one of their key three priorities, the symbol ● is shown; where more than 50% of groups selected the same priority the symbol ⊙ is shown; and if less than 50% of groups (but at least one) highlighted a priority the symbol o is shown. Loc = local market, Reg = regional market, Int = international market.

Priorities	Banana type and market level								
	East African highland banana			Plantain			Dessert		
	Loc	Reg	Int	Loc	Reg	Int	Loc	Reg	Int
Markets and trade									
Supply and demand	●	●	●				●	o	
Consumer needs and preferences	o	o	o	●	●	●			
Stabilize raw materials for processing				●	●	●			
Tailor technologies for industry needs					⊙	⊙	o	o	
Develop business support policies and models							⊙	●	⊙
Focus on local/regional/global markets	o	o	o				o		
Benefits of market involvement	o	o	o						
Liberalize trade						o	o	o	
Improve supply systems				o	o	o			
Match exports with production and marketing					o	o			
Production									
Planting material	●	●	⊙	●	●	●			
Rapid and reliable diagnostics	o	o	o	⊙	⊙		⊙	⊙	
Control mechanism	o	o	o	o			●	●	
Ecological durability	o	o		⊙	⊙	⊙	o	o	
Consistent genetic improvement			o	⊙	⊙	⊙			
Phytosanitary standards				⊙	⊙	⊙			
Reduction in post-harvest losses	o						●	⊙	
Ripening technologies							o	o	
Innovation systems									
ASTI linkages	●	●	●	●	●	●			
Information services	⊙	⊙		⊙			●	⊙	⊙
Accountable to small farm sector					⊙	⊙		⊙	
R&D organizations – impact				⊙	⊙	⊙			
Effective organizations	⊙						o		

See Tables 3, 4 and 5 for priority titles in full.

Priorities shared by two or more banana types

Matching supply and demand, and growers selecting the most suitable market types, are key priorities for both dessert banana and East African highland banana under markets and trade. For East African highland banana and plantain, recognition of consumer preferences is a key priority (to integrate the needs of consumers in technology development and dissemination). For plantain and dessert banana, the need to tailor technologies to scale of industry, and liberalizing trade, are key.

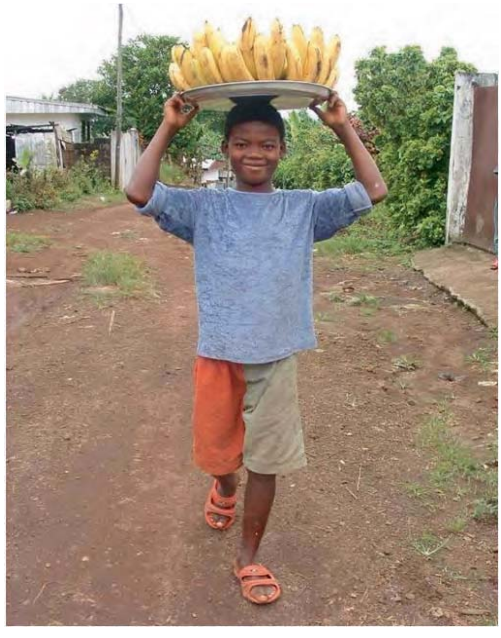
High priorities for production across all banana types are control mechanisms for pests and diseases, and technologies for rapid and reliable disease diagnostics. Two diseases dominated discussions: Xanthomonas wilt and banana bunchy top disease (BBTD). These diseases are currently spreading rapidly in Africa and are of special concern, both because of the severe losses they cause and because all types of cultivars seem to be susceptible. Xanthomonas wilt can be confused with Fusarium wilt, and the early stages of BBTD are difficult to identify, hence the need for rapid and reliable diagnostics. Fusarium wilt is a major problem for finger bananas and the widespread 'Kayinja' (ABB).

Another production priority for all banana types is ecological durability for intensified farming systems (especially the sustainability of nutrient use efficiency and knowledge of appropriate agronomic methods). Disease-free planting material and improved cultivars are crucial for East African highland banana and for plantain. For East African highland banana and dessert banana, excessive post-harvest losses are a key factor that needs to be tackled. During discussion, research on farming systems and water management was also identified as a key priority for East African highland and dessert bananas.

Improved information systems are a key priority for all banana types in order to promote innovation. Growers need access to useful, high-quality information, tools, services and support institutions. For East African highland banana and for plantain, linkages with agricultural science and technology need to be strengthened to increase innovative capacity and to learn continuously from feedback and impact evaluation. For East African highland and dessert bananas, improved support to help develop farmer and marketing organizations is key, to build business capacity and strengthen farmer-orientated marketing arrangements. In general, innovation systems need to be more responsive to the needs of smallholder farmers, with stronger mechanisms for farmers and farmer organizations to provide feedback to researchers and to the decision-makers guiding the research agenda.

Additional priorities for East African highland banana

As well as the priorities shared with other banana types, for East African highland banana the involvement of market representatives throughout the value chain is key. This will help establish major and lasting benefits for small-scale farmers in existing local and regional markets, as well as potential international markets, and reduce the influence currently exerted by middlemen. During discussion, the need for an effective extension service was identified to supply technical information and facilitate on-farm demonstrations, for all three market orientations.



Additional priorities for plantain

For plantain, in addition to the priorities shared with other banana types, the following are seen as key: for markets and trade, improved input supply systems and stabilization of raw material inputs for processing; for production, the need to develop and regulate phytosanitary standards; and for innovation systems, the need was highlighted to train and

reward research-and-development actors, so that organizations and staff deliver science for impact through more effective pathways.

Additional priorities for dessert banana

Key priorities for dessert banana, in addition to those shared with other types, include the development of business plans that include models and advocacy for policies. This is needed for all market orientations. During discussions this priority was reinforced, with an expressed need to analyse the value chain and to strengthen it through the identification and engagement of committed leaders, particularly for local and regional markets but also for international markets. Post-harvest ripening technologies are also a priority for dessert banana at local and regional market levels (but not international, as it is perceived that freight operators are aware of appropriate techniques). Across all market levels, institution-building is important as well as capacity-building to enable farmers to become more business orientated.

From priorities to action

Priority setting is a only first step in strategy development. The next step is identifying who needs to do what to achieve these priorities. Participants addressed this in a plenary session that aimed to identify the types of organizations and their roles and responsibilities for achieving the priorities. The essence of this discussion is presented below, grouped under key themes.

Improving linkages

Improving linkages along the value chain is crucial and urgent if the banana sector is to be transformed. Better linkages, which depend on improved information provision and communication between actors, are key to achieving many of the identified priorities. Within markets and trade, for example, successful matching of supply and demand depends to a large extent on information flow through effective linkages. Similarly for production, improved linkages are critical to solve the current disjunct between science and practice, and allow farmers to access knowledge so that they can address production constraints. And effective linkages are at the heart of successful innovation systems, which are vital for transforming the banana sector.

All stakeholders must recognize their responsibility to nurture synergistic relationships along the commodity chain. Principal actors (growers, traders, agribusiness, processors, retailers and consumers; see Table 6) must be open to sharing information with other stakeholders, while supporting actors (who provide services, inputs and technologies) and those determining the operating environment (governments and subregional trade organizations) have a key role in initiating and promoting new ways of working that encourage stronger linkages. Extension services provide a particularly critical link in the banana chain and need to be strengthened – a role and responsibility of governments.

To improve linkages across regions, participants suggested creating formal 'knowledge platforms' to share current knowledge and to facilitate multi-site testing, training and education with farmer groups. Regional platforms would feed into a pan-African system for consultative priority setting that would be charged with information exchange, strengthening capacity, forging partnerships and developing policy to support banana production and trade across the continent.

Empowering farmers

The banana sector will only be successfully transformed if the position of producers is strengthened. Farmers are greatly empowered by working together in cooperatives or farmer associations. Farmers who work together in groups are in a much better position to address production constraints and to respond to markets. Information sharing and training are greatly facilitated, and effective innovation systems can develop more easily as economy of scale is increased from individual farmers to farmer organizations. Supporting actors, such as NGOs and community-based organizations, have a key role in promoting development of farmer groups. It is also in the interest of agribusinesses to support the creation and operation of farmer groups, as it is more efficient and therefore financially viable for them to work with groups, for example for supply of inputs and purchase of greater volumes of product.

Production

Better linkages and farmer organization will greatly facilitate optimization of production practices, and also help to guide research priorities. Key actors to work with farmers in addressing production priorities are those providing technical services, particularly extension services, and those working to develop new technologies and stimulate innovation, particularly the national and international research community. Actors determining the policy and operating environments also have a role to facilitate access to technologies and services. Banana genetic resources underpin production systems, and collecting, characterizing and sharing of banana germplasm will require continuing efforts of the international agricultural research centres, national agricultural research systems, advanced research institutes, and regional research organizations and networks.

Markets and trade

Again, effective linkages and participation in farmers' organizations are crucial to enhance farmers' abilities to understand and respond to markets at all levels. However, markets are rapidly changing, and responding effectively and appropriately will be a major challenge across the banana chain.

At the local and regional level, expanding urban markets and the flourishing supermarket sector will offer many opportunities for banana growers and traders. Improved transport and market infrastructure, provided by local and national governments, will help to stimulate growth in this area. Processing into innovative and durable new products will become more important in order to access more distant regional markets and to even out seasonal discrepancies in supply and demand. Agribusinesses and regional trade organizations can guide interventions, with support from governments. Market information will be critical, and sharing this information will bring in actors in the communications field, such as mobile phone network providers.

At the international level the dessert banana will continue to dominate trade, but changes in European trade tariffs will mean that production and freight systems in Africa will need to become far more competitive. There may be opportunities for well-organized farmer groups, for example in supplying 'fair trade' and similar certified bananas. The main actors will include international traders, airlines and shipping companies, supermarkets, standard-setting and certification organizations, governments, and regional and international trade organizations. Inland production areas are seriously disadvantaged with regard to transport costs and will require development of creative market opportunities, such as value-added processing.

Promoting innovation

A starting point for the discussion of innovation systems was that African banana farmers had been ill served by the classical linear model of agricultural research and development, where innovation is presumed to arise mainly among public sector researchers and is passed via extension services to farmers. A new point of departure for the present discussion was provided by an agricultural science, technology and innovation (ASTI) system analysis recently carried out in several African countries and reported at the conference.

Once again, developing effective linkages and empowering farmers were recognized as holding the key to innovation in the banana sector. Information and communication pathways are also fundamental. There is potential for innovation in all relationships across the banana chain, so all principal actors are implicated; but those who focus on supplying new technologies and promoting innovation are particularly important, specifically research organizations at all levels (national, regional and international). These actors should however note the considerations in the box 'Innovation in African agriculture – some key considerations'. The private sector also has a role in facilitating innovation, as a source of new technologies and also as a conduit for transferring technologies that may be familiar in a different context to a new set of banana producers or marketers.

Innovation in African agriculture – some key considerations

Participants highlighted some considerations for actors involved in promoting innovation in African agriculture:

- Africa is a social economy (rather than purely capitalist) and therefore a different kind of commerce is required that respects farmers' needs and capabilities.
- Scientists may have answers, but technologies will not be adopted unless there is greater focus on shared practical testing in farmer communities.
- Two-way communication and trust needs to be increased, including recognition of the potential of indigenous knowledge and practical experience.
- Strengthening of institutional support frameworks (functional research institutes and extension services) in Africa is critical, but changes must recognize that institutions emerge from human interaction and agreement and thus these pathways cannot be designed, tested and replicated or scaled up as if they were technologies in the same way in each country; rather a flexible and dynamic approach is required.
- Any introduced innovation must be demonstrated to provide tangible financial benefits, but this poses a problem when technologies to increase ecological sustainability are proposed that do not have an immediate benefit; thus different approaches need to be considered to ensure adoption.

Implementing the strategy

In the absence of an organization with a mandate to implement this multifaceted strategy, FARA and its various elements will be pivotal to transforming Africa's banana sector. The priorities and actions identified in the banana strategy fit squarely into the mandate of FARA.

Participants at **banana2008** envisaged that implementation of the strategy will begin by building an informed knowledge base organized around innovation platforms that both engage stakeholders and engender ownership. Implementation of the strategy can happen under existing institutional arrangements, as follows. For research issues, national agricultural research systems feed into the subregional organizations WECARD, ASARECA and SADC; while for trade issues the key bodies are ECOWAS and COMESA. All of these, in turn, feed into FARA. Technical backstopping and technology validation at the regional level will be facilitated by the research centres of the CGIAR and their numerous and diverse research partners, both within Africa and outside the continent.

Banana researchers in Africa have been accustomed to collaborating within regional networks: *Réseau Musa pour l'Afrique Centrale et Occidentale* (MUSACO) for West and Central Africa and the Banana Research Network for Eastern and Southern Africa (BARNESA) for East and Southern Africa, under the auspices of WECARD and ASARECA respectively, and these networks have recently been broadened to include NGO and private sector participants. Links to banana researchers in other regions, for the exchange of information and technologies and for collaborative problem-solving research, are promoted through the global ProMusa network, which also constitutes the Banana and Plantain Section of the International Society for Horticultural Science.

Still broader innovation platforms are now envisaged that will unite researchers, extension agents, farmers and farmer organizations, agribusiness staff, traders, policy makers and development partners. Research priorities (see box) and technology dissemination strategies will need to be market orientated, participatory, and use approaches such as farmer collective action, farmer-to-farmer learning, market-led technology adoption, and mutual learning along the market chain.

In conclusion, the strategy for transformation of the banana sector in Africa fits precisely the FARA model for agricultural innovation and economic development, and can be implemented under existing institutional arrangements. Participants at **banana2008** proposed the adoption of this strategy as a 'test case' within the FARA framework. They believed this would facilitate increased visibility and the mobilization of the breadth of expertise and depth of resources needed for its successful implementation. Such an outcome could indeed help banana to realize its full potential as a major economic driver for sustainable and equitable development in Africa.

Research needs for bananas in Africa

Among the many needs identified by participants, some common thrusts include the need to increase

- Research to improve production in the face of significant biotic threats, including diagnostics, improved management, and resistant cultivars
- Research to improve production management in smallholder agriculture, including better weed and moisture management (e.g. mulch, irrigation), best bet nutrient practices, and more tolerant cultivars
- Research to improve seed systems to meet planting needs across all producer classes facing accelerated replacement rates in plantations impacted by diseases and pests; including tissue culture, improved traditional systems, distribution chains, and linked value chains
- Market research and information dissemination systems to enable producers to make enlightened choices in terms of planting, harvest, and marketing options to maximize on-farm profits
- Food science and technology research to identify and develop new innovative medium–high value domestic and international marketing opportunities for banana-based products
- Systems research to link increased production to increased market opportunities to prevent transient market gluts that impact prices.

Annex 1. Conference agenda

Sunday, 5 October

Conference opening

Meister Room

1700–1720	Opening address – Honourable William S Ruto, Minister of Agriculture, Kenya
1720–1740	Opening address – Honourable Janet Mukwaya, Minister of Tourism, Trade and Industry, Uganda
1740–1800	Opening address – Rev. Dr. Florence Muranga, Director, Presidential Initiative on Banana Industrial Development (PIBID), Uganda
1900	All-Tooke Dinner at Bustani Gardens hosted by PIBID, Uganda

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Monday, 6 October

Global trends affecting banana

	Plenary – Meister Room
0830–0855	Topic to be announced – R Tumusiime, Commissioner, African Union
0855–0920	Specialty banana products and niche markets – A Abera Kalibata, State Minister for Agriculture, Rwanda
0920–0945	Africa's move – Hartmann, Director-General, IITA
0945–1000	Oversight of strategy development – F Beed, IITA/Conference Organizing Committee
1000–1030	Discussion
1030–1100	Coffee / tea

Markets and trade

	Plenary – Meister Room
1100–1120	Banana growing for export: innovative approaches in production and marketing – the need for partnerships – N C Fehr, Gourmet Gardens
1120–1140	From tissue culture to the table: an assessment of the East African banana system's potential for raising smallholder farmer incomes – N S Harris, TechnoServe
1140–1200	Exporting bananas for improved livelihoods and social development: evidence and challenges from Latin America and Africa – N H Van der Waal, AgroFair
1200–1220	Vademecum on imports of bananas into the EU – B O'Connor, O'Connor and Company
1220–1240	Socio-economic impacts of tissue culture banana in Kenya through the whole value chain approach – R Njeru, AfricaHarvest
1240–1300	Discussion
1300–1400	Lunch at Diani Restaurant
1400–1615	Parallel session 1: Market segments – Meister Room
1400–1615	Parallel session 2: Policies and trade – Mandhari Room
1400–1615	Parallel session 3: Supply – Peponi Room
1400–1600	Parallel session 4: Processing – Likunda Room
1600–1630	Coffee / tea with assorted pastries at Meister Room
1700–1800	Poster and exhibition stands – Meister Tent
1730–1930	Special session: Innovating banana system: country perspectives – Meister Room
1730–1930	Special session: Lessons learnt from the first 25 years of Fair Trade banana – Peponi Room
1900–2000	Welcome cocktail at Malaika Terrace/ Baobab Lawn
2000	Dinner at Kivulini Beach Cove: African Beach Fiesta

Tuesday, 7 October

Production

	Plenary – Meister Room
0830–0850	Overview of current and projected future production issues in Africa – B Delveaux, Université Catholique Louvain
0850–0910	Role of biotech and transgenics in Africa – F Shotkoski, Cornell University
0910–0930	The potential of tissue culture banana technology in Africa: anticipated limitations and constraints – EM Kahangi, Jomo Kenyatta University of Agriculture and Technology
0930–0950	The role of national centres of excellence in banana research and development in eastern, central and southern Africa – W Tushemereirwe, NARO
0950–1010	The Role of NGO's in addressing regional banana problems – creating synergy through partnerships – lessons learned from Catholic Relief Services management of a multi country and multi partner banana program in East and Central Africa – S Walsh, CRS
1010–1030	Discussion
1030–1100	Coffee / tea
1100–1300	Parallel session 1: Plant health – Meister Room
1100–1300	Parallel session 2: Post-harvest – Mandhari Room
1300–1400	Lunch at Diani Restaurant
1400–1605	Parallel session 3: Agronomy – Meister Room
1400–1600	Parallel session 4: Seed systems – Peponi Room
1400–1600	Parallel session 5: Genetic improvement – Mandhari Room
1600–1630	Coffee / tea with assorted pastries at Meister Room
1630–1730	Poster and exhibition stands – Meister Tent
1730–1930	Special session: Media evening: An open event for researchers to get practical tips and inspiration on making the most out of the media to get their message across – Meister Room
1730–1930	Special session: Documentation and Information Network for Africa (REDIMA): Steering Committee – Peponi Room
1930	Dinner at Bahari Terrace: Karamu Ya Waswahili – Coastal Night

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Wednesday, 8 October

Innovation systems

	Plenary – Meister Room
0830–0900	Bananas and new thinking about pathways for science impact – N Röling, Wageningen University
0900–0920	Innovation systems, food security and economic development – JA Francis, CTA
0920–0940	Tracking the spill-over of introduced technologies: the case of improved banana germplasm in northeastern Tanzania – JG Mowo, African Highlands Initiative
0940–1000	Turning African farmers into businessmen or marketizing small-holder Agriculture? Reconciling the market versus social varieties of capitalism in the African agribusiness development debate – CMO Ochieng, Ecoagriculture Partners
100–1010	Meeting demand: what growers need and how to respond – E Boa, CABI
1010–1030	Coffee / tea
1100–1300	Parallel session 1: Tracking adoption and impact – Meister Room
1100–1300	Parallel session 2: Turning farmers into business people – Mandhari Room
1100–1300	Parallel session 3: Innovating delivery systems – Likunda Room
1100–1300	Parallel session 4: Profiling country perspectives – Peponi Room

1330–1400	Poster and exhibition stands – Meister Tent
1330–1430	Lunch at Diani Restaurant or packed lunch for field trips
1400	Field trip and excursion (Mombasa Town, Mombasa international port and banana market, snorkelling and dolphin watching tour, Banana 2008 Fun Golf for beginners, Safari to Shimba Hills)
2000	Dinner at Fisherman's Cove/ Mnazi Cove: Pirate's Night

Thursday, 9 October

Strategy

	First Plenary: Building strategies to mobilize the banana sector in Africa – Meister Room
0830–0850	Empowering small-scale farmers through banana processing plants – A Tibaijuka, UN
0850–0910	Donor perspective on strategy development – J Kalders, DGDC
0910–0930	Promoting research for health and prosperity – R Kahane, Global Horticulture Initiative
0930–0940	Discussion
0940–1000	Role and perspectives of ASARECA – F Opio, ASARECA
1000–1020	After 10 years of research: what needs to change? – R Markham, Bioversity
1020–1030	Discussion
1030–1100	Coffee / tea
	Second plenary: Reporting by theme coordinators from previous sessions – Meister Room
1100–1125	Markets and Trade – S Abele, IITA
1125–1150	Production – D Coyne and S Hauser, IITA
1150–1215	Innovations Systems – C Staver, Bioversity
1215–1300	Open forum to identify types of organizations and partnerships required
1300–1400	Lunch at Diani Restaurant
1400–1730	Break-out sessions to develop commodity-specific strategies with focus on local, regional and international markets • Break-out Session 1: East African highland banana – Meister Room • Break-out Session 2: Dessert banana – Mandhari Room • Break-out Session 3: Plantain – Peponi Room
1930	Gala dinner at Bustani Garden, with prizes, awards, closing remarks and live music

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Friday, 10 October

PROMUSA: Working Group on Production 0900–1730
Meister Room

Annex 2. Guidance for theme coordinators, conveners, session chairs and presenters

NOTES FOR THEME COORDINATORS, CONVENERS & SESSION CHAIRS

INTRODUCTION

Thank you for agreeing to be one of the theme coordinators, conveners or session chairs at the Banana 2008 Conference. A copy of the agenda is attached so that you can see where and how you fit into the schedule.

The conference will take place on October 5 – 9, 2008 at the Leisure Lodge Resort in Mombasa, Kenya. http://www.leisurelodgeresort.com/

PROCESS OVERVIEW

- **Monday to Wednesday – Theme Days**

the program includes a series of plenary followed by break out group sessions (oral and poster) for each of the 3 themes;

- Markets and Trade (Monday the 6th)
- Production (Tuesday the 7th)
- Innovation Systems (Wednesday the 8th)

For each session (plenary or break out), there will be a series of presentations followed by question and answer periods. The breakout sessions are as follows;

Monday the 6th – Markets and Trade – concurrent session:

- Market Segments
- Policies and Trade
- Processing
- Supply

Tuesday the 7th – Production – two concurrent sessions:

- Plant Health
- Seed Systems
- Agronomy
- Genetic Improvement
- Post Harvest

Wednesday the 8th – Innovation Systems – concurrent session:

- Delivery Systems
- Country Perspectives
- Tracking Adoption and Impact
- Turning Farmers into Business People

There will be a Session chair and Convener appointed for each of the sessions – plenary and break-out.

We anticipate having up to 400 participants who during plenary will be seated in rows and during break out seated in groups of 8 at round tables, arranged in "cabaret" style. The participant list has yet to be finalized, but the attached draft will give a sense of who we expect to attend.

➢ **Strategy Day**

On Thursday the 9th – the Strategy day – "building strategies to mobilise the banana sector in Africa" will consist of 3 modules:

- A plenary session with speakers (8:30 AM – 10:30AM)
- A report back session from the first 3 days by theme coordinators (Abele/Coyne & hauser/Staver) (11:00 – 13:00)
- Break out sessions organized by commodity (dessert, EAHB and plantain) with discussions focused on different markets (local, regional and international) (14:00 – 17:00)

The Theme Coordinators

On the Strategy day, the coordinators for each of the three themes (Abele/Coyne & Hauser /Staver) will report back key messages from the plenary and breakout sessions in their program. This information will be provided by Conveners and for each breakout session topic (vision element) will include recommendations of WHAT needs to be done (outcome statements) and HOW (strategies) this will be achieved in order to make progress. Theme coordinator presentations will be 25 minutes each and this will be followed by a 45 minute open forum discussion on which types of organisations and partnerships are required to achieve progress.

ROLE OF THE SESSION CHAIRS

Session chairs are responsible for managing their respective session;

- Starting on time
- Introducing the session via a brief 2 minute presentation
- Introducing and thanking speakers
- Managing speaker time – All speakers have been provided with strict guidelines (copy attached) to limit the time for presentations. For plenary presentations the time allocated to each speaker will be specified by the theme coordinator. For breakout sessions each speaker will be limited to a maximum of **15minutes**.
- Managing Q & A sessions from the floor. There will be conference staff with roaming microphones who will work with each session chair
- Finishing on Time

ROLE OF THE CONVENERS

the Conveners are responsible for taking succinct notes that will be used to develop the final conference report, and ultimately develop the strategy. More specifically we see the role as follows:

- Listening carefully to presentations and discussions and record:
    - Short presentation summaries noting key messages. We envision no more than 2 paragraphs per presentation
    - Summaries of any key points raised during Q & A sessions
- Visit and review any poster displays that are related to your breakout session topic.
- Participate in a final theme meeting on the day you have acted as a convener. this will be at 18.30 for markets & trade and production and at 13.00 for innovation systems. the purpose of this meeting is to liaise with theme coordinators and conference facilitators towards developing a summary of pertinet points from the day.

➢ **Role Of Conveners in Developing The Strategy**

In addition to taking notes as outlined, we would ask that each of the Conveners, based on what you have

heard over the course of your session, develop initial thinking that will be used in developing the overall Banana strategy. The thinking will take the form of:

- WHAT needs to be done to achieve progress for the breakout session topic – a desired future (outcome statement)?
- HOW can this be achieved (strategies)? Articulation of 3 objectives that would need to be accomplished in order to achieve the desired future

The following example illustrates the format that could be used for reporting to Theme Coordinators;

Plant Health (Session 2.1)

WHAT (Outcome statement);

Increased quantity and quality of produce for all markets

HOW (Three strategies):

2.1.1 Surveillance of pests and diseases in the field to determine their distribution and spread

2.1.2 Deployment and assessment of the efficacy of control options to manage pests and diseases in the field

2.1.3 Control of post harvest pests and diseases and implementation of regulations to certify produce is trade-safe

This information will be used by Theme Coordinators for their reports in the Strategy day plenary as outlined above, and will be further discussed by participants in the commodity focused break-out group sessions on day 4.

LAST WORDS

Again, we would like to express our sincere thanks to you for agreeing to accept this important responsibility at the conference.

looking forward to seeing you in Mombasa!

Conference Organisers

NOTES FOR PRESENTERS

INTRODUCTION

Thank you for agreeing to be one of the presenters at Banana 2008 Conference.

attached is a copy of the agenda so that you can see where and how you fit into the schedule. The conference will take place on October 5 – 9, 2008 at the Leisure Lodge Resort in Mombasa, Kenya. http://www.leisurelodgeresort.com/

We anticipate having up to 400 participants who during plenary will be seated in rows and during break out seated in groups of 8 at round tables, arranged in "cabaret" style. The participant list has yet to be finalized, but the attached draft will give a sense of who we expect to attend.

AUDIO/VISUAL EQUIPMENT

We'll have the following equipment available for your use:

- A laptop computer loaded with:

- Windows XP Professional™
- Microsoft PowerPoint™ Version 2003
- CD Rom drive and USB flash drive ports
- Neither overhead projector facilities nor 35 mm slide projectors are available. Furthermore personal laptops cannot be used.

- A digital projector
- Lapel, hand held or podium Microphones – whichever you prefer

Please load your presentation on the designated computer in the business centre next to the meister conference room the day before you are due to speak.

This room will be manned by a technician on the set up day and subsequently during Congress hours. The technician will check your presentation to ensure that software versions are compatible and that slides are correctly mounted and in the right order. Rehearsals of your presentation are strongly recommended.

SOME IMPORTANT POINTS

- **Our Presentation Model**
  - Feedback from earlier conferences indicates that people prefer an invigorating balance of "conversations" and "presentations". With this in mind, we will combine presentations with open forum discussions.
  - For plenary sessions the time limit for your presentation will be specified by your theme coordinator.
  - For breakout session the time allocation for your presentation will be limited to a maximum of 15 minutes in order to accommodate the diversity and experiences of a wide range of speakers. As you can see from the agenda, we have a very rich and full program, so it will be important for all speakers to honour this time allowance.
    - For the open forum discussion participants will be given the chance to present their reactions, and identify any questions for clarification or improved understanding. This period is intended to provide an opportunity for you to expand on the aspects of your topic which the participants express an interest in. This is usually the most fruitful part of all, leaving the presenter and the audience with a satisfying sense of accomplishment.
  - **Timing**
    - Time is invariably tight at events such as these, and we'd like you to do your utmost to help us in this regard.
    - Please, please, please try to stick to the time that has been allocated to you. If you don't, we'll have to recover the time by shortening the open forum discussions, and that would be a pity because arguably it's the most important part of the knowledge transfer process.
    - To help you, we will have a warning system to alert you to when 5 minutes are left and the allocated time is up! (using either a card system or bell)

TIPS FOR PRESENTERS

The Process

Your presentation will provide participants with a sense of the key issues related to the topic that will trigger thoughts and questions in their minds, i.e. to give them "food for thought".

During the open forum questions and answer session you'll be transferring information to participants in a way that responds to their needs for knowledge, as opposed to your assumptions of their needs.

- **Use of PowerPoint™**
  - Here's a suggestion that we believe you'll find useful.
    - When you've created your series of slides, go through them and select the "key message" slides that you'd like to present
    - Then use PowerPoint's "Hide Slide" feature (You'll find under the "Slide Show" menu) to hide the rest.
    - When you present your slides, the hidden ones will be passed over. However, they'll still be there for you to use on an "as required" basis, during the Part 2 open forum. All you have to do is type the number of the slide that you want to display, hit "Enter", and bingo – it will be there! The key to success is to have a sheet handy that lets you see at a glance a list (or picture) of all the slides with their slide numbers.

It is important that the quality of all presentation material is high. It is necessary, therefore, for authors to adhere to the following guidelines.

Use a clear, bold typeface.

Try to limit words per line to a **maximum** of 7 words with 5 lines of text per projected image.

Complicated images which are likely to be unreadable by the audience should be avoided.

PowerPoint presentations should not be too complex. Tables, graphs and histograms should be kept simple and clear. Three dimensional graphics can often be difficult to read and should not be used.

The use of light (e.g. white) text out of a dark (e.g. dark blue) background is recommended. Excessive use, and inappropriate combinations, of colour reduce clarity. Bold primary colours are preferred. However, red should be avoided if possible (especially in combination with blue).

Many organisations have introduced house styles which include a background colour but care should be taken to ensure that these are visible at the back of a large auditorium.

A trade name may appear only once within your total PowerPoint presentation.

A small, discreet logo may be used on all PowerPoint screens. Covert, or overt, commercial advertising is not permissible. If in doubt, check with your Session Organiser.

LAST WORDS

Again, we would like to express our sincere thanks to you for agreeing to give up your valuable time and share your experiences. we look forward to your participation at this exciting conference and to seeing you in Mombasa!

Conference Organisers

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