Seed Systems, Science and Policy in East and Central Africa
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Seed Systems, Science and Policy in East and Central Africa
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The Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA) would like to extend sincere gratitude to the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA\(^1\)) for collaborating with the Centre in co-hosting the CTA/ASARECA “Seed science and policy learning writeshop”, which was held in conjunction with the 2nd ASARECA General Assembly and Scientific Conference in Burundi from 9-13 December 2013. This workshop built on the outcomes of CTA’s interventions in increasing the engagement of universities in agricultural and rural development policy processes with a primary focus on the Comprehensive Africa Agricultural Development Programme in Africa and supporting selected universities to analyse their contributions to integrated seed sector development at a national level.

This publication would not have been possible without the commitment and dedication of all the individuals who ensured its successful completion. CTA recognizes and acknowledges the contributions of the authors and co-authors, the peer reviewer Dr Paul Kimani of the University of Nairobi, Kenya and all the members of the editorial team. Special mention is made of Judith Francis, CTA Senior Programme Coordinator, who had the overall responsibility for this project; Dr Michael Waithaka, who was the main ASARECA contact person and Ellen Mulder, CTA Project Assistant who supported Judith Francis in the collation and compilation of the various papers.

\(^1\) ASARECA is a non-political organization of the National Agricultural Research Systems (NARS) of 11 countries: Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, South Sudan, Sudan, Tanzania and Uganda. It aims to increase the efficiency of agricultural research in the region so as to facilitate economic growth, food security and export competitiveness through productive and sustainable agriculture.
Foreword

The importance of a reliable supply of high-quality seed to the growth and development of African agriculture cannot be overstated. This publication provides insights into the various seed systems; the policy environment; the value chain actors including universities, enterprises, farmers and women’s groups as well as regulatory and other support agencies; and the challenges faced in improving seed quality and availability in East and Central Africa. It is an output of the CTA/ASARECA ‘Seed Science and Policy Learning Writeshop,’ which was held in conjunction with the 2nd ASARECA General Assembly and Scientific Conference in Burundi in December 2013.

Africa’s share of the global seed trade, currently standing at less than 2%, can be increased if concerted, collective action is taken by government, industry and knowledge institutes. However, several factors limit investments in the seed sector. These include the differing systems; the inconsistent policies, standards, regulations and procedures; the high costs for registering new varieties; and the inadequate infrastructure that underpin the seed industry. These barriers to increased intraregional and global trade need to be effectively addressed.

The specific objectives of the CTA/ASARECA policy writeshop were to:
• bring together key academics, researchers, experts, farmers and policy-makers to share research results, knowledge and experiences, derive policy lessons and plan interventions to strengthen policies, programmes, and practices to promote seed entrepreneurship;
• enhance the contribution of universities as facilitators and catalysts in increasing food security through the provision of quality seeds and services; and
• enhance the capacity of and collaboration among seed-sector actors for promoting seed innovation and entrepreneurship.

These objectives were met and the result is this publication, in which the major contributors are actors directly involved in and committed to the integrated development of Africa’s seed sector. CTA is pleased to have collaborated with ASARECA, universities, research organisations, farmers’ and non-governmental organisations and related policy and regulatory organs in harnessing this knowledge. We are sure that it will serve as a basis for influencing future policy and practice to support the development of the seed industry in Africa.

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CTA/ASARECA Policy Brief: Seed systems, science and policy

Edited by J.A. Francis¹ and M. Waithaka²

Africa needs to develop and integrate its various seed systems if it is to increase its present contribution to more than 2% of the global seed trade. Quality improvements in the informal seed systems and enhanced linkages with the formal seed systems are critical. A strategic partnership of research, enterprise and government is necessary to achieve this goal.

Keywords: enterprise, government, research, strategic partnership

The importance of improved varieties and high quality seed to the growth and development of African agriculture cannot be underestimated. However, differing standards, regulations and procedures; low investment in science; and poor infrastructure act as barriers to enhancing quality seed production, intra-regional trade within the continent and global competitiveness.

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) has been supporting the development of a favourable policy environment through the Eastern Africa Seed Committee (EASCOM). This committee is comprised of breeders, regulators, policymakers and public sector representatives from each member country. The EASCOM platform facilitates the adoption and implementation of harmonised regional seed regulations, standards and procedures that were agreed in 2002. This has led to advances in variety evaluation, release and registration, seed certification, phytosanitary management, plant variety protection, and seed import and export procedures in Eastern and Central Africa (Box 1). However, policy makers need to be better informed on the many inter-related issues in seed industry development to be able to fast track the implementation of national and regional policies and programmes to achieve greater impact.

Box 1. Notable gains since harmonisation started

- Kenya has released 140 new crop varieties, 30% from the private sector;
- Uganda released 27 varieties, 50% from the private sector;
- Tanzania released 121 varieties, 30% from the private sector;
- Sudan released 243 varieties, all from the public sector.

The total welfare gain for the ECA region is estimated to be over US$727 million.

Seed systems in East and Central Africa

The seed systems are generally categorised as formal, semi-formal and informal and they co-exist in East and Central Africa. In some countries e.g. Burundi, Democratic Republic of Congo, Kenya and South Sudan, seed aid is part of the overall system.

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The **formal** seed system is regulated by governments and to some extent also by industry. It provides new and improved varieties of certified seeds of consistent quality and relatively high purity. On average, 3–20% of all seeds for a limited number of crops; mainly maize and rice is supplied through this system. In Kenya, maize accounts for 70% of all certified seeds used in production. Development of indigenous varieties is not given sufficient attention through the formal system.

The **informal** or **traditional** seed system is semi-structured and operates mainly at the individual or community level. It constitutes about 60–80% of the total seeds used, especially for indigenous vegetables, pulses, vegetatively propagated crops, oil crops, and cereals such as millet and sorghum. Seeds are generally more easily accessible and cheaper, but are of inconsistent quality. Farmer saved seeds predominate. In Ethiopia and Kenya, about 90% of seeds used is obtained through informal channels. This system lacks adequate support; knowledge, skills and incentives for self-regulation and attracting private sector investment.

The **semi-formal** seed system is a blend of the formal and informal systems. Farmers and community-based organisations multiply and sell small quantities of quality declared seed of improved varieties to other farmers within a restricted zone, with minimal formal quality control. In Tanzania, quality declared seed is inspected and approved by the Tanzania Official Seed Certification Institute at the district level where sales are restricted.

While the various systems coexist, they need to be better integrated. Rwanda has developed a strategy for strengthening the overall seed system and increasing the uptake of certified seed by 2017 (Figure 1). The success of which is contingent on increased availability of quality declared seeds, declining reliance on farmer-saved seeds, and a rise in farmer confidence in and demand for locally certified seeds. The commodities targeted are maize, potato and wheat.

**Figure 1. Strategic plan of seed systems in Rwanda by 2017**
The role of universities

The number of universities in Africa has grown in the past decade. In Kenya, public universities grew from six in 2000 to 33 in 2013. Most universities have faculties of agriculture and offer courses in plant breeding and biotechnology, seed science and seed enterprise management, and related biophysical and social sciences. Many are contributing to seed industry development through research, marketing and capacity building in seed science and technology (Box 2). Several are working in partnership with other value chain actors in seed breeding, production, multiplication, conservation, certification and marketing, and with regulatory agencies.

However, many well trained scientists attached to the universities are not meaningfully engaged in research and development activities, largely due to inadequate financial resources; outdated facilities including laboratories and inconsistent policies which result in exorbitant fees for validation of candidate varieties in mandatory national performance trials and distinctiveness/uniformity tests. In Kenya these two tests cost US$2,400 per entry. In addition, there is no provision for variety maintenance programmes or benefit sharing when new varieties are commercialised. This negates gains made in cultivar development and limits access to new seed technologies. Some universities are pursuing intellectual property protection for product innovations and benefit sharing. In 2013 the University of Nairobi revised its intellectual property policy to take into consideration global trends and to cover a much broader range of innovations.

Box 2. Examples of contributions by universities

Mekelle University in Ethiopia, working in collaboration with local farming communities, developed three high-yielding barley varieties with improved nutritional qualities ($\beta$-glucans, iron and zinc), which were officially released.

The University of Nairobi (UON), working with Iowa State University and other collaborators in the seed value chain, has established a Seed Enterprise Management Institute, which is offering certificate, diploma and soon degree courses in various aspects of seed science and technology, including seed production, processing, storage, quality control and entrepreneurship. In the past five years the university has released more than 18 improved bean varieties, including Africa’s first biofortified bean varieties, and short-duration, drought-tolerant pigeon pea varieties for semi-arid areas. It has registered a seed company to produce certified breeder seed, and partnered with seed companies, processing industry and other actors to commercialise its varieties and to ensure rapid and sustainable seed dissemination. UON also hosted a regional bean breeding programme for the past 10 years and developed a wider impact strategy that has been adopted by more than 28 African countries; between 2000 and 2011 it shared its genetic resources with more than 32 countries worldwide.

Universities can play a greater role in supporting countries in addressing societal and development challenges. In East and Central Africa, they need to provide additional support to seed sector development, policy formulation and marketing. This would require them to extend beyond their traditional teaching and research roles. This expanded role is reflected in recent policy changes in Kenya and is referred to as the ‘third mission’. The Science Agenda for Agriculture in Africa, developed by the Forum for Agricultural Research in Africa (FARA) and partners, also places importance on science and the need for each country to develop sufficient scientific capacity to participate in the transformation of agriculture.
**Role of policy**

Policies should provide coherence, allowing for the recognition and integration of all seed systems and a level playing field that benefits the various stakeholders. They should facilitate development of the informal seed system, its alignment with the formal seed system and eventually the availability and accessibility of higher quality competitively priced seed on a consistent basis. Rwanda’s strategy for transforming the multiple seed systems by 2017 is a good example for other countries to consider pursuing.

Policies should also support the capture of accurate data on seed demand, varieties and agronomic characteristics as well as monitor trends in use and availability, IPR, variety release and registration procedures and integrated seed system development to facilitate the development of the national seed system and the link with regional and international markets. This will provide the pulling force and motivation needed to increase productivity and attractiveness for mobilising investments.

Policies that encourage private sector investment in the seed sector and ensure institutional support to develop new and improved varieties; provide quality assurance; upgrade laboratory and market infrastructure; enforce regulations and contracts; and simplify procedures are all important for the growth of the sector. Tax incentives for equipment, supplies and training aimed at capacity building and enhancing skills in the seed sector should also be considered.

These various proposals are already reflected in key policy documents and programmes in several countries in East and Central Africa (e.g. Kenya, Madagascar, South Sudan). Speedy promulgation of regulations that have already been drafted (e.g. IPR legislation in Madagascar) and adequate implementation and enforcement of existing national and regional agreements (e.g. harmonized seed regulations in East and Central Africa) need to be addressed.

**Recommendations**

- Africa remains a minor player in the global multi-billion-dollar seed trade. This trend needs to be reversed by eliminating the barriers that severely limit market size and penetration; effectively gauging demand; strengthening capacities in seed delivery systems; and investing in adequate science and entrepreneurial capacity for commercialising seed innovations and increasing the competitiveness of African seed products. African farmers need access to quality seeds.
- The African seed sector at national and regional level remains fragmented. All stakeholders must work together to strengthen linkages between farmers, regulatory organisations, national agricultural research institutes (NARIs), universities, extension agents, the private sector and policymakers. They should collaboratively undertake studies to identify gaps, provide reliable data on the seed markets, develop interventions and inform policy formulation processes.
- Governments should enhance coordination, consultatively develop long-term strategies to guide interventions and avoid duplication of efforts to maximise the benefit from synergies among the different stakeholders. Governments should also encourage researchers and the private set or to undertake research on locally important varieties that are adopted to local environments.
- Seed system actors should be given the required training to improve the quality of the seeds produced. The informal seed system should be supported as it is being transformed to a more formal system. Quality declared seed for crops that are not adequately covered under the formal system should be recognised where applicable.
• Regulatory institutions should be strengthened. There is a need for more highly skilled human resources, modern facilities, and easily accessible and up-to-date information on approved regulations and procedures for effective implementation of quality assurance schemes and timely delivery of services.

• There is limited cross-border seed trade within Africa. Enhanced domestication and implementation of the harmonised seed standards, procedures and regulations are needed. Conformity with international seed standards could increase ECA’s participation in the international seed trade.

• Universities and national agricultural research institutes should undertake joint seed business ventures with private companies to ensure new varieties developed are marketed and accessed by farmers. Awareness, application and enforcement of intellectual property rights should be enhanced to motivate seed producers, plant breeders and the private sector to invest in the research and development of new and improved varieties which can take up to ten years.

Acknowledgements
This policy brief is the joint effort of all the authors whose papers are featured in this publication. The papers were presented at the 2nd ASARECA General Assembly in Bujumbura, Burundi, December 2013. The content of the policy brief reflects the information in the papers.

Bibliography


Enhancing adoption of harmonised seed standards, regulations and procedures in Eastern and Central Africa

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Low agriculture productivity characterises most countries in Eastern and Central Africa (ECA), which remain food insecure despite the availability of new and improved technologies. Seed is one of the most important inputs in agricultural production that determines the quantity and quality of output. Until recently, the unfavourable seed policies, regulations and procedures that existed in the region were known to hamper access to quality seed. ECA countries had different laws, policies and regulations governing the seed industry and seed trade, resulting in restricted movement of seed across borders and a smaller market, which was not attractive for investment in the seed industry. Efforts to develop harmonised seed standards, regulations and procedures, and to promote their adoption, have been ongoing since 1999 through the former Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA) and the Policy Analysis and Advocacy Programme (PAAP) of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The areas covered by these agreements include variety testing, release and registration procedures, plant variety protection, seed certification, phytosanitary requirements, and import and export documentation. Although harmonised East African seed standards, regulations and procedures (HESSREP) were agreed upon and published in 2002 (ECAPAPA, 2002), their implementation has been slow, with individual member countries not completely adapting them to their national systems. To address these bottlenecks, PAAP has been working with partners in the region to spearhead initiatives for fast-tracking the adoption and implementation of HESSREP. A 2013 initiative involved working with key stakeholders in five pilot countries (Burundi, Kenya, South Sudan, Tanzania and Uganda) to undertake an audit of the level of implementation in each country, identify challenges for adoption and implementation, draw road maps for implementation and enhance adoption. This paper features the processes, results and lessons learned.

Key words: increased crop productivity, seed trade, variety testing

Introduction

Seed is a key determinant of agricultural productivity as it determines both the quantity and quality of the output. The use of quality seed has potential to double or even triple the yields of most crops, offering higher value and consumer appeal.

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Most African counties are plagued by low crop yields, with implications for high levels of undernutrition and cyclical hunger periods experienced on the continent. However, widespread and timely availability of improved varieties and quality seed is a challenge and can be overcome if the seed system is improved, and small and medium-sized as well as large commercial seed entrepreneurs can attract more investment and thrive.

Currently Africa’s share of the global seed market is limited in terms of volume, and accounts for less than 2% of the estimated international seed trade (Waithaka et al., 2011). It is also restricted to a narrow range of crops led by hybrid maize, and small amounts of cash crops such as sunflowers, cotton, soybeans, wheat and vegetables (Minde and Waithaka, 2006). It is estimated that half of the seed traded in Africa occurs within countries of Southern Africa (Rohrbach et al., 2003), indicating that seed trade and movement in Eastern and Central Africa (ECA) is lower.

The 11 member countries (Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, South Sudan, Sudan, Tanzania and Uganda) of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) have established crop variety development programmes and seed delivery systems in an attempt to improve crop productivity. However, most of the programmes are run by public organisations that are often unable to meet national seed demand due to delays in the release procedure. The seed sub-sector is also not vibrant enough to attract investors to support seed distribution, and this is exacerbated as each ECA country has different policies, regulations and procedures on production and marketing of seed.

Many regulatory features are crucial for the development of a market-oriented seed industry, including, for example, enabling easy entry for new seed companies; allowing seed companies to contract with farmers of their choice and to introduce new varieties; and giving seed companies responsibility and authority to ensure seed quality. However, local seed companies have a difficult time because several government licences and approvals are required at different stages.

Harmonisation is critical to the development and promotion of a modern and competitive seed industry. Between 1999 and 2007, the former Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA) and the Policy Analysis and Advocacy Programme (PAAP) of ASARECA carried out the first phase of the initiative aimed at rationalisation and harmonisation of seed policies and regulations in Eastern Africa (ECAPAPA, 2002, 2004). The second phase was implemented between 2008 and 2011, and included harmonisation of policies and regulations in sectors including dairy, root crops and biosafety. This led to a harmonisation agreement in five key areas: protection of plant variety rights, transparent variety release and registration procedures, and common phytosanitary regulations and certification standards, which were aimed at simplifying seed trade procedures.

The intention was to facilitate trade across national boundaries and thus to improve domestic and foreign investment and expansion of markets beyond national borders. Effective regulatory reform requires strengthening producer and consumer capacities through discussions and debate among a wide range of stakeholders (Tripp, 2005). Preliminary analysis showed that implementation of HESSREP has been slow and inconsistent, and that the agreements lacked ownership by the relevant actors and stakeholders in member countries. Furthermore, some key institutions and organisations lacked the requisite capacity to interpret, implement, monitor and/or undertake necessary lobbying and advocacy. The latest initiative, in 2013, aimed at enhancing awareness of HESSREP and creating
ownership by key stakeholders in order to fast-track domestication, adoption and implementation in five pilot countries (Burundi, Kenya, South Sudan, Tanzania and Uganda). Increased adoption of HESSREP was expected to lead to increased regional seed trade, improved access to high quality seed and increased crop production.

Although agreements were relatively easy to reach in all countries, implementation did not move as quickly as anticipated. Yet Eastern Africa has made the greatest progress in implementing these agreements (Rohrbach et al., 2003).

**Partner institutions**

Six key partners from the five pilot countries worked together to implement the 2013 initiative. They are described below.

**National Potato Council of Kenya**

The NPCK is a multi-stakeholder and public–private partnership organisation that was registered in 2010 in Kenya. It is run by an executive board that approves and governs its operations through the secretariat headed by a chief executive officer. The executive board and secretariat are comprised of a highly qualified team of experts including university professors and experienced research scientists at PhD and master’s levels. The NPCK structure allows it to draw synergy from a wide membership representing public and private institutions that include farmers, traders, processors, extensionists, research, academia, financial institutions, national and regional governments and development partners. The Council brings together expertise from member associations to articulate and address the agricultural issues.

The NPCK has implemented projects and conducted studies funded by ASARECA, Kenya Agricultural Productivity and Agribusiness Programme (KAPAP), the UN Food and Agriculture Organization (FAO) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) since 2011. The project and studies have led to the production of sub-sector documents that include: *A Policy Maker’s Guide to Crop Diversification; Seed and Variety Potato Catalogue 2013; National Seed Potato Master Plan; Potato Production Manual; and Post-Harvest Losses in Potato Value Chains in Kenya*. In addition, the NPCK was a key organiser of the 9th Triennial Africa Potato Association (APA) conference on Transforming Potato and Sweet Potato Value Chains for Food and Nutrition Security, held in July 2013 at Naivasha, Kenya. It was attended by more than 280 participants (scientists, business communities and farmers) from all over the world. The Council was also the lead institution in implementing a one-year (2012–13) project funded by ASARECA which involved up-scaling innovations for quality seed potato production in Eastern and Central Africa (Burundi, Kenya and Uganda).

**Seed Trade Association of Kenya**

STAK is an association for seed companies registered in Kenya by Kenya Plant Health Inspectorate Service (KEPHIS), to produce, process and/or distribute seed. STAK members control 90% of the formal seed sector in Kenya (STAK, 2008). It strives to promote the interests of seed enterprises through use of quality seed. Members sell certified seed only, which is produced following quality control, and adhere to ethical practices at all times. Its main mission is to promote trade in quality seed and technologies in Africa for the benefit of members and farmers. STAK is currently made up of 24 member institutions. The Association was a member of the Eastern Africa Seed Committee (EASCOM), which worked with national seed traders and national regulatory agencies in member countries to harmonise seed policy in the region since 2004.
Institut des Sciences Agronomiques du Burundi
ISABU is the national agricultural research institute (NARI) under the Ministry of Agriculture and Livestock of Burundi. Its mission is to promote the scientific development of agriculture and livestock. The role of ISABU is to provide and deliver agricultural technologies/innovations, knowledge and information through diverse research programmes and components. It has participated in national seed policymaking, and is strategically positioned and has the necessary expertise to guide both public and private initiatives in changing standards and the regulatory framework for the seed sector. ISABU has experience in implementing national, regional and international projects that involve extension, policy, innovation dissemination, and marketing initiatives (http://isabu-bi.org).

Ministry of Agriculture, Animal Industry and Fisheries, Uganda
The main role of the MAAIF is to create an enabling environment in the agricultural sector in Uganda by enhancing crop production and productivity, in a sustainable and environmentally safe manner, for improved food and nutrition security, employment, widened export base and improved incomes of the farmers. Its key functions include formulation, review and implementation of national policies, plans, strategies, regulations and standards, and enforcing laws, regulations and standards along the value chain of crops, livestock and fisheries.

Directorate of Research, Ministry of Agriculture, Forestry, Cooperatives and Rural Development, Republic of South Sudan
The Directorate of Research in MAFCRD is tasked with the development, validation and transfer of demand-driven agricultural technology. The directorate also formulates and provides guidance on research and seeds regulatory standards. It participates in regional and international agricultural forums, and collaborates with national and international agricultural research institutions as well as universities.

Ministry of Agriculture Food Security and Cooperatives, Tanzania
The MAFC’s main objective is to provide policy guidance and services in the development of modern, commercialised, competitive and effective agriculture and cooperative systems in Tanzania. It aims at providing quality agricultural and cooperative services, a conducive environment for stakeholders, building capacity of local government authorities, and facilitating the private sector to contribute effectively to sustainable agricultural production, productivity and cooperative development of HESSREP.

Activities
The study used a combination of an extensive review of literature and secondary data provided by stakeholders in five target countries. Baseline and end line surveys were conducted. Key partners were also trained in HESSREP implementation. The main activities are described below.

Determination of level of awareness of HESSREP and implementation
Appraisal of awareness and adoption of HESSREP in the participating countries was conducted by use of questionnaires, literature review and stakeholder awareness meetings in cities and towns. Sensitisation of stakeholders on the need for domestication of the HESSREP was conducted through workshops. The importance of HESSREP and the possible benefits of its rationalisation were elaborated.

Drafts of road maps for each of the five project countries were developed. A strategic plan for advocacy and sensitisation of the beneficiaries on the harmonised standards was also developed. Areas for
intervention for the harmonisation of seed standards, regulations and procedures in ECA were chosen, and committees were set up to spearhead their implementation. Road maps and domesticated HESSREP were then shared with actors and stakeholders using electronic copies (flash disks) inside and between project countries.

Enhancing the capacity of value chain actors – implementation and monitoring skills

Task forces and stakeholder platforms were formed in each participating country and their terms of reference was developed and distributed. A training workshop on strategy for developing domestication plans and lobbying was conducted by NPCK after the development of training materials and tools. The following areas were covered:

- lobbying and advocacy;
- strategy development;
- monitoring and evaluation of domestication of HESSREP.

Regulators and implementers of the domestication plan were made aware of the importance, benefits and potential of domesticated HESSREP. This greatly influenced the drafting of the revised seed and plant variety regulations in 2013, plant breeders’ rights, and national performance trials (NPT) in Kenya.

Enhancing access and availability of information on domesticated HESSREP

In order to increase adoption and domestication of HESSREP, it was important that tools for communicating its implementation be created. Training in the development of information and communication tools was conducted in Kenya, and communication tools for the project were identified. A Google group was created and all PIs were invited to join and share information with other relevant stakeholders.

Outputs

Regional standards, regulations and procedures analysed

All parts of the five agreements of HESSREP were discussed and analysed by the stakeholders in the five project countries as planned. Each country held awareness creation workshops, which involved policymakers, regulators and beneficiaries. The workshops enhanced awareness and helped to create ownership of the agreements by relevant stakeholders. They also built the capacity of stakeholders to interpret the five areas of HESSREP. Each country held at least three stakeholder workshops and retreated to develop road maps and or engagement plans for implementations that were approved by the stakeholders.

Road maps (strategic plans) for domestication and implementation of HESSREP developed

Five road maps were developed, each showing what part of each agreement will be implemented by when, and the responsible institution (Figure 1). The road maps constituted strategic plans for advocacy and sensitisation of the beneficiaries on the harmonised standards.

All were presented and approved by the various stakeholders in the member country. The approved road maps were made available to all actors and stakeholders in electronic and print formats.

Actor (stakeholder) capacity building needs addressed

About 340 stakeholders were trained in the five countries, compared with 175 targeted by the project. The numbers trained in each county were: Burundi 85, Kenya 146, South Sudan 30, Tanzania 48
and Uganda. Training included development of road maps for implementation of HESSREP and awareness-creating plans; effective methods of lobbying and advocacy; development of communication tools; and monitoring and evaluation.

Information products and delivery channels
The Burundi task force developed four brochures through a writeshop and disseminated them. Special features on HESSREP were presented through national TV, a newspaper (Syfia Grands Lacs, www.syfia-grands-lacs.info), online (www.notreterre.org), and two radio scripts. The task force in Uganda generated a national road map and brochures on HESSREP that were printed and distributed to stakeholders. These were used to create awareness and to emphasise the importance of the seed trade. In Kenya, STAK produced a regional variety list, a regional Q-list, road maps for Kenya and a press release. The NPCK produced brochures on seed certification and held several press conferences on HESSREP (e.g., www.coastweek.com/3621_agriculture_02.htm).

Five main information delivery channels were used: print media, radio, TV, brochures/flyers and the internet. Brochures were important as they reached all those who interacted with the various project teams. Radio, television and print media were used to reach a wider audience and the general public. A webpage was created on the NPCK website to host details of the five agreements. A Twitter account was also opened for purposes of disseminating information on HESSREP. Google Groups and Dropbox accounts were opened and shared with project implementers across the five countries for information and knowledge-sharing amongst the project team members.

Key lessons learned
• There is a need to continue creating awareness among new players in the seed sub-sector on the importance of HESSREP, and to promote the achievements.
• It is important to continue to hold regional meetings to clarify or review some of the HESSREP areas, which member States interpreted differently or are not ready to implement, e.g., an agreement on compulsory on-farm testing.
• Holding regular workshops in each country is useful for increasing bonds between actors in the seeds sector. Participants can share views from different cultures and gain additional and consistent knowledge from their colleagues.
• Many policymakers are not well informed of the many issues affecting the development of the seed industry. For them to fully understand and appreciate the intervention in terms of legislature and other legal frameworks, continuous lobbying and advocacy are necessary.
• Involvement of policymakers and parliamentarians in the task force helps in fast-tracking adoption and implementation of HESSREP.
• Mentoring proved to be very effective and helps fast-track implementation for countries that are behind or have limited capacity.

Conclusion
The project was successful in creating awareness of the importance of adoption of the five HESSREP agreements in each participating country. The development of country road maps was also crucial in guiding the implementation and ensuring the process continues after the end of the life of the project. The communication tools used were simple and effective. However, the project period was too short for a policy project. It is important to expand the interventions to the other ASARECA member countries and to use the lessons learned for effective interventions.
<table>
<thead>
<tr>
<th>Activities</th>
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<th>Who to do (institution)</th>
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<tr>
<td>1. Create awareness on standardized documents and procedures for variety evaluation, release and registration in EAC</td>
<td>1.1. Identify stakeholders (policy makers, regulators, private sector) to sensitize</td>
<td>TF, ONCCS</td>
<td>MINAGRIE, TF, ASARECA, EASCOM</td>
</tr>
<tr>
<td></td>
<td>1.2. Convene awareness creation meetings on standardized documents and procedures in EAC</td>
<td>TF, ONCCS</td>
<td>MINAGRIE, TF, ASARECA, EASCOM</td>
</tr>
<tr>
<td>2. Conduct training on standardized documents and procedures in EAC</td>
<td>2.1. Identify policy makers and regulators to train</td>
<td>TF, ONCCS</td>
<td>MINAGRIE, TF, ASARECA, EASCOM</td>
</tr>
<tr>
<td></td>
<td>2.2. Convene training</td>
<td>TF, ONCCS</td>
<td>MINAGRIE, TF, ASARECA</td>
</tr>
<tr>
<td>3. Develop the implementing regulation on variety evaluation, release and registration procedures in EAC</td>
<td>3.1. Identify and invite actors involve in draft preparation</td>
<td>ISABU, ONCCS</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>3.2. Convene meetings of actors to study the national existing and the EAC documents</td>
<td>ISABU, ONCCS</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>3.3. Convene enlarged meetings of stakeholders to validation text</td>
<td>TF</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>3.4. Submit the final draft to the legislation committee for reviewing Ministry of agriculture</td>
<td>TF, actors</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>3.5. Submit the final regulation copy to the Ministry of agriculture for signature</td>
<td>Legislation committee</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td>4. Create and execute a lobby and advocacy plan</td>
<td>4.1. Convene a meeting to create a plan of L&amp;A</td>
<td>TF</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>4.2. Identify actors to execute the plan</td>
<td>TF, EASCOM &amp; other actors</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>4.3. Follow up TF to forward final draft regulations to the Minister for signing and gazettement</td>
<td>TF, ONCCS, EASCOM</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>4.4. Lobby for mainstreaming of printing of regulations under ONCCS</td>
<td>TF, ONCCS, EASCOM</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>4.5. Developing communication materials</td>
<td>TF, ONCCS, EASCOM</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
<tr>
<td></td>
<td>4.6. Sensitisation of the signed harmonisation standards on variety evaluation, release and registration</td>
<td>TF, ONCCS, EASCOM</td>
<td>MINAGRIE, TF, EASCOM, CNS</td>
</tr>
</tbody>
</table>

To do | Done | In progress | Delayed, serious issues | Duration unknown | Milestone
<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Implementers to be made aware</th>
<th>Lobbying &amp; Advocacy needed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public and private sector</td>
<td>MINAGRIE</td>
<td>NO</td>
</tr>
<tr>
<td>Public and private sector</td>
<td>MINAGRIE</td>
<td>NO</td>
</tr>
<tr>
<td>Public and private sector</td>
<td>MINAGRIE</td>
<td>NO</td>
</tr>
<tr>
<td>Public and private sector</td>
<td>MINAGRIE</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, ASARECA</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, Researchers, Seed Industry players, NGOs</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>NO</td>
</tr>
<tr>
<td>ISABU, ONCCS, MINAGRIE, DPSP, DPV, FACAGRO et les privés</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>NO</td>
</tr>
<tr>
<td>MINAGRIE, Researchers, Seed Industry players, NGOs</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>YES</td>
</tr>
<tr>
<td>MINAGRIE, Researchers, Seed Industry players, NGOs</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>YES</td>
</tr>
<tr>
<td>MINAGRIE, Researchers, Seed Industry players, NGOs</td>
<td>MINAGRIE, Researchers, Seed Industry players</td>
<td>NO</td>
</tr>
</tbody>
</table>
Further implementation of the road maps, with many planned activities that extend beyond the pilot period, will need further support and, after enactment into law, domestication and implementation. Other areas requiring further support include popularisation of the laws among stakeholders; development of more flyers and policy briefs; development of regulations and protocols for implementation of the laws; and support for infrastructural development. In addition, the seed laboratories will need support in terms of equipment and capacity building of value chain actors for the implementation of HESSREP to enhance cross-border seed trade.

Acknowledgements
The authors are very grateful to ASARECA for providing financial and technical support for implementation of the HESSREP project, an important project in the region. Many thanks to the project partners from the five pilot countries: Dr Evans Sikinyi of Seed Traders Association of Kenya, the project coordinator in Kenya; Ms Michelline Inamahoro of Institut des Sciences Agronomiques du Burundi, the coordinator in Burundi; Mr David Wanyama of Ministry of Agriculture, Animal Industry and Fisheries, the coordinator in Uganda; Mr Cirino O. Oyiki and Mr George Tadu of Directorate of Research, Ministry of Agriculture, Forestry, Cooperatives and Rural Development, who were coordinating the project in South Sudan; and Mr Patrick Ngwendiagi of Ministry of Agriculture Food Security and Cooperatives, the project coordinator in Tanzania. We also would like to acknowledge the contribution of the National Potato Council of Kenya, which was the project lead institution.

References


Banana seed systems and practices in eastern DR Congo

E. B. Basengere¹ and D. Birindwa Rutega¹

Following the spread of banana *Xanthomonas* wilt in Eastern and Central Africa, banana-dependent smallholders are facing a shortage of quality planting material. This paper discusses how the seed policies and practices in Democratic Republic of Congo (DR Congo) are promoting quality planting material for farmers. An analysis of available information on how the banana seed sector is organised showed that only genotypes cultivated in the western part of the country have been described, while those cultivated in other parts are yet to be described. The formal and informal sectors coexist, but do not provide and facilitate access to planting material for most farmers. There is a need to mobilise diversified banana genetic resources, and to provide technical information on their adaptation and agronomic performance in each zone following multi-location trials. Banana plantlets must be produced from adapted genotypes so farmers can respond easily to the increasing need for planting materials and use them to enhance banana productivity.

**Keywords:** agronomic, genotypes, performance

**Introduction**

For more than 100 million people in sub-Saharan Africa, banana (banana and plantain, *Musa* spp.) is a staple food crop and a source of income. Total annual production volume ranks it in fourth position behind maize, cassava and yams (FAO, 2009). Mainly grown in mixed plots, banana is also valued for its contribution to soil fertility management and field water management. It is also used to produce local beverages consumed at weddings and other social ceremonies (Raemekers, 2001). West and Central Africa, including the Great Lakes Zone of Eastern Africa, harbour the world’s greatest diversity of banana and are regarded as a secondary centre of diversity of plantain and highland banana genotypes (Tenkouano et al., 2003). Banana and its products represent the most important food in Burundi, Rwanda and Uganda, where 35 to 50% of household food budget expenditure is allocated to banana products (Tushemereirwe et al., 2006). In DR Congo, banana is grown on 65% of arable lands especially in North and South Kivu, and provides 45% of the income for rural populations there.

Banana production is facing several constraints that include low productivity of local genotypes, and pests and diseases. Among the diseases, banana *Xanthomonas* wilt (BXW) is probably the most serious threat to productivity (Ndungo et al., 2005; USAID, 2010). Banana wilt was first reported in Ethiopia four decades ago on ensete, which is closely related to banana (Yirgou and Bradbury, 1968, 1974). It was first reported on banana in Uganda and in DR Congo in 2001 (Tushemereirwe et al., 2004). Banana wilt subsequently spread to Kenya (Mbaka et al., 2007), Tanzania (Mgenzi et al., 2006), Rwanda (Murekezi, 2009) and Burundi (Kalyebara et al., 2006). In Eastern and Central African countries, the disease is considered to be the most devastating in banana-growing areas. Banana wilt and low soil fertility are now considered the two biggest production constraints in Eastern Africa.

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(Tripathi et al., 2009). Banana wilt can cause 80 to 100% of crop loss, especially where susceptible genotypes are grown intensively (Ndungo et al., 2005; Kalyebara et al., 2006; Tushemereirwe et al., 2006; Mbaka et al., 2009). In all the affected areas, most of the cultivated genotypes are susceptible (CIALCA, 2010). According to the CIALCA report, in eastern DR Congo, more than 40% of banana fields have been abandoned and replanted by other crops, while in the remaining affected fields, 60% of infected plants were removed. The disappearance of banana genotypes in affected areas, combined with the rapid spread of banana Xanthomonas wilt in partially affected and yet-to-be affected areas, have exacerbated the situation. Banana seed availability and access in the region will probably become the most important intervention of the banana value chain in the near future.

**Banana seed system: production, control and regulation mechanisms**

Agriculture activities in DR Congo are organised and sponsored by the Ministry of Agriculture at the national level, and represented at the provincial level by the provincial Ministry of Agriculture. In 2011, a revised agriculture law was adopted to govern the organisation and functioning of the agricultural sector, in terms of access to and use of land for crop production. Little additional information was given about access to agricultural inputs such as seeds, fertilisers and harvest infrastructure.

At the national and provincial levels, the Ministry of Agriculture operates under a specific service focusing on seed issues. This is locally known as the National Seed Service (Service National des Semences, SENASEM). It is responsible for seed quality control and certification. In 2012, the national Ministry of Agriculture received support from the Belgian Technical Cooperation Agency (Coopération Technique Belge) to strengthen its capacity in providing goods and services to farmers for improving crop productivity. Many reports and documents were produced under this initiative; two reports specifically address the seed sector and they are the definitive guides for the seed industry in DR Congo.

The first report, *Réglement technique de la production, du contrôle et de la certification des semences des principales cultures vivrières et maraîchères* (MINAGRI, 2012a), is focused on technical rules for the production, control and certification of seeds for the major food crops in DR Congo. This document outlines the general recommendations applicable to major food crops; the criteria for good quality seeds; seed production organisation and requirements; stakeholders and their responsibilities; and the certification process. It aims to help SENASEM improve its performance and adhere to international seed industry requirements. According to the rules outlined, only seeds from varieties recognised by SENASEM and listed in the official catalogue can be used by farmers. Several categories of seeds are defined on a general scale (ranked as follows: parental seeds, pre-base seeds, base seeds, certified seeds, quality declared seeds, standards seeds). Specific rules on production of each seed category are provided in this document.

The process of certification includes: (1) crop field declaration; (2) crop field monitoring by SENASEM; (3) acceptation of the seed crop field by SENASEM; (4) sampling of the harvest; (5) laboratory analysis for quality control; and (6) certificate delivery.

This report also provides specific technical rules for each food crop that includes each crop’s biological properties and production practices. The crops detailed are: cereals (maize, rice), roots and tuber crops (cassava, potato and sweet potato), legumes (groundnuts, common beans, cowpea and soybean), vegetables and banana.
The second report, *Catalogue variétal des cultures vivrières (maïs, riz, haricot, arachide, soja, niébé, manioc, patate douce, pomme de terre et bananier)* (MINAGRI, 2012b), presents the available varieties of the crops listed along with their agronomic characteristics and performance in different agro-ecological zones of DR Congo. This presentation of genotypes allows farmers and other stakeholders to have a clear idea about genotype performance to guide their choice of food crop varieties.

### Table 1. Origin, type and mean bunch weight of banana varieties and corresponding main production zones in DR Congo

<table>
<thead>
<tr>
<th>Variety name</th>
<th>Origin</th>
<th>Year of release</th>
<th>Type of banana</th>
<th>Cultivation area</th>
<th>Bunch weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS 210</td>
<td>IRAZ (Burundi)</td>
<td>2008</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>20</td>
</tr>
<tr>
<td>BS 529</td>
<td>IRAZ (Burundi)</td>
<td>2008</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>26</td>
</tr>
<tr>
<td>BUBI</td>
<td>Unknown</td>
<td>2008</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>19</td>
</tr>
<tr>
<td>DIYIMBA</td>
<td>IRAZ (Burundi)</td>
<td>2002</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>15</td>
</tr>
<tr>
<td>FHIA 21</td>
<td>INIBAP (Honduras)</td>
<td>2008</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>23</td>
</tr>
<tr>
<td>MFUMBA</td>
<td>Unknown</td>
<td>2005</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>30</td>
</tr>
<tr>
<td>NSELUKA</td>
<td>Unknown</td>
<td>2008</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>16</td>
</tr>
<tr>
<td>NSIKUMUNA</td>
<td>Unknown</td>
<td>2008</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>45</td>
</tr>
<tr>
<td>ORISHELE</td>
<td>IITA (Ibadan)</td>
<td>2003</td>
<td>Plantain</td>
<td>Bas Congo</td>
<td>20</td>
</tr>
<tr>
<td>BITA 3</td>
<td>INIBAP Cameroun</td>
<td>2001</td>
<td>Cooking banana</td>
<td>Bas Congo</td>
<td>21</td>
</tr>
<tr>
<td>CARDABA</td>
<td>INIBAP (Honduras)</td>
<td>2001</td>
<td>Cooking banana</td>
<td>Bas Congo</td>
<td>15</td>
</tr>
<tr>
<td>FHIA 25</td>
<td>INIBAP (Honduras)</td>
<td>2008</td>
<td>Cooking banana</td>
<td>Bas Congo</td>
<td>51</td>
</tr>
<tr>
<td>SABA</td>
<td>INIBAP (Philippines)</td>
<td>2003</td>
<td>Cooking banana</td>
<td>Bas Congo</td>
<td>25</td>
</tr>
<tr>
<td>FHIA 01</td>
<td>INIBAP (Honduras)</td>
<td>2008</td>
<td>Dessert banana</td>
<td>Bas Congo</td>
<td>30</td>
</tr>
<tr>
<td>FHIA 03</td>
<td>INIBAP (Honduras)</td>
<td>2008</td>
<td>Dessert banana</td>
<td>Bas Congo</td>
<td>20</td>
</tr>
<tr>
<td>FHIA 23</td>
<td>INIBAP (Honduras)</td>
<td>2008</td>
<td>Dessert banana</td>
<td>Bas Congo</td>
<td>24</td>
</tr>
<tr>
<td>GROS MICHEL</td>
<td>Guadeloupe</td>
<td>1970</td>
<td>Dessert banana</td>
<td>All DR Congo</td>
<td>30</td>
</tr>
<tr>
<td>IBOTA</td>
<td>Guadeloupe</td>
<td>2008</td>
<td>Dessert banana</td>
<td>Kisangani area</td>
<td>10</td>
</tr>
<tr>
<td>MAFUTA</td>
<td>INERA</td>
<td>2000</td>
<td>Dessert banana</td>
<td>Kisangani area</td>
<td>25</td>
</tr>
<tr>
<td>MWASI ZOBA</td>
<td>INERA</td>
<td>2002</td>
<td>Dessert banana</td>
<td>Bas Congo</td>
<td>20</td>
</tr>
<tr>
<td>SH3640</td>
<td>INIBAP (Honduras)</td>
<td>2008</td>
<td>Dessert banana</td>
<td>Bas Congo</td>
<td>25</td>
</tr>
</tbody>
</table>

*Source: MINAGRI (2012b)*

Most of the banana genotypes described are cultivated in the western part of the country, where many new genotypes were introduced after 2005 (Table 1). There is limited information on widely cultivated banana genotypes introduced before 2005 in eastern and western DR Congo. This highlights the need to comprehensively update and compile the information on existing genotypes to provide a clear status on the diversity of banana germplasm available in DR Congo.

Additional work on the characterisation of banana genotypes was reported by Dowiya et al. (2009). They describe local and improved banana genotypes cultivated by farmers in South and North Kivu. Congolese genotypes were compared with those from Tanzania using local names and morphological tools. They showed that cultivars for wine making (AAA-Cavendish, AAA-Gros Michel, AAA-Ibota, AAB-Kamaramasengi and ABB) are more predominant in farmers’ fields than the other banana sub-group genotypes used for cooking, roasting and dessert. They identified 29 genotypes cultivated in South Kivu province, and 32 in North Kivu province.
Figure 1. Distribution of banana genotype groups in South (a) and North-Kivu (b) provinces

Source: Dowiya et al. (2009)

Figure 2. Banana seed system stakeholders and their roles and responsibilities in the banana seed value chain in DR Congo

<table>
<thead>
<tr>
<th>Creation of new genotypes</th>
<th>Adaptation field trials in different agro ecologic zones</th>
<th>Banana seed producers and multipliers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Involved stakeholders</strong></td>
<td><strong>Genotypes transfer</strong></td>
<td><strong>Suckers transfer</strong></td>
</tr>
<tr>
<td>CGIAR and international research organizations: IITA, INIBAP, Bioversity, IRAZ, ...</td>
<td>National agriculture Institute: INERA</td>
<td></td>
</tr>
<tr>
<td>National agriculture Institute: INERA</td>
<td>SENASEM Follow up Quality control process and certification</td>
<td>Certified banana suckers</td>
</tr>
</tbody>
</table>
**Formal seed delivery system**

Introduction and development of new banana varieties is conducted by INERA (Institute National pour l’Etude et la Recherche Agronomique) in partnership with international research institutes such as Bioversity, IITA and INIBAP (Figure 2). INERA, which is responsible for crop improvement, also conserves introduced and local banana germplasm collection located in INERA research stations at Mulungu, Yangambi and Mvuazi. Introduced materials are evaluated in field adaptation trials for yield potential and resistance to major pests and diseases such as banana weevils, banana bunchy top disease, black sigatoka, BXW and nematodes. After the field trials, the selected genotypes are entered into the seed multiplication system. Banana seed multiplication can only be carried out by individuals with technical skills or those who work in biotechnology laboratories, universities or in the private sector.

**Constraints in formal seed delivery system**

Despite the existence of a formal delivery system for producing banana planting materials, delivery is poor because:

- few multi-location field trials are conducted due to inadequate funding from the government and other donors;
- no private companies and/or individuals are involved in banana seed production because it requires specialised technical skills and expensive laboratory facilities;
- the few public and private universities with biotechnology laboratories such as Kinshasa, Kisangani and Bukavu use them for training students, and are not yet involved in seed multiplication and planting material production;
- although the national seed service (SENASEM) is required to monitor multiplication of banana genotypes by private organisations and in farmers’ fields as part of quality control activities, it has no diagnostic laboratories for detecting viruses, bacteria, etc. in banana planting materials.

**The informal system**

Although banana genotypes move from one country to another in the region, carried by visiting small-holder farmers, a well developed informal seed delivery pathway does not exist. The small quantity of material that farmers import into DR Congo from neighbouring countries (Burundi, Rwanda and Uganda) (one or two suckers on average) is not enough to create an informal seed system. At the local level, farmers usually exchange planting material in an uncontrolled pathway.

**The way forward**

Following the spread of BXW epidemic in eastern DR Congo, there is an urgent need for new, productive banana genotypes to enhance food availability. The banana seed value chain is facing a great challenge, which will require the involvement of several stakeholders to ensure planting materials are available and farmers can easily access them. This will require:

- systematic characterisation of all banana genotypes to complement those described in the DR Congo catalogue, via enhancing the human and physical capacities of INERA to support and sustain an effective banana research and development programme in DR Congo;
- promoting and supporting the introduction of multi-location evaluation of new genotypes for key traits and consumer acceptability;
• the involvement of university biotechnology laboratories in banana plantlet production and dissemination to increase the volume of new and productive planting material;
• catalysing the emergence of private entrepreneurship in the banana seed value chain (similar to AGROBIOTECH in Burundi), private investment, lobbying for seed policies favourable to the local business environment, and facilitating access to technical information on banana seed technologies and innovations.

References


Seed sector policies in Madagascar
E. Randrianatsimbazafy

This paper summarises the seed sector policies in Madagascar. It aims to give an insight into seed laws and regulations through an inventory, identification of gaps, solutions and lessons for a way forward. The seed sector in Madagascar is governed by several laws and regulations. There is specific legislation on variety release; phytosanitary activities; plant variety regulation; and export and import of seeds. Madagascar also has a national seed strategy and a national catalogue of crop varieties and species. However, the seed sector is constrained by a failure to enforce, or limited application of, seed laws; ineffective seed control; and limited privatisation of seed production and marketing. The seed sector is further constrained by an unfavourable business environment; lack of incentives for breeding activities; and incoherent policies among government ministries. The seed industry in Madagascar is not competitive compared with others in the region. Farmers have limited access to quality seeds. Public–private partnerships are weak. Actors in the seed sector have limited human, physical and financial capacities. There is limited communication and information exchange among actors in the seed value chain. As a result, available information on the seed sector is unreliable. To develop an integrated seed system in Madagascar, it is necessary to implement the seed act and legislation; improve the seed sector environment by creating intellectual property rights to give incentives for breeding activities; update and harmonise local laws with regional laws; build human and physical capacities of actors in the seed value chain; and strengthen public–private sector partnerships. A database to provide information on seed imports and exports and other relevant information should be developed and made available to diverse stakeholders through appropriate communication channels.

Keywords: intellectual property, national seed strategy, public–private partnerships, seed legislation

Introduction
The Republic of Madagascar is an island nation off the south-east coast of the African continent in the south-west Indian Ocean. Madagascar covers an area of 595,000 km², Antananarivo is the capital. The official languages are Malagasy and French. The newspapers, radio and television programmes are usually in the Malagasy and French languages. The majority of the estimated 20 million population are Malagasy; there are also Indian, African, European (mainly French) and Chinese minorities. Madagascar has diversified agro-ecological zones.

The development of the seed sector is considered to be the basis of development of the agricultural sector in Madagascar. The seed industry in Madagascar comprises formal and informal seed sectors. The law that incorporates the regulations and guides seed operations was made in 1994. A national seed strategy, which also governs seed production and trade in Madagascar, was adopted on 11 November 2008.

AMPROSEM, 123 Rue Evêque Jérôme Rakotomalala–Antanimena, Antananarivo, Madagascar
In the beginning, during the liberalisation of the national seed industry in 1980, 14 private seed companies were registered by the Ministry of Agriculture. On 9 September 1998, 30 private seed companies joined together to form the Malagasy Association for Professionals in Seed and Plants (Malgache des Professionnels des Semences et Plants, AMPROSEM), which plays a predominant role in the seed sector. These companies produced seed of cereals (sorghum, maize and wheat), beans, groundnuts, sweet potatoes, cassava and rice, as well as vegetables (tomato, lettuce, cucumber, watermelon, pepper, carrot, cabbage, eggplant, onion and potato), forest trees, fruit trees, tobacco and cotton. AMPROSEM is currently involved in updating the seed trade and production regulations and harmonising seed certification standards.

There are two systems of seed distribution: formal and informal. The companies in the informal system do not respect the regulations; they have been in operation in Madagascar principally for the benefit of small-scale rural farmers.

The source and quality of most of the planting materials and seed purchased, multiplied and marketed by the informal seed sector are not known. The sources of seed of forest and fruit trees are not documented. Known informal sources of seed include farm-saved seed, farmer-to-farmer exchange, and local markets. Growers of flowers and vegetables multiply planting material for their own use or for sale to other local growers. The movement of seed between Madagascar and other countries is restricted by regulations governing seed certification and standards, phytosanitary measures, variety testing and release procedures, and import and export requirements.

**Status of seed laws and regulations**

Several laws and decrees to regulate the seed sector in Madagascar have been enacted in the past two decades. These are summarised in Table 1.

<table>
<thead>
<tr>
<th>Date</th>
<th>Legislation No.</th>
<th>Purpose/significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 January 1995</td>
<td>94-038</td>
<td>Seed law</td>
</tr>
<tr>
<td>22 August 2006</td>
<td>2006-618</td>
<td>Implementation of seed law</td>
</tr>
<tr>
<td>30 November 2010</td>
<td>2010-0958</td>
<td>Finalisation of national catalogue of varieties and species</td>
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<tr>
<td>30 November 2010</td>
<td>2010-0959</td>
<td>Establishment of fund for seed sector support</td>
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<tr>
<td>14 December 2010</td>
<td>2010-1009</td>
<td>Establishment of seed production, control, certification and trade regulation</td>
</tr>
<tr>
<td>14 December 2010</td>
<td>2010-1010</td>
<td>Establishment of a national agency for seed control services and determination of its powers, competence and attributes</td>
</tr>
<tr>
<td>11 November 2008</td>
<td></td>
<td>National seed strategy</td>
</tr>
<tr>
<td>December 2011</td>
<td></td>
<td>Publication of the first national catalogue of varieties and species</td>
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</table>

The laws are a rule of conduct or procedure established and made by legislative bodies or national assembly or members of parliament. The decrees are the application of the law established by the Council of Ministers.

In spite of these laws and regulations, the major problem is the failure to enforce and respect the seed laws. As a result, there is a lack of quality seed and farmers depend mainly on their own farm-saved
seed. The existence of the law and regulation is only one requirement in the development of the seed sector. There is need to strengthen and to enforce the laws.

**Regulations and standards**
The Seed Control Service (Service Officiel de Contrôle des Semences, SOC) is the main regulatory body established under the Ministry of Agriculture. Seed certification, and seed control in the market and in the field, are undertaken by the SOC. The Service is also responsible for variety release, phytosanitary regulation, plant variety protection and the export and import of seeds.

The main regulation and standards concerning seed are as follows.

- **Seed certification**: According to the Malagasy seed law, SOC is responsible for informing and applying for technical regulations about the production, marketing, quality control and certification of varietal and sanitary seeds.
- **Variety release system**: Before being certified, seeds must be listed in the national catalogue. This list, compiled by the Ministry of Agriculture, may comprise particular registers of cultivated plants and special variety or varietal types that can be multiplied on the national territory.
- **Phytosanitary measures**: During seed circulation there is phytosanitary risk, and so phytosanitary requirements involving certain standards and measures for import and export of seed are required.
- **Plant variety protection**: The inventors of new varieties need protection of their research.
- **Seed import and seed export**: The Phytosanitary Border and Quarantine Inspection Service (Service de la Quarantaine et de l’Inspection Frontalère, SQIF) is responsible for the import and export of plant products, particularly seeds. All seeds coming into the Malagasy territory must pass through this control. In the same way, seeds for export must pass through SQIF in order to detect any pest organisms.

**Functions of the Seed Control Service**
The main function of the SOC is to enforce the laws on seed certification. The specific responsibilities are to:
- receive and record the application for seed production in line with the established standards;
- sample seed lots for analysis in the seed laboratory;
- carry out any tests to determine seed quality (moisture content, germination, inert matter, seed health, etc.);
- undertake varietal purity trials for post-control testing.

**Seed certification**
All commercialised seed – with the exception of vegetable seeds (where certification is optional) – must be certified.

- There must be labels on the seed package delivered by the SOC. The following colours are used for various seed classes:
  - white with purple for breeders and pre-basic seeds;
  - white for basic seeds;
  - blue for certified seeds of first generation (R1);
  - red for certified seeds of second generation (R2) and for hybrid seeds (F1);
  - green for quality declared seeds.
Seed classes

Malagasy seed laws define seed classes as follows.

- **Parental line (G0)**: The initial material with a precise production method used for maintenance breeding.
- **Pre-basic seeds (G1, G2, G3)**: Seed categories between the parental line and basic seeds. They are produced by the breeder(s) or their mandated representative.
- **Basic seed (G4)**: Produced from pre-basic seeds according to a precise production method by the maintainer. It is used to produce certified seed.
- **Certified seeds**: Produced from basic seeds; may be the first (R1) or the second generation (R2) from basic seeds.

Certification processes

Only seed of varieties registered in the catalogue can be certified. The certification process involves:

- field inspection (isolation, off-types, etc.) by the seed inspector;
- seed laboratory testing (varietal purity, germination rate, moisture content, seed health, etc.);
- control of packaging;
- sealing by the SOC.

The main constraint in the certification process is the limited number of inspectors and field control officers. This limits the number and acreage of crops that can be inspected. There is need to train more personnel to meet the country’s needs. Another constraint is inadequate value for cultivation and use (VCU); distinct, uniform and stable (DUS) test material; and the lack of an accredited seed laboratory. These constraints have contributed to ineffective seed production and a limited seed control system.

Variety release system

When the varieties are released, they are registered in the national variety catalogue managed by the Minister of Agriculture. Crops that are eligible for registration include food crops, fodder and pasture, forest trees, vegetables, fruit trees and ornamental species.

There are two lists in the national variety catalogue of Madagascar.

- **List A**: Varieties whose seeds can be multiplied and sold in Madagascar.
- **List B**: Varieties whose seeds can be multiplied but not commercialised in Madagascar. This means the seed is only for exportation according to the commitment between the destination country and Madagascar.

The national variety catalogue contains a list of old varieties and landraces that have been characterised by the national agricultural research system for their agronomic traits and organoleptic characteristics such as taste, as well as lists of:

- old varieties of vegetables and fruit species;
- traditional or local varieties known for their taste or other characteristics.

For registration, a new variety must meet the following conditions.

- **For registration in list A**: A new variety must pass the DUS test; must pass the VCU test, and must have a variety denomination approved in Madagascar.
- **For registration in list B**: A new variety must pass the DUS test, and must have a variety denomination approved in Madagascar.
The first national seed catalogue was compiled in December 2011 with inappropriate material. It contains only 50 varieties and species. Before establishing the second seed national catalogue of Madagascar, we need to inspect the DUS and VCU information within the species and varieties national catalogue (*Catalogue National des Espèces et Variétés de Plantes Cultivées, CNEV*).

**Phytosanitary measures**
The objectives of the phytosanitary measures are to ensure that prohibited plants and plant products are not introduced into the country, and that those that are allowed for production and use in Madagascar meet the phytosanitary regulations.

The procedure to ensure plants and plant products meet the phytosanitary requirements has six steps.

**Step 1: Application for inspection**
The importer is required to notify the regulatory agency of the merchandise to be inspected 24 hours before it arrives. The importer is required to apply for inspection. The quarantine service or the phytosanitary control agent registers the application and assigns it to an agent in charge of phytosanitary control.

**Step 2: Documentary control**
The phytosanitary control agent checks the import documents to determine if they are consistent with the regulations. If this is confirmed, the agent arranges for physical evaluation of the products at an agreed location. If the products do not conform, the agent notifies the importer through an inspection report (step 6). If they meet the criteria in the regulations, the process continues to step 3.

**Step 3: Evaluation of the feasibility of transit**
The continuation of the phytosanitary control process depends on the collection of a licence fee and the amount is decided by the regulation. If the licence fee is paid, the process continues to step 4 or to step 6a.

**Step 4: Identity check**
The identity check is carried out during the application for phytosanitary inspection. It is made according to the statement document presented on arrival of the product, and compares what is stated in the document and the identity of the seed.

**Step 5: Phytosanitary control**
The objective is to avoid the introduction and dissemination of pest organisms.
- If the check shows conformity, the agent goes to step 6.
- If the check shows nonconformity, the agent goes to step 6b.
- If there is a 'plant quarantine crop' present, the agent sends to SQIF.

**Step 6: Delivery of inspection report**
The agent delivers the inspection report to the owner of the product.

**Step 6a: Delivery of inspection report to the operator**
The agent explains in the inspection report the reason for nonconformity, which may be in relation to documents, identity or the phytosanitary requirements.
If the detected pest has not been listed by the regulations, but it has a potential phytosanitary risk, then it must be sent to SQIF.

In the case of reinforced control, the product must be kept at the customs while waiting for the result of the analysis and information on the operator of the consignment.

**Plant variety protection**
The Malagasy Office for Intellectual Property (Office Malgache de la Propriété Industrielle, OMAPI) is responsible for patenting of industrial inventions. This office does not handle plant variety protection. Although it is important for plant breeding activities in Madagascar, there is no law on plant variety protection. The Southern African Development Community (SADC), of which Madagascar is a member, has a regional draft law, but it has not been adopted in the country.

The seed sector depends on OMAPI for plant variety protection services. An intellectual property right policy for the seed sector has been drafted, but is yet to be approved and integrated into the seed law; the national assembly and senate (members of parliament) are expected to adopt the new law in the near future. At that time, the seed sector will have its own intellectual property rights.

There is no law and regulation on plant variety protection to cover innovations and investment in the seed sector. This has discouraged foreign seed companies from introducing their varieties into the country.

**Seed import and export documentation and procedures**
SQIF is responsible for plant and seed importation and exportation. All the seed lots imported to Madagascar have to pass through SQIF to ensure that no pests are present and to avoid their introduction into the country. Madagascar has a quarantine pest list.

**Seed import and export procedures**
Seed importation and exportation follow the general rules for external trade in Madagascar. There must be a preliminary declaration submitted to the Control and Certification Service.

The importer or exporter of conventional seed must submit the following information about the seed lot, which includes the:

- company name;
- name and address of the suppliers or the receivers;
- species and variety in accordance with official control of variety;
- category and generation;
- lot number;
- declared weight of lot;
- number of packages;
- unit weight of package;
- label number (specifying first and last numbers);
- chemical treatments used and name of active ingredient.

The importation and exportation of non-conventional seeds is governed by the regulation between the two countries.
Phytosanitary certificate
All seed lots imported or exported are accompanied by a phytosanitary certificate issued by the national plant protection organisation (NPPO).

Control of importation
The importation of plant contaminated by quarantine pests is prohibited. For phytosanitary reasons, the importation of a plant may be authorised or totally prohibited. The regulations stipulate that any organisation or individual who wishes to import plants must:

• have a plant import permit from the quarantine service;
• hold a phytosanitary certificate of origin or a phytosanitary certificate of re-exportation according to the international regulations, and provide any other additional information;
• submit products to phytosanitary control on arrival;
• meet the requirements of the quarantine services.

Control of exportation
An agent of the quarantine services is responsible for export of plant products and decides on the necessary measures. All importers must obtain a phytosanitary certificate from SQIF.

Based on the health status of the plant to be exported, the quarantine service may refuse to deliver the certificate or grant it after possible treatment. The exportation of some endangered plants may be prohibited or require authorisation.

Investment in the seed sector, especially for importing or exporting, is very difficult because of unreliable data on seed for better decision-making and planning. There is no communication plan or information on the possibility of seed market opportunities and promotional activities. A major problem is the lack of competitiveness for the seed industry of Madagascar in the regional market; the solution is strengthening research.

Policy support and seed enterprise development
Policy serves as a tool to promote enterprise development. It supports efforts to streamline business processes; improve access to finance and programmes targeting seed sector enterprises; and a level playing field for private enterprise development.

Research could play a more central role in the policy process, and could be complemented by improved data on the seed sector. Improved research and data collection on seed enterprises would help inform effective policymaking and programme implementation.

The policy implementation strategy should include a national development plan, an enterprise policy framework, a national seed strategy, a law and a decree.

National development plan
This outlines the government’s priorities and strategies on economic development, and should make reference to the seed sector as a target group. It also identifies the mechanisms to be put in place to ensure implementation.
Enterprise policy framework
This identifies the policy framework for enterprise development, and whether it makes reference to the seed sector as a target group. The policy framework could take the form of a government-endorsed document that defines medium-term targets for the proportion of enterprises owned and led by the seed sector.

National seed strategy
This outlines the government’s strategy for improving the seed sector in terms of its political, social and economic viewpoint. It identifies whether a national seed strategy exists, and briefly summarises the policy implications with relation to seed enterprises or economic status.

Intellectual property rights
Stakeholders in the seed sector feel that the legal framework is very important for establishing and implementing plant breeders’ rights. Researchers and seed companies need protection against cheats and copies. In general, the company may have its own researchers or plant breeders. The intellectual property right protects the new variety and the results of the research, i.e., it is a guarantee for developing seed research. As mentioned previously, the legislative framework for intellectual property rights in Madagascar is at draft stage; it will eventually be enforced and promulgated.

Seed certification
The main objectives of seed certification are to ensure that:
• farmers receive the best possible quality seed to maximise their crop production;
• farmers do not get low quality seed from fraudulent traders.

National variety catalogue
The variety of seed in the market should be registered in the national catalogue to facilitate identification and define precise characteristics. Official recognition of quality-guaranteed seed has two advantages – it facilitates international trade and it removes technical trade barriers.

Seed import and export
The standards and regulations in the seed import/export sector aim to reduce the risk of contamination of seed with pests.

A range of policies and regulations has been adopted to protect farmers from low quality seed, including minimum standards, voluntary or mandatory seed certification, import restrictions, licensing and registration of seed companies, and legal protocols for testing seed quality. In turn, farmers support the seed industry.

In the case of Madagascar, there is a mismatch between the policy at the Ministry of Agriculture and at the Ministry of Finance and Trade. The Ministry of Agriculture is interested in using improved seed and certified seed; whereas the Ministry of Finance is interested only in the tax generated. Improved dialogue between the two ministries is necessary to resolve this issue and generate a more coherent, integrated policy within government.
Public–private partnership
Both private and public sectors have a role to play in developing the seed sector and an efficient seed system. Developing new seed varieties involves fixed costs (equipment) and scientific expertise. The development process can take up to 10 years. The pay-off for these investments is uncertain, especially in cases where seeds are easy for farmers to reproduce. Only a large private company can afford to invest in an activity with such uncertain, long-term pay-offs.

The public sector must play a bigger role in plant breeding and some aspects of quality control, whereas the private sector can focus in the areas of seed multiplication, processing and distribution. In addition, the state, especially in poor countries where the private sector is not sufficiently developed, can play a role in limiting the risks associated with seed production and distribution.

Support of the seed industry is provided by a multidisciplinary team, including policymakers, farmers, researchers, seed associations and providers of financial services (especially credit for seed entrepreneurs). Farmers provide the demand for seed, which in turn encourages the seed industry to produce and distribute high quality seed.

A good partnership among researchers, policymakers, farmers and the seed industry ensures that:
• the infrastructure, personnel, genetic and financial resources required to operate the seed industry are available;
• all respect the regulations, which allows the seed industry to develop;
• farmers buy and use improved certified seed according to the regulations.

The ineffective privatisation of seed production blocks the improvement of the seed sector. For example, the seed production centre in Madagascar belongs to the government. There is no development due to lack of incentives for breeding activities and seed research. In summary, a public–private partnership is the best strategy for a sustainable, productive and competitive seed system.

Conclusion
This paper provides an overview of the seed sector in Madagascar, reviewing national seed regulations as well as procedures and standards in the country. The seed sector is constrained by lack of a policy on intellectual property rights. However, a draft policy has been developed. Although several laws and regulations have been enacted, implementation is poor. The Government of Madagascar is making efforts to ensure that appropriate legislation is being put in place to ensure the development of a viable seed sector. A national seed strategy that includes political, social and economic considerations has been developed but has not been implemented. Effective implementation of seed policy, laws and regulations will promote professional seed production and improve access to quality seed by end users.
Regional bean breeding and seed systems approaches for increased impact: Evidence from East and Central Africa Bean Research Network (ECABREN)

J. C. Rubyogo¹, E. A. Birachi², C. M. Mukankusi³ and E. Katungi³

Bean production in sub-Saharan Africa is largely done by small-scale farmers (less than 2 ha), predominantly by women for both household food security and cash. Bean productivity is limited by biotic and abiotic constraints such as diseases, pests, poor soil fertility and drought (Beebe et al., 2012). One of the major interventions being pursued by regional bean research networks to address bean productivity in smallholder systems is enhancing the use of adapted varieties (Buruchara et al., 2011). Based on bean agro-ecological adaptations and market demand similarities across several African countries, a regional breeding programme based on regional constraints and variety demand was introduced by the Pan-African Bean Research Alliance (PABRA) in 1996. Through the alliance, national bean research programmes (NBRPs) in partnership with the International Center for Tropical Agriculture (CIAT) have developed a range of farmer-preferred bean varieties with useful adaptation and consumer-preferred traits. Through this alliance, countries share germplasm and variety evaluation data that accelerate the release process, often leading to simultaneous release of a variety in several countries. It is therefore logical that seed systems are developed and implemented to facilitate seed access in each member country, and to promote regional seed business development. This paper describes the PABRA approach and experience in the development of regional seed systems to facilitate access to seed of improved bean varieties by farmers.

Keywords: adapted varieties, constraints, demand

Why a Pan-Africa bean research perspective?
Based on agro-ecologies (latitude, altitude, available moisture/rainfall regime, soil pH and rainfall regime), Wortmann et al. (1998) clustered bean production systems into 14 African bean environments (AFBEs) cutting across several countries (Table 1). These AFBEs determine the types of bean germplasm, cropping systems and uses. There is regional bean trade with similar bean market classes (grain types) produced and traded across countries (Table 2).

The Pan-Africa Bean Research Alliance (PABRA) is a consortium of African-owned regional bean networks consisting of National Agricultural Research Systems (NARS), other bean value chain actors (including traders, extension service providers and seed producers from 29 countries in sub-Saharan Africa).

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Africa) and the International Center for Tropical Agriculture (CIAT), working to improve productivity, utilisation and commercialisation of the common bean (*Phaseolus vulgaris*) for the benefit of the urban and rural poor. The capacity of National Agricultural Research Systems (NARS) at country level to conduct bean research for development varies from one country to another. They range from a single scientist working on a broad range of legume crops, to multidisciplinary teams of scientists and specialists in crop breeding, plant pathology, entomology, agronomy, nutrition, seed systems, markets and social science working on a single crop (bean) in other countries. A coordinated regional breeding programme that facilitates information-sharing, technical expertise and germplasm is hence justified. The ultimate goal is to enhance the food security, income generation and health of poor communities in a gender-equitable manner.

Table 1. African bean environments (AFBE)* across East and Central Africa Bean Research Network (ECABREN) countries

<table>
<thead>
<tr>
<th>AFBE</th>
<th>Burundi</th>
<th>DRC</th>
<th>Ethiopia</th>
<th>Kenya</th>
<th>Madagascar</th>
<th>Rwanda</th>
<th>Uganda</th>
<th>Tanzania</th>
<th>Sudan</th>
<th>South Sudan</th>
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* Wortmann et al. (1988)

Table 2. Major bean market classes in ECABREN countries

<table>
<thead>
<tr>
<th>Market class</th>
<th>Burundi</th>
<th>DRC</th>
<th>Ethiopia</th>
<th>Kenya</th>
<th>Madagascar</th>
<th>Rwanda</th>
<th>Tanzania</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red mottled</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>Browns: yellow, brown, tan</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>Reds: dark red kidney and small red</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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<td>✗</td>
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<tr>
<td>Creams: sugar, carioca and pinto</td>
<td>✗</td>
<td>✗</td>
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<td>✗</td>
<td>✗</td>
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<tr>
<td>Whites, large and small white</td>
<td>✗</td>
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<td>Blacks</td>
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</table>
PABRA has three regional bean networks. These are: Eastern and Central Africa Bean Research Network (ECABREN) covering ten countries; Southern Africa Bean Research Network (SABRN), covering nine countries; and the West and Central Africa Bean Research Network (WECABREN), covering ten countries. ECABREN, SABRN and WECABREN are semi-autonomous and respond to priorities defined by corresponding sub-regional organisations, which are the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); Centre for Agricultural Research and Development for Southern Africa (CARDESA); and West and Central African Council for Agricultural Research and Development (CORAF/WECARD), respectively. All the networks use a uniform log-frame under the PABRA umbrella. Activities in the PABRA work plan are developed using a bottom-up approach, and are based on the outcome of national programme planning followed by planning at the regional network level. The alliance provides a forum for building and maintaining linkages to multiple partners in areas of bean research and development. These collaborative linkages are maintained and strengthened through joint priority-setting, planning, agreed division of responsibilities, joint implementation of activities, and joint reporting and sharing of experiences. PABRA facilitates collaborative research linkages across different but complementary areas, from breeding to product utilisation, including markets, nutrition and integration of beans in the agro-ecosystems.

**Pabra logic model 2009–13**

**Regional breeding strategies**

The PABRA breeding strategy uses a market-led approach as farmers also produce beans both for food and sale. Preferences for bean types differ with markets, countries and regions; no single variety or class of bean can meet the diversity of market and consumer needs. Currently, the breeding programme is focusing on seven market classes (Buchara *et al*., 2011). For each market class, the breeding objectives and methods are well defined and the germplasm requirements to meet their breeding goals are identified. The research priorities are based on both demand (bean market classes and nutrition) and agro-ecological adaptation/constraints that often go beyond national borders and require a regional approach. The main priorities for the breeding programme are:

- yield improvement;
- improvement of resistance to major biotic and abiotic constraints;
- identification, characterisation and utilisation of new and better sources of resistance to major biotic (also targeting new disease races and pest species) and abiotic constraints (e.g., drought, low soil fertility, acidity, low N, low P and salinity);
- cooking and nutritional quality including improvement of iron and zinc content;
- improving canning quality of dry bean for the canning industry and developing new niche market varieties (snap/green beans).

New priorities include tolerance to heat or cold, tolerance to waterlogging/excessive water, and assessment of advanced and fixed lines for productivity in different cropping systems, particularly intercrop and sole cropping systems.

The PABRA members share the breeding responsibility depending on national members’ interest and on the comparative advantage of each member. Stronger NARS may handle segregating populations or develop populations themselves, while the weaker NARS start with evaluation of advanced lines.
and gradually handle segregating materials. In this way, the evaluation is accelerated due to sharing of characterisation and variety performance data. Through this approach, countries or regions without structured bean breeding programmes (e.g., Angola, Burundi, Cameroon, Congo Brazzaville, DRC, Guinea Bissau, Lesotho, Mozambique and Swaziland) have released bean varieties as a result of collaborative evaluation and sharing of germplasm. More than 200 multiple stress-resistant and farmer accepted bean varieties have been released in PABRA, of which 140 have been released in ECABREN since 2009, representing over 65% of the total releases (Table 3). Some of these varieties target niche markets such as snap beans in Rwanda and canning beans in Ethiopia, while others have an added trait of high iron and zinc grain content. The collaborative process has contributed significantly to scaling up and widening of the impact efforts. Bean technologies and approaches have been moved across countries or networks. For example, most countries have adopted participatory variety selection (PVS) approaches and impact-oriented seed systems.

Table 3. Bean variety releases in ECABREN countries, 2009–14

<table>
<thead>
<tr>
<th>Country</th>
<th>Marketable varieties*</th>
<th>Niche market varieties</th>
<th>Micronutrient-rich</th>
<th>Total</th>
<th>Percentage release by country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>8</td>
<td>0</td>
<td></td>
<td>8</td>
<td>5.7</td>
</tr>
<tr>
<td>DRC**</td>
<td>19</td>
<td>7</td>
<td>15</td>
<td>41</td>
<td>29.3</td>
</tr>
<tr>
<td>Rwanda</td>
<td>16</td>
<td>4</td>
<td>10</td>
<td>30</td>
<td>21.4</td>
</tr>
<tr>
<td>Uganda</td>
<td>13</td>
<td>0</td>
<td></td>
<td>13</td>
<td>9.3</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>22</td>
<td>0</td>
<td></td>
<td>22</td>
<td>15.7</td>
</tr>
<tr>
<td>Madagascar</td>
<td>12</td>
<td>0</td>
<td></td>
<td>12</td>
<td>8.8</td>
</tr>
<tr>
<td>Kenya</td>
<td>11</td>
<td>0</td>
<td></td>
<td>15</td>
<td>10.0</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>11</td>
<td>28</td>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>

* Marketable dry bean varieties with multiple stress tolerance.  
** Varieties released in eastern and western DRC.

Variety development

In the period 2009–14, 140 releases were made in seven ECABREN countries (Table 3). Most progress has been made in the dry bean multiple stress-tolerant variety category, which accounted for more than 72% of the releases (Table 3). This is mainly because dry bean has been prioritised in these countries. Similarly substantial progress was made in the development of micronutrient-rich beans based on the PABRA target of 13 releases. Twenty-eight high-iron and -zinc varieties were released in ECABREN, with iron levels ranging between 75 and 95 ppm and zinc levels ranging between 31 and 37 ppm. Most of the varieties were released in only three out of the ten ECABREN countries, indicating the need for other countries to prioritise this trait in their breeding programmes. However, only a few of the released varieties reached the new PABRA target of >90 ppm iron, indicating the need to increase efforts to achieve this target. A similar pattern was observed for releases of niche market varieties. Only two ECABREN countries (DRC and Rwanda) released 11 niche market varieties. Most of the varieties are in the dry bean market class (DRC) and snap bean in Rwanda.

Most varieties released in Ethiopia (small whites and small reds) and in Madagascar (large whites) target the niche canning market, although they were classified as multiple stress-tolerant varieties (Table 3). Income earned from niche markets allows farmers to diversify their diets and have more
purchasing power to acquire essential household items and hence improve their livelihoods. However, these niche market products are faced with a number of challenges. The most fundamental bottleneck for snap bean production in the region is the lack of locally adapted varieties combining high pod yield, pest and disease resistance, and market-demanded pod characteristics. This is because the varieties grown in the region are imported from temperate regions, have a narrow genetic range and are vulnerable to major pests and diseases (Silbernagel et al., 1991; Kimani, 2004). Seed is costly as it is imported; it cannot be recycled as in some instances reproduction has been constrained (PABRA, 2012). Similarly, great potential exists for canning beans as a niche market product. However, existing bean processing industries rely on a very small number of canning bean varieties. In spite of its susceptibility to diseases such as rust, MEX 142 is still the most popular variety because it meets canning industry specifications.

Regional and multiple variety releases
As a result of the collaborative regional breeding and variety evaluation, several varieties have been released in several countries. These regional efforts hastened the release process and/or allowed countries with limited breeding capacities to target desirable varieties and carry out minimum additional evaluation. Table 4 lists varieties released in more than one country in the ECABREN (ASARECA) region.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Burundi</th>
<th>DRC</th>
<th>Ethiopia</th>
<th>Kenya</th>
<th>Rwanda</th>
<th>Tanzania</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR 708</td>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAB 19</td>
<td></td>
<td></td>
<td>2004</td>
<td>2006</td>
<td></td>
<td></td>
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<tr>
<td>KAT B1</td>
<td>2008</td>
<td></td>
<td>2013</td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KAT 56</td>
<td>2008</td>
<td></td>
<td>2013</td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KAT B9</td>
<td>2008</td>
<td></td>
<td>2013</td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KAT 69</td>
<td>2009</td>
<td></td>
<td></td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G 5621</td>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td></td>
<td>1990</td>
<td></td>
</tr>
<tr>
<td>Gasilida</td>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2010</td>
</tr>
<tr>
<td>CAL 96</td>
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<td>2008</td>
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<td></td>
<td></td>
<td>1994</td>
</tr>
<tr>
<td>GLP 2</td>
<td>2011</td>
<td></td>
<td>2011</td>
<td>1984</td>
<td></td>
<td></td>
<td>1970</td>
</tr>
</tbody>
</table>

Linking regional breeding to seed systems
In order to accelerate the use and facilitate the dissemination of seed of new bean varieties to the wider farming community, NBRPs in collaboration with CIAT and seed value chain actors have evaluated various approaches. These include aligning seed systems activities to respond to the bean value chain seed quality requirement, e.g., navy beans in Ethiopia (Teshale et al., 2006); pluralistic seed systems with multiple seed actors and complementary roles (Rubyogo et al., 2010; Table 5); and use of small, affordable packs (TL II, 2012). Stemming from these interactions and functional partnerships, an integrated seed systems approach was adopted for wider impact. The approach encourages partnership among local seed producers, entrepreneurs, local extension service providers
and NBRPs in seed production and marketing. This complements the centralised formal seed system that usually provides 2–6% of the seed requirements in many countries (Rubyogo et al., 2010).

The integrated seed systems approach has very significantly increased seed availability to farmers especially for new varieties, and reduced the lag period between variety release and use (Rubyogo et al., in press). In addition, several seed training and resource manuals developed in one country have been adapted or translated from English into local languages (Table 6). A small and affordable seed packs approach, initiated in Rwanda and validated in Kenya and Ethiopia with the private sector, has spread to other ECABREN countries such as Burundi, DRC, Madagascar and Uganda (PABRA, 2014a,b).

Table 5. Integrated seed systems actors and their complementary roles

<table>
<thead>
<tr>
<th>Actors</th>
<th>Roles and responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>NARS</td>
<td>Variety development</td>
</tr>
<tr>
<td></td>
<td>Production of breeder/foundation seed</td>
</tr>
<tr>
<td></td>
<td>Provision of information on new varieties</td>
</tr>
<tr>
<td></td>
<td>Support for seed production skills enhancement</td>
</tr>
<tr>
<td>Seed parastatals/seed companies</td>
<td>Facilitation of variety testing</td>
</tr>
<tr>
<td></td>
<td>Seed multiplication of preferred and released variety</td>
</tr>
<tr>
<td></td>
<td>Marketing of certified seed of popular varieties</td>
</tr>
<tr>
<td></td>
<td>Provision of business opportunities and capacity building for contracting farming (outgrowers)</td>
</tr>
<tr>
<td></td>
<td>Provision of initial seed for bulking</td>
</tr>
<tr>
<td>Local extension services (GOs/NGOs/CBOs/FOs)</td>
<td>Decentralised testing of varieties</td>
</tr>
<tr>
<td></td>
<td>Decentralised seed production</td>
</tr>
<tr>
<td></td>
<td>Popularisation of preferred varieties</td>
</tr>
<tr>
<td></td>
<td>Community mobilisation</td>
</tr>
<tr>
<td></td>
<td>Local skill building (e.g., in enhancing seed quality)</td>
</tr>
<tr>
<td></td>
<td>Information development: variety promotional materials</td>
</tr>
<tr>
<td></td>
<td>Development and/or translation of training manuals in relevant languages</td>
</tr>
<tr>
<td>Farmers (seed producers/entrepreneurs)</td>
<td>Carrying out local seed production and supply/marketing of locally preferred genotypes</td>
</tr>
<tr>
<td></td>
<td>Farmer (customer) awareness creation</td>
</tr>
<tr>
<td></td>
<td>Popularisation of preferred varieties</td>
</tr>
<tr>
<td></td>
<td>Training of other farmers in bean agronomy and post-harvest management (farmer implements)</td>
</tr>
<tr>
<td>Farmers (individuals/groups)</td>
<td>Testing and providing feed about potential genotypes</td>
</tr>
<tr>
<td></td>
<td>Grain production which pulls the seed supply</td>
</tr>
<tr>
<td>Local grain traders</td>
<td>Linking local seed producers with wider bean seed markets and moving varieties beyond local zones</td>
</tr>
<tr>
<td></td>
<td>Provision of grain market intelligence</td>
</tr>
<tr>
<td>CIAT/ECABREN</td>
<td>Provision of potential promising germplasm to NARS</td>
</tr>
<tr>
<td></td>
<td>Co-research key bottleneck areas</td>
</tr>
<tr>
<td></td>
<td>Support for skills enhancement in seed/business skills</td>
</tr>
<tr>
<td></td>
<td>Support for monitoring and evaluation</td>
</tr>
</tbody>
</table>

Source: adapted from Rubyogo et al. (2010)
Posters, brochures and flyers developed in one country have been adapted and used in other network countries.

**Impacts**

Between 2009 and 2013, an estimated 22,459.3 t of bean seed was produced and made available to farmers in ECABREN countries (Table 7) using the supportive interventions described above (Table 5). This quantity of seed is enough to plant about 312,374.2 ha (at an average rate of 70 kg/ha).

**Table 7. Amount of seed supplied to farmers in ECABREN region between 2009 and 2013**

<table>
<thead>
<tr>
<th>Country</th>
<th>Amount of seed supplied and estimated total areas under new varieties 2009–13</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seed directly supplied to farmers by seed producers (t)</td>
<td>2009</td>
<td>2010</td>
<td>2011</td>
<td>2012–13</td>
<td>2009–2012/13</td>
</tr>
<tr>
<td>Burundi</td>
<td>116.7</td>
<td>249.7</td>
<td>220.0</td>
<td>192.9</td>
<td>9,704.8</td>
<td></td>
</tr>
<tr>
<td>DRC-East</td>
<td>2,076.8</td>
<td>2,610.5</td>
<td>1,402.0</td>
<td>77.2</td>
<td>88,093.9</td>
<td></td>
</tr>
<tr>
<td>DRC-West</td>
<td>52.1</td>
<td>160.4</td>
<td>7.8</td>
<td>4.3</td>
<td>3,035.7</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>922.2</td>
<td>1,111.3</td>
<td>1,430.0</td>
<td>1,932.1</td>
<td>77,080.0</td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>242.0</td>
<td>237.8</td>
<td>321.0</td>
<td>1,030.0</td>
<td>26,154.3</td>
<td></td>
</tr>
<tr>
<td>Madagascar</td>
<td>33.2</td>
<td>56.5</td>
<td>165.0</td>
<td>102.8</td>
<td>5,107.1</td>
<td></td>
</tr>
<tr>
<td>Rwanda</td>
<td>230.0</td>
<td>345.7</td>
<td>1,35.0</td>
<td>985.9</td>
<td>35,495.1</td>
<td></td>
</tr>
<tr>
<td>Tanzania (N)</td>
<td>66.1</td>
<td>87.0</td>
<td>45.0</td>
<td>97.2</td>
<td>4,219.3</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>917.7</td>
<td>1,101.0</td>
<td>1,367.0</td>
<td>1,103.2</td>
<td>64,126.7</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,656.9</strong></td>
<td><strong>5,959.9</strong></td>
<td><strong>6,317.0</strong></td>
<td><strong>5,526.0</strong></td>
<td><strong>312,374.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Estimated area (ha) under new varieties 2009–2012/13 (seed rate 70 kg/ha)

**Seed access**

Using the integrated seed systems approach, it is estimated that during 2003–08, PABRA reached 7.5 million households with seed of improved bean varieties, impacting about 35 million people with bean-based technologies (Rubyogo et al., 2010). Between 2009 and 2013, another 6,816,365 households in the ECABREN region, of which 56.9% were women, had access to quality seed of improved varieties (Table 8).
Increased bean production and productivity

Significant bean yield increases have been recorded from the use of improved varieties coupled with complementary integrated crop management practices in areas where PABRA operates. On average, a 48% increase in on-farm yield attributed to improved bean varieties was made since 2009, based on data from ten countries drawn from the three networks (PABRA, 2013). Changes in on-farm bean yield levels were observed in several countries across PABRA. The target sought to increase yield from as low as 0.6 t/ha in some countries in 2009 to as high as 2 t/ha by 2013. To date, several PABRA countries have doubled the on-farm bean yield levels, while all countries have seen a positive change in on-farm bean yields (PABRA, 2013). Three factors seem to drive dramatic upward shifts in on-farm bean yield levels:

- adoption of climbing bean varieties where these were widely promoted, e.g., Rwanda;
- better access to markets and associated commercialisation of bean production, which stimulates farmers to invest in intensive bean production and post-harvest management, e.g., Ethiopia (IFPRI, 2010);

### Table 8. Number of farmers who accessed seed of improved bean varieties in the ECABREN region between 2009 and 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Seed access (number of households)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
<td>Female</td>
<td>Male</td>
<td>2010</td>
<td>Female</td>
<td>Male</td>
<td>2011</td>
<td>Female</td>
<td>Male</td>
<td>2012</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Burundi</td>
<td>104,900</td>
<td>80,649</td>
<td>134,208</td>
<td>112,982</td>
<td>115,900</td>
<td>95,350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRC-East</td>
<td>357,689</td>
<td>139,204</td>
<td>258,645</td>
<td>153,470</td>
<td>220,450</td>
<td>167,030</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRC-West</td>
<td>24,165</td>
<td>11,750</td>
<td>46,800</td>
<td>14,250</td>
<td>5460</td>
<td>2340</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>46,249</td>
<td>107,914</td>
<td>42,713</td>
<td>128,140</td>
<td>47,900</td>
<td>145,490</td>
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<tr>
<td>Kenya</td>
<td>155,861</td>
<td>104,998</td>
<td>213,425</td>
<td>168,635</td>
<td>120,900</td>
<td>146,900</td>
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<tr>
<td>Madagascar</td>
<td>24,293</td>
<td>15,338</td>
<td>27,859</td>
<td>7,373</td>
<td>45,890</td>
<td>28,800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rwanda</td>
<td>94,900</td>
<td>73,590</td>
<td>202,692</td>
<td>90,150</td>
<td>252,450</td>
<td>187,900</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanzania (Northern Zone)</td>
<td>21,600</td>
<td>10,090</td>
<td>25,990</td>
<td>13,073</td>
<td>12,900</td>
<td>6,709</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td>907,966</td>
<td>639,242</td>
<td>1,035,253</td>
<td>791,421</td>
<td>1,087,415</td>
<td>926,189</td>
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</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Seed access (number of households)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tr>
<td></td>
<td>2012</td>
<td>Female</td>
<td>Male</td>
<td>2013</td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burundi</td>
<td>67,511</td>
<td>28,933</td>
<td>39,744</td>
<td>15,456</td>
<td>462,263</td>
<td>333,370</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>DRC-East</td>
<td>38,500</td>
<td>16,500</td>
<td>10,890</td>
<td>5,648</td>
<td>886,714</td>
<td>483,852</td>
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<tr>
<td>DRC-West</td>
<td>1,506</td>
<td>645</td>
<td>450</td>
<td>358</td>
<td>78,381</td>
<td>29,343</td>
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<td></td>
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<tr>
<td>Ethiopia</td>
<td>28,950</td>
<td>164,050</td>
<td>106,089</td>
<td>247,541</td>
<td>271,901</td>
<td>793,135</td>
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<td></td>
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</tr>
<tr>
<td>Kenya</td>
<td>141,625</td>
<td>115,875</td>
<td>177,789</td>
<td>142,211</td>
<td>809,600</td>
<td>678,619</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Madagascar</td>
<td>33,410</td>
<td>17,990</td>
<td>121,390</td>
<td>77,610</td>
<td>252,842</td>
<td>147,111</td>
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</tr>
<tr>
<td>Rwanda</td>
<td>367,486</td>
<td>157,494</td>
<td>71,799</td>
<td>31,533</td>
<td>989,327</td>
<td>540,667</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tanzania (Northern Zone)</td>
<td>15,273</td>
<td>12,496</td>
<td>7,459</td>
<td>6,061</td>
<td>83,222</td>
<td>48,429</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>848,705</td>
<td>580,174</td>
<td>748,128</td>
<td>625,485</td>
<td>4,625,467</td>
<td>3,562,511</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: PABRA (2014a)*
• localised high-intensification production systems such as production using irrigation or residual moisture, e.g., Madagascar (PABRA, 2014a).

Table 9. Levels of on-farm bean yields across some PABRA countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Bean yield (t/ha)</th>
<th>2009</th>
<th>2012</th>
<th>Desired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td></td>
<td>0.3</td>
<td>0.45</td>
<td>0.8</td>
</tr>
<tr>
<td>Ethiopia</td>
<td></td>
<td>0.75</td>
<td>1.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Rwanda (climbing beans)</td>
<td></td>
<td>1.0</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Zambia</td>
<td></td>
<td>0.72</td>
<td>0.9</td>
<td>1.5</td>
</tr>
<tr>
<td>DRC East (bush beans)</td>
<td></td>
<td>0.45</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>DRC East (climbing beans)</td>
<td></td>
<td>0.9</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Madagascar (residual moisture)</td>
<td></td>
<td>0.6</td>
<td>1.5</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: PABRA (2014a)

However, there is still a huge yield gap between on-station and on-farm productivity. For example, Ethiopia reported a yield potential of up to 3 t/ha for bush beans on-station and 1.5 t/ha on-farm (PABRA, 2013). The average yield potential of climbing beans in experimental plots in Rwanda was 4 t/ha, compared with the national average of 1.3 t/ha (PABRA, 2013). The situation may worsen as a result of the impacts of climate change on bean production. For instance in areas where a 4°C temperature rise has been predicted, losses are likely to be severe, diminishing the options available to most smallholders (Beebe et al., 2011). Current crop varieties and agricultural practices will often be inadequate, and food security will be more difficult to achieve because of commodity price increases and local production shortfalls. Even where adaptation strategies already exist, considerable institutional and policy support, such as a better organised and more profitable bean market, is needed to develop a sustainable bean sub-sector at the required scale. The profitability of the bean value chain incentivises farmers to invest in high-yielding production systems (use of quality seed and complementary improved agronomic practices) and post-harvest management, including marketable products (PABRA, 2014b).

Conclusion
The regional approach has proven its efficiency in breeding and seed delivery at both regional and national levels. However, despite multiple variety release across ECABREN countries and an increasing regional bean trade based on specific bean market classes, cross-border seed movement is still limited to breeder seed and informal seed exchange across common borders. With the harmonisation of seed rules and regulations in the ASARECA region through the East African Community (EAC) and Common Market for East and Southern Africa (COMESA) region, PABRA member countries should take advantage of multiple releases to increase access to quality bean seed by farmers through the cross-border seed business.

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Although farmers in South Sudan rely largely on agriculture for their livelihoods, they practice subsistence agriculture, which does not create the surpluses needed to feed a rapidly growing number of rural and urban consumers. Agricultural practices are broadly divided between mixed cultivation in the ‘green belt’, and livestock rearing and extensive cultivation in the Ironstone Plateau and semi-arid zones. Quality seed is a key factor in successful agricultural development. An effective seed delivery system should guarantee the availability of quality seed to farmers at the right time and place, and at affordable prices. The 21-year protracted violent conflict and recurrent floods and drought exacerbated seed shortages in South Sudan. The Ministry of Agriculture Forestry, Tourism, Animal Resources, Fisheries, Cooperatives and Rural Development (MAFTAFCRD) is committed to providing the lead support role and creating a favourable operating and economic environment for private sector investment in the national seed system. There are four types of seed system: formal, informal, relief, and community-based market-oriented. The formal seed system is less effective and operates mainly for imported seeds. Informal farmers’ seed and seed aid provide the largest portion of seed, reaching the majority of farmers.

The community-based market-oriented (CoBaMa) system is a strategic approach to the development of an integrated seed sector by combining local isolated experiences and linking seed sector stakeholders to a more efficient and sustainable seed sector aimed at supporting food and seed security through domestic seed production for increased productivity. Under this system, three farmer seed production initiatives were transformed into sustainable market-driven local seed businesses to address new crops and varieties, quality, marketing and organisational aspects. Lessons learned were used to develop seed for a development project. Currently, the Alliance for a Green Revolution in Africa (AGRA) is supporting five crop breeding programmes (cassava, maize, rice, sorghum and cowpeas) and three seed companies (Century Seed, Green Belt Seed and Afroganics). The breeding programmes have short-term plans to quickly evaluate introduced improved crop varieties for release and adoption by the local farming communities to improve seed availability. Maize, rice and cassava programmes have a total of nine selected varieties for release – four maize, four rice and one cassava. These three programmes also bulk basic seeds and supply to the seed companies and some individual farmers. Three seed companies have begun seed multiplication, selling and awareness creation on the use of quality seeds of improved crop varieties. Initiatives for the development of policies, rules and regulations favourable for private seed sector development, including improvement of physical infrastructure, have started.

**Keywords:** community-based market-oriented seed system, efficient, affordable

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Agricultural overview

Improvement of farmer livelihoods in South Sudan depends largely on agricultural activities, which account for about 80% of employment. More than 1.25 million farming families are involved in agricultural input and output value chain activities. Depending on their geographic location and agro-ecologies, South Sudanese farmers practise traditional subsistence agriculture in which crop production, wild food crop collection, rearing livestock and fishing are combined in undefined ratios (Bigirwa and DeVries, 2010). Subsistence farming is not effective or sufficiently efficient to supply the surpluses needed to feed large numbers of returnees and internally displaced persons (IDPs), who continuously add to a rapidly growing number of rural and urban consumers.

Agricultural practices in South Sudan could be broadly categorised into mixed cultivation in the 'green belt', where maize, cassava, upland rice, sorghum and legumes as well as tropical fruits are grown along the southern borders with Uganda and Democratic Republic of Congo (DRC); and the Ironstone Plateau and semi-arid zones in the central, eastern and northern regions that focus more on livestock rearing, including extensive cultivation of sorghum, groundnuts and sesame in addition to niche market crops.

Over 50% of the land in South Sudan has high potential for agriculture. In these high potential areas, climate and soils are suitable to grow a wide range of both field and horticultural crops. Most farmers practise shifting cultivation, with an average cultivated area of two feddans (0.84 ha) per household.

According to FAO (2011), the average yield of cereal production over the past ten years is less than 800 kg/ha. The major factor contributing to low yields is widespread use of seeds of local cultivars or landraces with poor genetic potential. Local varieties and landraces often have yield potential of less than 1 tonne (t) on a hectare of land. The farmers do not use quality seeds as they have limited access to improved varieties, there are inadequate supplies of seed, and prices are high.

Seed systems

Transformation of the agricultural sector could be achieved through commercial distribution of improved seed and other essential inputs. Studies conducted by the International Food Policy Research Institute (IFPRI) on investment options for poverty alleviation in Eastern and Southern Africa indicate that the most significant impact on poverty and growth will come from investments in a range of agricultural sub-sectors, particularly crops for export to regional markets (James et al., 2007).

Seed is a key factor in any agricultural production system. An effective seed system should guarantee availability of quality seed to farmers at the right time and place, and at affordable prices. Most farmers in South Sudan receive their seed supply through the informal seed system by saving from their own farms, or through gifts from relatives and neighbours, or by buying from local markets. At present, seed aid provides the largest portion of seed that reaches farmers. The formal seed system, which produces improved varieties, is not well organised.

The largest portion of the formal seed system in South Sudan currently depends on imported varieties. A formal seed system guided by a regulatory framework, which produces seed of modern varieties in an organised chain of institutions specialised in the conservation of genetic resources; plant breeding, seed production, seed quality control; and seed marketing and distribution, is being
initiated by MAFTAFCRD in collaboration with development partners such as AGRRA, the Dutch Government and USAID.

Seed supply systems serve to make seed available to the users and guarantee sufficient quantities of good quality seed are available to farmers, at the right time and at an affordable price. Most of the farmers in South Sudan, similarly to elsewhere in sub-Saharan Africa, obtain their seeds through the informal system. Farmers save seed from their crops from year to year, receive seed from neighbours and relatives, or buy seed from local markets. A large proportion of farmers still depend on aid agencies for their seed.

Justification for urgent establishment of seed system
Agriculture in South Sudan is zone-dependent. The principal food crops are cassava, sorghum, groundnuts, sesame, maize, sweet potatoes, cowpeas, beans, pigeon peas, tomatoes, onions, okra and pumpkins.

MAFTAFCRD has the primary responsibility of ensuring that adequate and timely supplies of high quality seed are available to farmers at competitive prices. MAFTAFCRD takes the lead in guaranteeing public service support for maintaining an efficient seed supply, generates farmer demand for improved seed, and creates an operating and economic environment favourable for private sector investment in the national seed system.

MAFTAFCRD and development partners collaborate to create a system that will focus on sustainable provision of the highest quality seed (genetic, physical, physiological, and phytosanitary quality components) consistent with potential economic returns, and with all applicable quality requirements to ensure seed reliability for farmers.

The current seed system of South Sudan

Availability
Shortages of essential seeds and planting materials necessary to enable farmers to produce sufficient food for their families and a surplus for sale have been a constraint for many generations in South Sudan. The situation of seed shortages has been exacerbated by the 21-year violent conflict. In addition, recurrent floods and drought have impacted on the local seed supply.

The increased influx of returnees, refugees and internally displaced persons (IDPs) means that an increased demand for seed has worsened the seed shortages, creating a situation in which farmers may not be able to purchase available seeds in the local markets due to lack of buying power.

Because farmers recycle their harvested crop grain as seed, food shortages result in seed shortages, which may justify relief seed interventions. A small fraction of the total harvest is required to establish a new crop. For example, the seed requirement for sorghum is 5–10 kg per farm household, compared with an average annual household food requirement of 300 kg. Imported seed carries a risk of uncertain quality and may not be adapted to local conditions. Unless farmers know the quality and performance of imported seed, they are unlikely to use it until its performance has been proven locally.
As the seed production system in place is inadequate, the majority of improved seeds used in South Sudan are imported from Kenya, Uganda or Sudan. MAFTAFCRD, FAO and other partners have initiated the use of locally adapted crop varieties through a ‘seed recollection programme’, in which seeds are supplied to farmers and then repurchased from them. In 2009, 25 organisations (20 local and five international organisations) were subcontracted to recollect seeds through letters of agreement that specified the activities to be carried out, including type and quantity of seeds, recollection points and destination of the seeds. These organisations worked closely with local farmers’ organisations and with an expert or extension agent from the ministry to identify good seed producers and growers, preferably those who previously had been provided with good quality seed by FAO. In addition, they organised seed quality testing. Recollection and bagging was carried out after the seed quality had been checked and certified by MAFTAFCRD officials. A total of 350 t of seeds was recollected and distributed in 2009. However, the genetic quality of the parent stock in this system is uncertain. The community-based seed production and supply initiative broadened the scope of seed and food security and created an opportunity for seed sector development. This resulted in a 42.7% reduction in seed imports in 2008, and a 54.7% reduction in 2009, and ensured availability of quality seeds of locally adapted crop varieties to the needy populations. Although 800 farmers were trained in seed production and produced 500 t of seeds in 2009, the training and management of the fields and farmers they worked with were weak and the results were not validated. The seed and input trade fair (ITF) approach adopted in some areas has encouraged seed growers to practise market-oriented seed production, with cash received during these fairs acting as an important incentive to farmers to continue as seed producers. This has been an appropriate strategy to reach those in need of seed aid.

**Accessing the seed**

There is very limited understanding of how farmers traditionally manage seed in South Sudan. Seed is distributed through various channels, including government, NGOs, international commercial sector, relief agencies, farmers’ own production and exchange with relatives or friends. For several years, relief seed markets have been at the centre of seed assistance schemes in Southern Sudan, for example in Western Equatoria. Without a commercial farming sector, development of a formal seed system is difficult. Apart from hybrids (primarily maize), the nascent seed industry generally markets only vegetable seeds and some cash crops such as sunflower. Very few seed companies are willing to multiply and maintain large inventories of certified seed for a market where there is uncertain demand. Thus most of the seed being marketed is ‘conditioned’ grain sold at ‘seed’ prices. As a result of several bad experiences in the local market, aid agencies now generally insist that the seed they purchase is tested for germination, but determination of varietal integrity is possible only through growing out the crop. Emergency seed interventions have been implemented in South Sudan for more than a decade. The much needed seeds that are provided to returnees, IDPs and vulnerable resident households by FAO’s Emergency Rehabilitation and Coordination Unit (ERCU) is justified due to seed unavailability and poor quality of farmer-saved seed.

In order to supply seed to affected communities, aid agencies usually seek out commercial seed companies from either Kenya or Uganda, where established seed companies exist. Decisions on seed procurement are often made on the basis of what seed is available from these commercial suppliers. As the need for imported seed cannot be forecast until harvest, aid agencies have a short time frame in which to source and distribute seed before the start of the next planting season.
Farmers save their own seed, but often do not select seed from the plants with the best characteristics. In addition, traditional on-farm seed storage facilities consisting of grass thatch and mud construction often cause seed damage. It is common for crops to be stored over the kitchen fire as one way to decrease pest infestations, with a negative impact on seed viability. There are no data on storage and post-harvest losses, but anecdotal evidence suggests that such losses are considerable (Itto and Wongo, 2004). Development, testing and marketing of new varieties requires considerable investment. These costs can be prohibitive if the size of the market is small. Because South Sudan’s seed market is so small at present, private seed companies have few incentives to develop new local varieties.

Utilisation

In South Sudan, very few improved varieties for a wide variety of crops are intercropped. Cassava is widespread and is often intercropped with maize, groundnuts, sorghum and sesame, especially in semi-arid regions. As a result of the conflict, the public agricultural research system collapsed and has not yet become fully functional. However, new varieties are being imported and tested. Local varieties are also being improved. Most farmers are forced to use seed retained from their previous year’s harvest, supplemented as needed by purchases from the market or from relatives or friends. The amount of imported certified seed used is negligible. As in previous years, the Government of South Sudan (GoSS), FAO and NGOs provided some seed and hand tools, principally to IDPs and returnees, and to farmers classified as vulnerable. However, the amounts of seed have been extremely small compared with the amount required by the farming community, and many farmers have complained of shortages. In 2010 and subsequent years, in areas where late rains prompted several replantings, the problem of seed shortages was further exacerbated.

Despite the fact that government and some development partners introduced many food crop varieties such as cassava mosaic disease (CMD)-resistant and cassava brown streak disease (CBSD)-tolerant cassava, improved maize (Longes) and rice (Nerica), some farmers continue to grow their traditional local varieties. According to the seed assessment conducted by AGRA, all crops grown in South Sudan, except maize, are of traditional, landrace varieties, late-maturing, low-yielding and generally unresponsive to improved crop management practices (Bigirwa and DeVries, 2010). Farmers practise methods common to the cultivation of low-yielding crops, with either broadcast seeding or the use of five or six seeds per hill, poor weed control, and near-zero use of either organic or inorganic fertilisers. Cassava fields planted with local varieties are heavily infected with mosaic disease and are very late maturing. However, a variety introduced from Uganda, TME 14, appears to be resistant to the disease. Rice fields planted with landrace varieties nearly as tall as maize take over 6 months to mature and show low (far less than 1 t/ha) yields. In contrast, Nerica rice (variety Nerica 4) appears to be considerably more productive than the landrace varieties. Sorghum varieties are invariably very low-yielding and late-maturing. Groundnut fields are heavily infected with both rosette disease and Cercospora leaf spot. Maize fields are planted with a mixture of local and improved varieties, resulting in cross-pollinations. Introduced hybrid maize 4M 19 displayed superior vigour.

Community-based market-oriented seed production

This is a strategic approach for the development of an integrated seed sector – shifting from isolated local production towards a system approach linking seed sector stakeholders. The goal of this approach is a more efficient and sustainable seed sector to ensure food and seed security through domestic seed production. It is expected to increase productivity and create an enabling environment/business climate in South Sudan. To develop the seed sector, MAF-GoSS prioritised capacity building
and institutional development. The project focuses on linking farmers, extensionists and researchers to optimise available resources, experiment with new approaches involving government, NGOs and farmer groups, and work towards the development of a coherent seed strategy.

The project has two important components:

- a field-level component, in which seed sector stakeholders from government and NGOs work with farmer groups on variety selection and market-oriented seed production;
- a policy component, in which lessons learned from the field feed into a discussion at GoSS policy level to develop a strategy that supports integrated seed sector development in South Sudan.

Three farmer groups were identified and formed stakeholders’ teams of business cluster groups at Lopit, Lopa County, Eastern Equatoria State, Magwi Payam, and Ye in Yei County. The business cluster groups were linked with researchers and extensionists during variety selection. The cluster at Lopit chose sorghum for participatory varietal selection (PVS); the Magwi group at Owinkyibul chose cassava and sesame; the Ye cluster tested maize and sorghum. The three farmer seed production initiatives were transformed into sustainable, market-driven local seed businesses addressing new crops and varieties, quality, marketing, and organisational aspects. Lessons learned were used in the development of roles, responsibilities and incentives for seed sector stakeholders. Seed stores were built for the three groups in the areas.

The team members were trained in crop and varietal selection, quality seed production, marketing and effective farmers’ organisation. Action plans for PVS and seed production activities were developed. A SWOT analysis was conducted for establishment of effective market-oriented farmer seed producer groups, in terms of crops and varieties, quality aspects, identification of markets, organisational aspects (i.e., fieldwork) for the three farmers’ organisations.

**Multiplication of basic seeds and variety development**

Crop breeding programmes were initiated for various crops such as: cassava, maize, rice, sorghum and cowpeas, with support from AGRA. Evaluation and adaptation of introduced improved varieties for the selected crops started in 2012. Some varieties are in development for release, although the variety release committee is incomplete.

In the short-term maize breeding strategy, evaluations were conducted of maize varieties sourced from national and international agricultural research institutes in multi-locational trials and multiplication/maintenance of basic seeds. Four hybrid maize varieties (KH500-22A, KH500-43A, Longe 6H and Longe 10H) were selected for release.

Three maize parental lines (PML 1, PML 3 and PML 5) sourced from the National Crops Resources Research Institute (NaCRRI) are being bulked at Palotaka Basic Seed Centre (PBSC). Local maize germplasm was collected and will be tested for general field performance in the next growing season.
Cassava variety NASE 14 is being bulked for distribution to cassava seed growers for multiplication and wider distribution to farmers. Cassava NASE series varieties with proven tolerance of CBSD are on PVS trials at seven locations.

Seventy-three rice varieties (27 upland and 46 lowland) sourced from NaCRRI, International Rice Research Institute (IIRI) and Institut d’Economie Rurale of Mali were evaluated in field participatory trials in the green belt agro-ecology for two consecutive seasons. The four best performing varieties (NERICA 4, NERICA 1, NERICA 10, DKA-P27) were selected and recommended for release to farmers for adoption.
Three private seed companies (Green Belt Seed, Century Seed and Afroganics) who work closely with MAFTAFCRD received grants from AGRA to improve their seed production activities. They aim to increase availability and accessibility of seed of improved varieties, increase farmers’ awareness of the importance of using quality seeds, and train them in production of clean, quality seed of various crops (sorghum, maize, sesame, rice, cassava, beans and selected vegetables).

The companies mobilised seed outgrowers; organised training workshops for selected farmers and/or farmer groups; and sourced basic seeds from the national research centres or from research institutes in neighbouring countries such as Namulonge and Serere in Uganda, and IITA in Nigeria. They also liaised with the national and state ministries of agriculture, and local and international NGOs dealing with relief and agricultural development in the country. The seed companies organised selling points and were linked to agro-dealers trained by the International Fertilizer Development Center (IFDC). Activities included the introduction of fertiliser use. Demonstration plots were established at various levels (e.g., boma level) to ease distribution of improved seeds and to facilitate dissemination of technologies.
The local seed companies have managed to produce and sell improved seeds to farmers, farmer groups, foreign seed companies and aid agencies. For example, Afroganics produced 25 t of quality maize and sorghum seeds and sold 10 t of sorghum and 5 t of Longe 4 in 2012. It also supplied South Sudanese Red Cross and Aim Global Agribusiness Quality Seeds with cassava variety TME 14 cuttings, maize and sorghum seeds. The Green Belt Seed Company sold 2.8 t to FAO and local farmers. In 2013, Green Belt sold 3.75 t of sorghum and maize valued at US$4,113. During the second season, it sold 11.75 t of beans, sorghum, maize and cowpeas valued at US$19,037.

**Challenges**

Some of the challenges facing the development of the seed sector and agriculture in general include:

- poor infrastructure, such as roads;
- difficulties in accessing foundation and/or breeder seeds;
- lack of farming machinery including dryers, threshers, graders and packaging machines;
- inadequate processing and storage facilities;
- unavailability and/or high cost of skilled labour;
- erratic rainfall;
- farmers’ unwillingness to buy seeds and other inputs;
- high cost of transportation (of foundation seeds) from Uganda and Kenya;
- persistent resistance by some sections of farmers to accept improved seeds;
- high taxes on seeds, fertilisers and tools (22%) inhibiting growth of the private sector – seed companies have to pay multiple taxes that are often inconsistently applied.

**Figure 5. Poor roads pose a challenge for providing seeds for improved food security, South Sudan, October 2012**
Introduction of harmonised seed standards, regulations and procedures
The Republic of South Sudan, through MAFTAFCRD, has adopted the harmonised seed standards, regulations and procedures for Eastern and Central Africa. Currently South Sudan is implementing a project funded by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) for enhancing the adoption of harmonised East African seed standards, regulations and procedures (HESSREP), designed to develop and implement a national engagement plan for adoption of the project, and to enhance the capacity of value chain actors and share information on domestication and implementation of the project. South Sudan conducted a baseline survey and a series of awareness-creation meetings for different stakeholders: policy- and law-makers, crop breeders and research scientists, administrators and key agricultural informants, farmers’ and producers’ unions, institutions of higher learning, and business groups.

The baseline results indicate that more than 90% of those who participated were not aware of HESSREP and lacked knowledge of seed standards and procedures related to seed trade. A national task force was formed to facilitate domestication of the HESSREP process. An awareness training workshop on international treaties, a phytosanitary import and export regulatory system, export certification system, import inspections, and the draft Seed and Variety Act was conducted on 28–29 November 2013. The workshop was facilitated by the National Potato Council and the Kenya Plant Health Inspectorate Service (KEPHIS). Participants asked for more education and the formation of specialised committees to facilitate development of policies, bills/acts and regulations, including procedures required for development of new varieties, and for local and cross-border seed trade.

Recommendations
The following recommendations are made for an enabling policy and regulatory framework in support of seed sector development.

• Formation and empowerment of specialised committees related to seed standards, regulations and procedures as required by Eastern and Central African countries.
• Advocacy and lobby for promotion of HESSREP in South Sudan.
• Empowerment and operationalisation of the border post to regulate cross-border trade.
• Support to develop seed regulations, laws, guidelines and protocols for quality seed production.
• Support for a specific consultancy for faster development of a vibrant seed system and formation of a separate seed administration within the structure of MAFTAFCRD.

References
Evolution of animal breeding and performance testing policy and practice in Kenya

D. W. Nyongesa

In 1908, commercial farmers in Kenya introduced dairy breeds (Friesians) from South Africa into the stock at the government farm in Naivasha, following a high prevalence of breeding diseases that rendered several bulls sterile. The establishment of veterinary quarantine facilities and laboratories, and the adoption of artificial insemination (AI) services, were introduced through the Kenya cooperative creameries that were established in 1925. AI was introduced in 1935 at the government farm in Naivasha, and a central AI station was established. The Dairy Recording Society of Kenya was set up in 1949; the Kenya Dairy Board (KDB) was set up in 1958; and after independence the Kenya National Artificial Insemination Service (KNAIS) was established with the support of the Swedish Government. AI services took place up to 1992 when they were liberalised and the private sector took over field services. There have been many challenges since the inception of AI services, including increased delivery costs due to privatisation, from KES 1 in 1971 to an average of KES 1,000 in 2013. There has been an increase in the number of private service providers, but they are not evenly distributed throughout the farming regions, as economic conditions often influence the location of private services. The service of inputs (liquid nitrogen and semen) and the distribution mechanism in place have affected the growth of AI. The central artificial insemination station has been unable to provide an adequate supply to all the regions where AI is in demand. However, overall AI has had a large impact on the dairy industry (Okeyo et al., 2000) as a biotechnological tool for genetic improvement of the Kenya dairy cattle herds (Republic of Kenya, 2004). Efforts are being made to lower the cost of AI by encouraging community self-help groups and cooperatives to offer these services; the infrastructure should be in place to make liquid nitrogen and semen available in all regions of the country.

Keywords: artificial insemination; veterinary quarantine

Introduction

The first breeding animals were imported into Kenya in 1908 from South Africa by white settlers. At that time there were many disease challenges, such as East Coast fever, babesiosis and campylobacteriosis, affecting farmers as there were no disease control measures in place. Between 1908 and 1935, the imported animals multiplied through natural mating, but the disease challenge was rampant and the mating system was not sustainable. In 1935, white settlers decided to start AI on their farms. At that time, Kenya was second only to Russia in the use of AI technology. Tick control services were initiated in 1937, mainly to control tick-borne diseases such as East Coast fever. In 1942, a set of four breeding freshman bulls were imported into the country.

In 1946, the Central Artificial Insemination Station (CAIS) was launched in Lower Kabete by the settler government; the field services were organised by the cattle breeders’ societies and focused

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1 Kenya Animal Genetic Resources Centre, PO Box 23070-0604, Lower Kabete, Nairobi, Kenya
on large-scale farms, serving mainly the white settler community. The station’s objectives were to produce quality semen for use in imported exotic dairy animals owned by white farmers, and to control rampant breeding diseases such as brucellosis in order to increase the productivity of the imported herd. This station is still the only one in Kenya to this day. Following the Swynerton plan of 1954, Africans were allowed to use AI services by 1956, and the Kenya Dairy Board was established and licensed in 1958 to regulate the expanded dairy industry.

At independence in 1963, the management of veterinary services was handed over to an African director. In 1966, the Kenya National Artificial Insemination Service (KNAIS) was launched with the assistance of the Swedish Government. The cost of AI dropped from KES 10 to KES 5 for every four inseminations. These services covered much of the White Highlands in the Rift Valley, Western and Coast regions. They focused on cross-breeding with the zebu cattle. In 1971, following an executive order, there was an improvement in the delivery of services as the cost of insemination was brought down to KES 1 per four inseminations.

From 1971, there was increased uptake of AI services, and by 1979 the country recorded the highest number of inseminations in the history of AI delivery (Figure 1).

Figure 1. Inseminations during 1948–2012

From 1980, the AI service began to face challenges such as old vehicles, high delivery costs and reduced support from donors. Following the structural adjustment programme of 1986 that recommended liberalisation of AI, tick control and clinical services for renewed economic growth, AI services were privatised, but the government continued to offer these services in areas where privatisation had not taken place (Karanja, 2003).

Following the policy change in 1992, farmer groups, cooperative societies, private veterinarians and technicians started to provide AI services. Many challenges increased, including tick-borne diseases; inaccessibility of services in areas where privatisation had not taken place; distribution of inputs such as liquid nitrogen and semen; and the high cost of AI equipment.
In 2004, new initiatives on the distribution of semen were put in place by CAIS management. Twenty-six agencies were identified and appointed in regions to maintain the supply of semen and liquid nitrogen. The number of agencies increased to 48 between 2004 and 2014. During this period, four policies were put in place:

- dairy policy 2006 (reviewed in 2010) (Republic of Kenya, 2006);
- livestock policy 2008 (currently under review);
- draft breeding policy 2009;
- draft feeds policy 2010.

These policies were intended to give direction to the revamped dairy livestock sector in line with the country’s ‘Vision 2030’ of increased productivity in the agricultural sector.

Between 1935 and 1966, breeding services were led by the private sector; from 1966 to 1991 they were run by the government; and from 1993 to 2004 they were run by the government and the private sector.

From 2004 to date it became a public–private partnership. The government provided the regulatory role and the private sector offered the services. The highest number of inseminations was recorded in 1990 (400,000 app) which dipped to about 140,000 app. In 1990/91 and increased to about 230,000 in 2013.

The institutions involved in breeding services during this period were the Department of Veterinary Services, CAIS, Livestock Recording Centre (LRC) and the Kenya Livestock Breeders Organization (KLBO). The Department of Veterinary Services offered a regulatory service; CAIS provided services for the collection and distribution of semen and liquid nitrogen; the LRC evaluated the performance of breeding bulls; and the KLBO was involved in the identification, performance recording and registration of breeding animals and keeping the Kenya stud book. [The Kenya stud book is a register of all pedigree animals (e.g., cattle, goats, sheep, pigs) in the country.] These institutions are still offering the above services.
Breeding activities
The main animals involved in breeding are cattle, camels and goats. The bulls at CAIS are identified and selected with the assistance of the Genetic Advisory Committee, which has members from the universities, breeders’ association, service providers and government agencies. The breeds are: Friesian, Ayrshire, Jersey and Guernsey for dairy; Sahiwal for both beef and milk; and Boran for beef.

The bulls enter the station at 1 month old and start semen production when they reach 14 months of age. The progeny testing programme and contract mating started in 1984, but has remained disorganised because of low levels of collaboration between farmer groups and the AI station. There is no breeding policy to give guidance on management of the bulls at the station. Similar initiatives to maximise productivity of the dams has been hampered by low use of the contemporary technology of in vitro fertilisation (IVF), embryo transfer (ET) and ovum pick-up (OPU). There is need to build capacity in these technologies in order to complete and operationalise the draft breeding policy.

The demand for semen in the country has now risen to 1.2 million doses per year, half of which is supplied by CAIS and another 300,000 doses from imported semen (Figures 3 and 4).

The imported semen is mainly for the Friesian and Ayrshire breeds in order to improve the productivity of the national herd. Milk is sold in terms of quantity rather than quality, which has been the trend for the past ten years.

Figure 3. Imported semen figures from 2005 to date

Figure 4. Service providers of artificial insemination in Kenya 2002–12
Challenges and opportunities
Breeding rules and guidelines were developed and have been in use in the past year; these aim to regulate service providers and to guide the establishment and operation of breeding facilities in the country.

These rules also guide the management of bulls within the facility in terms of how long they should be retained, and the enforcement of the progeny testing programme. The main objective is to keep a record of all of the animals used for breeding in order to evaluate and improve the breeding schemes in the country. The process requires the harmonisation of service delivery by institutions involved in breeding services to ensure proper record-keeping, evaluation of records and subsequent registry of the animals. The owner of each dairy herd should be familiar with good record-keeping as the livestock recording centre requires these records for performance evaluation. This process has been hampered by lack of harmonisation in the institutions involved in progeny testing. There is a need to harmonise the services of the institutions (KLBO, LRC and CAIS) involved in progeny testing and to build staff capacity in order to improve service delivery.

Breed organisations and service provider associations should be created by the owners of breeding animals, who should participate in recording and registration of those animals. The owners are also the beneficiaries of trade in animals and their products. AI service providers are the breed experts, who interpret the bull information and determine the suitability of a given bull to breed with a dam. In order to increase the productivity and sustainability of breeding programmes, these two groups of service provision must be anchored in progeny testing programmes.

For agribusiness to flourish in the breeding sector, there should be a public–private partnership in the performance evaluation and registration of breeding animals. This linkage will promote movement and trade of germplasm and other animal products.
In Kenya, breeding animals are mainly raised on rainfed pastures, which results in a fluctuation in the availability of forage and feed. Breeding contributes to 70% of the productivity of the animal; during the rainy season there is a milk surplus and during the dry season there is a milk deficit. Therefore a policy for feeds is required in order to stabilise forage and feed availability. Similarly, it should influence decision-making with regard to the sale of milk (by volume or quality). The feed policy is currently still in draft form.

In Kenya, the per capita consumption of milk is 110 litres against a global average of 200 litres. Only 20% of all produced milk is processed. To enforce policy on consumption of processed milk, there is need to build the agribusiness capacity of milk sellers to stabilise the price per litre of milk and consequently raise the amount of milk that reaches the processing industry.

In Kenya, the population of breeding animals according to the 2009 census is 17 million head of cattle and over 27 million goats. This is a large population of animals to breed from (Republic of Kenya, 2009). Kenya has a large genetic pool, which has yet to be fully characterised to facilitate the development of a more effective breeding strategy. There is a need for a policy on conservation of animal genetic resources; ongoing breeding initiatives mainly involve Bos taurus semen, which is used to cross with the adapted breeds. If this is not done, it may contribute to instability in the breeding industry, under-utilisation of available genetic resources and unsustainability. The genetic diversity of the large indigenous or adapted zebu herd should be determined and used to improve productivity.

There can be no meaningful breeding without research for development, because it is through research that technologies are generated and tested. There is an urgent need to develop research institutions and equip them. Young scientists should be recruited to undertake research in breeding and technology transfer, which will enhance innovation in response to strategic challenges that affect productivity in animals. Intellectual property rights policies are needed to motivate scientists and retain them in research institutions.

In addition to the above, linking research institutions with universities, policymakers and extension staff can enhance teamwork and synergy in solving strategic breeding challenges. There is need to enhance efficiency and effectiveness in research that will increase the productivity of breeding animals. The industry suffers from poor linkages among the key actors.

But this requires an adequate and appropriate infrastructure and a quality monitoring system. Progress has been made in developing rules and regulations to enhance setting up quality compliance in semen collection centres and the liquid nitrogen cold chain, and equipping laboratories and gene banks. These should be implemented vigorously.

The high cost of energy and fluctuations in supply affect the efficiency of the cold chain and subsequent processing of breeding inputs such as semen, liquid nitrogen and consequently the costs of milk. This should be addressed through a policy on energy supply and consumption as it pushes up the cost of breeding services.
Conclusion
The future of the breeding industry should be research-based and technologically driven in order to maximise the productivity of the animals. We should promote genetic conservation programmes, which will create a stable, diverse and sustainable genetic resource. This should be informed by policies that encourage public–private partnership to enhance ownership and strategic formulation in breeding programmes and address our strategic challenges. We should encourage synergy and teamwork in our research institutions. Overall, we realise that research should answer the needs of future food security; we should build capacity, modernise our facilities and nurture research through student internships and mentoring programmes.

References
Access to improved seed potato and seed entrepreneurship in south-western Uganda

S. Tindimubona¹, A. Barekye³, I. Rwomushana², R. Kanzikwera³, B. Isabirye² and B. Biryomumaisho¹

Potato production among farmers in Uganda has always been limited by unavailability of quality seed. To minimise this challenge, in 2004 the Uganda National Seed Potato Producers Association (UNSPPA) with support from the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) began promoting the adoption of positive selection (PS) and seed plot techniques (SPT) in south-western Uganda – a major potato production zone in the country. UNSPPA has been offering technical support and encouraging smallholder farmers who can produce seed on their own to adopt and demonstrate quality seed in potato production through PS and SPT. Positive selection involves identification and marking of healthy looking plants for seed generation. In a participatory approach with farmers, trials comparing seed generated from PS and seed obtained through farmers’ practices were demonstrated. A tuber yield increase of 34% (6.8 t/ha) was recorded since the introduction of the technique in 2004 in the region. This provides an economic gain with minimal or no increase in cash investment. The SPT, which requires growing small quantities of high-quality seed under intensive management on raised, disease-free beds and close spacing, was demonstrated in participatory, on-farm experiments involving researchers, development agents and farmers. Validation trials indicate that SPT achieved a 2.5 to 3 times increase in land productivity and about 50% bacterial wilt reduction compared with conventional ridge planting. Over 5,890 farmers from south-western Uganda have been reached by UNSPPA in programmes supported by ASARECA. About 80% of farmers reached have adopted the technologies. It was concluded that these simple, low-cost technologies can enhance the quality of seed potato used by smallholder farmers every season. Technology adoption was achieved more quickly through stakeholder participatory experimentation and group learning. These are some of the simple, low-cost approaches supported by ASARECA, which can be used to enhance technology uptake in seed systems in south-western Uganda.

Keywords: Adoption, positive selection, seed plot technique

Introduction

Potato (Solanum tuberosum L.) has continued to be an important food and cash crop in south-western Uganda. However, the potato sector has been constrained by challenges related to production and marketing, which consequently compromise food security and incomes for farmers. Due to the growing attraction to potato production, the area under this crop has continued to increase steadily over the years, principally under smallholder production systems, which are characterised by high population density and small land parcels of 0.25 to 5 ha (UBOS, 2010). However, smallholder

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farmers’ access to quality seed potato has continued to be a major challenge to increased potato production in the region (Gildemacher et al., 2009). The potato seed system in Uganda is largely informal. Seed is produced mainly by farmers using recycled, home-saved seed. To contribute to the alleviation of this, the Uganda National Seed Potato Producers Association (UNSPPA) was formed in 1995.

Although the near-formal system practised by UNSPPA, which uses a flush-out system, provides improved seed, it satisfies less than 2% of national demand. The largest proportion of farmers depend on home-saved seed that has been recycled over a number of years, which can make it deteriorate and may contribute to low productivity. UNSPPA has 120 (48 female and 72 male) active, individual, registered members and 4,712 (2,928 female and 1,784 male) affiliated members through community-based groups (UNSPPA, 2013). Technologies that aim to increase the quantity of seed have been developed and validated. This paper describes the experiences of UNSPPA along the potato value chain.

Situational analysis
The production of seed in the Kigezi region is largely informal. Farmers use uncertified seed potato because there are no seed certification services. The absence of the formal seed potato production system compelled UNSPPA and Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI) to develop an internal quality control system, which involves field inspection and indexing of seed samples for bacterial wilt and virus diseases. Under this system, the seed multiplication fields are monitored by a team from the National Agricultural Research Organisation (NARO) to detect any visible disease symptoms. After harvesting, samples are collected by the same team and tested for bacterial wilt and virus disease. Seed lots that pass these two stages without any detected disease are then recommended for further use or sale for production as ware potatoes, or for more home-saved seed.

Access to seed in south-western Uganda
Basic seed is produced by KAZARDI, which is mandated to conduct research on potatoes. A number of varieties have been released with different attributes, as desired by consumers and processors. The varieties released so far include Uganda Rutuku (commonly known as Uganda 11), Victoria, Sangema, Kisoro, Kabale, NAKPOTs 1 to 5 and KACHPOTs 1 and 2, among others (Table 1).

The basic seed is then sold to registered seed multipliers such as UNSPPA. The seed potato multipliers who obtain basic seed from NARO (KAZARDI) multiply it for one further season and sell it to other farmers using a flush-out system. Registered seed multipliers comprise individual farmers registered with UNSPPA, or indirectly through any other recognised seed producers’ group, or through community-based groups. Non-registered seed producers include all other farmers who generate seed from their potato fields but are not formally registered.

In order to improve the availability of adequate quantities of high-quality seed potato, innovative ways of multiplying seed potato, known as the seed-plot technique and positive selection, have been developed for smallholder farmers. UNSPPA, in partnership with KAZARDI, with support from ASARECA and the International Potato Center (CIP), have created farmers’ awareness about quality seed production technologies and the profitability of venturing into them. The seed plot technique is similar to a seed potato nursery; positive selection is conducted from the conventional fields.
## Table 1. Characteristics of Ugandan potato varieties

<table>
<thead>
<tr>
<th>Common name</th>
<th>Year of release</th>
<th>Tuber size</th>
<th>Skin colour</th>
<th>Flesh colour</th>
<th>Tuber shape</th>
<th>Maturity period (days)</th>
<th>Dormancy period (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda Rutuku</td>
<td>1974</td>
<td>Large</td>
<td>Light red</td>
<td>Cream</td>
<td>Oval round</td>
<td>110–130</td>
<td>12–16</td>
</tr>
<tr>
<td>Cruza</td>
<td>1988</td>
<td>Large</td>
<td>White mottled</td>
<td>White ringed</td>
<td>Oval</td>
<td>100–120</td>
<td>3–5</td>
</tr>
<tr>
<td>Victoria</td>
<td>1992</td>
<td>Large</td>
<td>Red</td>
<td>Light cream</td>
<td>Round</td>
<td>90–110</td>
<td>8–10</td>
</tr>
<tr>
<td>Kisoro</td>
<td>1992</td>
<td>Medium</td>
<td>White</td>
<td>Cream</td>
<td>Oval large</td>
<td>110–120</td>
<td>10–12</td>
</tr>
<tr>
<td>NAKPOT 1</td>
<td>1999</td>
<td>Large</td>
<td>White</td>
<td>White</td>
<td>Oval long</td>
<td>90–110</td>
<td>9–12</td>
</tr>
<tr>
<td>NAKPOT 2</td>
<td>1999</td>
<td>Medium</td>
<td>Rose Red</td>
<td>Cream</td>
<td>Round</td>
<td>85–100</td>
<td>9–11</td>
</tr>
<tr>
<td>NAKPOT 3</td>
<td>1999</td>
<td>Medium</td>
<td>White</td>
<td>White</td>
<td>Round</td>
<td>85–100</td>
<td>9–12</td>
</tr>
<tr>
<td>NAKPOT 4</td>
<td>2002</td>
<td>Medium</td>
<td>Red</td>
<td>Cream</td>
<td>Round</td>
<td>100–120</td>
<td>9–12</td>
</tr>
<tr>
<td>NAKPOT 5</td>
<td>2002</td>
<td>Large</td>
<td>White</td>
<td>Cream</td>
<td>Oval</td>
<td>100–120</td>
<td>12–16</td>
</tr>
<tr>
<td>Sangema</td>
<td>1988*</td>
<td>Medium</td>
<td>Pink</td>
<td>Yellow</td>
<td>Oval long</td>
<td>90–110</td>
<td>10–12</td>
</tr>
<tr>
<td>KACHPOT 1</td>
<td>2007</td>
<td>Medium</td>
<td>Red</td>
<td>Cream</td>
<td>Round</td>
<td>90–100</td>
<td>10–12</td>
</tr>
<tr>
<td>KACHPOT 2</td>
<td>2007</td>
<td>Medium</td>
<td>White</td>
<td>Cream</td>
<td>Round</td>
<td>90–100</td>
<td>10–12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Common name</th>
<th>Resistance/ Tolerance</th>
<th>Storability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda Rutuku</td>
<td>Tolerant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>Cruza</td>
<td>Resistant</td>
<td>Tolerant</td>
</tr>
<tr>
<td>Victoria</td>
<td>Resistant</td>
<td>Tolerant</td>
</tr>
<tr>
<td>Kisoro</td>
<td>Resistant</td>
<td>Tolerant</td>
</tr>
<tr>
<td>Kabale</td>
<td>Highly susceptible</td>
<td>Susceptible</td>
</tr>
<tr>
<td>NAKPOT 1</td>
<td>Resistant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>NAKPOT 2</td>
<td>Resistant</td>
<td>Tolerant</td>
</tr>
<tr>
<td>NAKPOT 3</td>
<td>Resistant</td>
<td>Tolerant</td>
</tr>
<tr>
<td>NAKPOT 4</td>
<td>Moderate</td>
<td>Fair Tolerant</td>
</tr>
<tr>
<td>NAKPOT 5</td>
<td>Resistant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>Sangema</td>
<td>Tolerant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>KACHPOT 1</td>
<td>Resistant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>KACHPOT 2</td>
<td>Resistant</td>
<td>Tolerant</td>
</tr>
</tbody>
</table>

## Production techniques

### Seed plot technique

The seed plot technique (SPT) involves growing small quantities of high-quality seed under intensive management on raised beds at close spacing (Kinyua et al., 2010a,b). Farmers were trained in SPT through demonstration nursery plots measuring 1.8 m wide and varying lengths depending on the availability of land and farmer groups’ seed needs. Well sprouted tubers of the variety preferred by a particular farmer were planted in hills at a spacing of 30 × 30 cm in well prepared plots. The technique allows a farmer to produce large quantities of seed potato from a relatively small piece of
land through high-density planting (112,500 plants/ha) to maximise the production per unit area. The small size of the plots also encourages intensive crop management practices that lead to better quality seed potato (Kinyua et al., 2013). This is achieved through strict field hygiene and intensive control of pests and diseases, which is easier to carry out than in large potato fields. Watering on a small scale can be done to produce off-season seed potato. The system requires 50% less land than the conventional production system to meet on-farm seed tuber requirements. It is recommended that the ‘freed’ land be managed as next season’s seed plot by leaving it fallow or planting a short-season, non-solanaceous crop.

UNSPPA recommends that healthy tubers for seed plot establishment should be obtained from a reliable source, preferably a seed production station or a recognised seed potato dealer. The tubers should not be infested with bacterial wilt, viruses, nematodes or other tuber-borne pathogens (disease-causing agents) that lower seed potato quality. Tubers should also be free of pests such as potato tuber moths, mites and aphids. Tubers should be 25–55 mm in diameter (about the size of a chicken’s egg). Good tubers should have well hardened skin and multiple sprouts. Dormant or poorly sprouted tubers lead to uneven crop stands due to poor emergence. Old (senile) tubers should be avoided as they give rise to weak plants. Selected tubers should be devoid of any physical damage (such as bruises and cuts), and should not be malformed. In potato-growing areas, the land that is conventionally used for potato production could, at one time or another, have been exposed to potato pests and diseases. However, a farmer can identify small portions of the land that have lower or no risk of pests or diseases. Such portions are targeted for establishment of seed plots.

Management of diseases
Experience shows that, in order to avoid the risk of infestation by bacterial wilt and other pests or pathogens, a seed plot must be established on land that does not have a history of potato production or other solanaceous (potato family) plants such as capsicums, tomatoes and eggplants, preferably for three or more years; where volunteer hosts have not been allowed to establish during the non-solanaceous crop period; where no run-off water flows in; where potato residue/peelings are not dumped; and where no manure/compost made from diseased host residue has been applied or deposited. Seed plots should be established on land that is fertile in order to ensure high tuber yields. If soil fertility levels are low, improvements can be made by application of appropriate inorganic fertilisers. Well-decomposed manure may also be applied but should not be made from host plant residues that could have harbouraged potato pests and diseases. The soil surface should be fine and should be loosened to a depth of about 20–30 cm. Properly prepared land enables adequate air circulation, good water or rainfall infiltration, free drainage and decomposition of plant residues to provide organic matter to the soil. This enhances the development of plant roots and tubers. Weed management during crop growth also becomes easier.

The recommended fertiliser for potato production should be broadcast on the seed plot at the rate of 1 kg for every portion measuring 1.8 m width by 9 m length (space for 180 plants), or 1 kg fertiliser for 16 m². Fertilisers such as diammonium phosphate (DAP) or NPK 17:17:17 should be used, depending on the usual practice in an area. Mix the fertiliser with the soil using a rake or similar tools. Using a hoe, shallow furrows at a spacing of 30 cm from one furrow to the next should be made along the length of the bed. The furrows should be about 15 cm deep. Well sprouted tubers should be planted at a spacing of 30 cm along the furrows (six tubers per furrow). The appropriate depth can be achieved by deepening the furrow with a sharpened stick or a panga (broad, heavy knife). Tubers should be
covered well with soil. Watering may be done if necessary. Hand weeding is recommended; this is achieved by pulling out emerging weeds before they reach a competitive stage. If soil appears very compact after plant emergence, it should be loosened. This can be done using sharpened sticks or pangas at the time of weeding. Hilling (earthing up) carried out in ware production fields is not necessary if the recommended planting depth is adopted. However, disease-free soil from around the seed plots should be added to the beds as soon as the potato plants emerge in order to cover the auxiliary buds, leading to increased tuber formation. This should be done at the time of the first hand weeding (Kinyua et al., 2013).

Seed plots need to be inspected frequently to ensure pests and diseases are controlled promptly. In particular, pests and diseases that have a direct impact on the quality of seed tubers must be prevented or managed appropriately. Such diseases include bacterial wilt, which greatly reduces tuber yield and leads to condemnation of seed potato and land over a long period of time (Kinyua and Smith, 2007). Bacterial wilt control starts with the planting of clean seed in disease-free soil. If bacterial wilt is noticed in a seed plot, roguing and appropriate disposal of infected plants prevents build-up of the pathogens and improves the quality of seed potato available to farmers who are unable to access certified seed. Other diseases should be prevented. Late blight and early blight are the most damaging foliar diseases of potato. They can be managed by:

- application of protective or contact fungicides containing mancozeb, or copper every 7 to 10 days, or more frequent application of fungicides with systemic and/or curative effects such as Ridomil Gold MZ 68WG, Acrobat MZ, Galben 8-65, Agrolaxyl, or Victory, especially under very humid weather conditions, as per manufacturer’s recommendations;
- use of disease-free certified seed potato;
- dehaulming – cutting the stems to ground level when the tubers reach an optimum size for seed, to prevent tuber infection from infected foliage;
- sampling plants by digging out and examining the tubers to ascertain the absence of disease symptoms;
- ensuring appropriate sanitation measures such as destruction of cull piles and removal of volunteers;
- growing resistant or tolerant varieties, if available.

Management of viruses and insect pests
UNSPPA’s experience is that viruses in potatoes are incurable. However, virus diseases can be controlled by:

- using virus-free seed;
- roguing and destroying or burying plants infected with viral diseases;
- controlling insects that can spread viral diseases such as aphids, thrips, mites and whiteflies.

Pests such as aphids, leaf miners, cutworms, mealy bugs, potato tuber moths and spider mites can lead to serious reduction of potato yield and quality of the resultant seed. Aphids are also known to transmit potato viruses. Arthropod pests can be controlled by use of appropriately selected insecticides that are available from agrochemical shops. Common examples include: Duduthrin, Dursban, malathion dust, Sherpa, Agrothoate and cypermethrin. Use traps made of pieces of yellow plastic smeared with oil to control aphids around seed potato plots and in stores. The yellow colour attracts
aphids and they get stuck on the traps. Traps need to be changed periodically; seed potato should be stored in diffused light stores (DLS) with aphid-proof nets, ensuring that tubers are covered with soil in the field to prevent potato tuber moth infestation.

In order to prevent excessive enlargement of tubers, potato vines (haulms) should be removed earlier than would ordinarily be the case for ware potato production. The decision to remove the haulms is reached by sampling to ensure the majority of tubers from randomly selected plants are in the seed size range (chicken egg size). Removal of haulms also causes faster hardening of the tuber skin to reduce bruises during harvest and reduce transmission of diseases to tubers. The haulms are removed by cutting them as close to the soil line level as possible. However, care should be taken not to injure the tubers in the soil.

**Positive selection**

Positive seed selection involves identifying healthy-looking plants in potato fields, marking them before plant senescence, and harvesting the selected plants first in order to obtain seed potato for the next season. Removal of volunteers in a seed plot is very important in pest and disease management. Roguing involves removal of volunteer, off-type or sick plants. It contributes not only to varietal purity, but also to disease management. When the first symptoms of the disease appear, a plant has to be removed with all its tubers, if they have already formed, and some of the soil from the planting hole. The soil should not be spread or re-used. It should be placed in a bucket or other container, carried out of the field and disposed of in a pit. This ensures the disease cannot spread (Kinyua et al., 2013). To enhance the effect of roguing, some ash or lime can be mixed in the hole where the plant had been. Ash contains nutrients, especially potassium, and some phosphorus. Although there is no recommended rate, one handful of lime or two handfuls of ash can be used as a maximum dose per planting hole.

Selecting the best disease-free plants is the most feasible way of reducing seed degeneration as a result of virus diseases in a ware potato crop. Positive selection will work not only against viruses and bacterial wilt, but also against other seed-borne diseases. Any serious seed-borne disease will give rise to a plant showing symptoms. In other words, the plants will appear different, and unhealthy. Validation of positive selection in south-western Uganda has proved that it can lead to an increase in seed quality production of 34% or 6.8 t/ha, as attained in Kenya (Gildemacher et al., 2012). This provides an economic gain with minimal or no increase in cash investment.

**Progress made**

Field validation results indicated that SPT achieved 2.5 to 3 times the land productivity and about 50% the bacterial wilt reduction compared with conventional ridge planting. Over 5,890 farmers (3,660 females and 2,230 males) were trained in SPT and PS. More than 80% of these farmers (49.7% female, 30.3% male) adapted the technologies during the 2012B and 2013A seasons (UNSPPA, 2013).

**Seed production by UNSPPA**

UNSPPA’s seed production capacity is constrained mainly because of failure to obtain the required amounts of consumer-preferred basic seed varieties from the research station. This has resulted in low production over the years. Figure 1 shows the production data for UNSPPA of seed potato from 2008B to 2012B.
Although UNSPPA uses the flush-out system of providing quality disease-free seed, it satisfies less than 2% of national demand. This implies that the largest proportion of farmers depend on home-saved seed that has been recycled over years, which means it is of poor quality and consequently of low productivity.

**Future for seed production flow**

Arrangements are under way for the provision of seed potato certification services by the Ministry of Agriculture, Animal Industry and Fisheries, in a bid to move from the informal to the formal seed potato production system.

**Marketing of seed**

Seed marketing in south-western Uganda is carried out by individual farmers or seed merchants who buy it from seed producers and retail it either at home or on the open markets. In such cases, it is difficult to determine the actual price of certain grades of seed potato at a particular moment. However, the price can be determined when marketing is done collectively by farmers’ associations such as UNSPPA or groups. Table 2, for instance, indicates the prices by NARO and UNSPPA in November 2013.

**Table 2. Prices of seed potato in Uganda, 2013**

<table>
<thead>
<tr>
<th>Seed source</th>
<th>Seed grade (mm)</th>
<th>Est. current price per bag of 80 kg (UGX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NARO</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;60</td>
<td>40,000</td>
</tr>
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<td></td>
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<td>UNSPPA</td>
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<td></td>
<td>Ungraded</td>
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</tbody>
</table>
The NARO prices in Table 2 are subsidised and may change upwards depending on the prevailing circumstances. Figure 2 indicates gross income realised by UNSPPA members between 2008B and 2012B.

**Figure 2. UNSPPA farmers’ amalgamated gross income levels for nine seasons, 2008B–2012B**

![Graph showing gross income levels](image)

**Lessons learned**

- Based on the data from UNSPPA members, it is evident that farmers who were engaged in seed potato production have generated income that has enabled them to improve their standard of living, which is a great achievement.
- Farmers preferred to produce and sell seed potatoes instead of ware potatoes, because seed gave 100% better return compared with ware potatoes.
- Farmers embraced the quality seed production technologies introduced to them as an alternative source of quality seed.
- Farmers appreciated the importance of collective marketing because of its higher bargaining power, increased quantity and maintenance of quality.
- Potato innovation platforms were successfully established which brought together different chain actors in the potato sector, which enabled development and implementation of strategies for overcoming bottlenecks in the value chain.

**Challenges**

- The supply of basic seed potatoes is too low to meet growing demand. The only source of basic seed in south-western Uganda is KAZARDI. It aims to conduct agricultural research, and limited resources and personnel are engaged in production of foundation seed. The private sector needs to carry out basic seed production to alleviate this problem.
- The cost of agro-inputs is very high. Fertiliser and pesticide use is low because many farmers cannot afford them. This renders the crop vulnerable to disease and pest attacks, and contributes to low levels of production. However, farmers need to be trained in alternative methods of organic farming.
• Inability to add value in terms of grading, labelling and packaging. Seed from the research station is graded, although not always properly labelled; the rest of the seed producers have not adopted the practice of grading, labelling and packaging seed in different units. This has made it difficult for potential buyers to trace the source of seed and obtain the grade and quantities they want and can afford.

• Lack of awareness on seed quality standards. Farmers are not aware of seed quality standards such as seed grades, freedom from seed-borne diseases, and certification, as required for each category of seed. Most farmers assume any sprouted potato tuber is seed. This has led to some farmers buying poor quality planting materials from open markets and seed merchants.

**Recommendations**

To strengthen the potato value chain, action is required on the following issues.

• There are locally grown varieties that have consumer preferred attributes which have never been released by the government (e.g., Rwangume, Rwashaki and Kinigi). As these varieties are already in circulation, efforts should be made for them to be cleaned, recommended for release, and subsequently multiplied in sufficient quantities.

• An intervention is needed to strengthen and coordinate the established potato innovation platforms and to promote additional platforms in other areas as deemed necessary.

• Although collective marketing of seed potato is being carried out, there are no established collection centres for them. Appropriate structures should be established to facilitate easy marketing of, and access to, seed potatoes. Similar structures are also necessary for marketing ware potatoes.

**Conclusion**

The collaboration between farmers and stakeholders has resulted in the achievements described in this paper. More interventions are needed to fill the existing gaps in the potato value chain.

**Acknowledgements**

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**References**


The role of women in seed production in Uganda: The case of Victoria Seeds

S. Namazzi, J. Okot and E. Ogwok

Seed is one of the most important inputs in agronomy, making development and provision of new varieties to local farmers a critical investment. The sustained production of and timely access to seed of appropriate genetic, physiological and phytosanitary quality by farmers are the basic features of a functioning seed system. Climate change has been a major obstacle to good seed production. This has resulted in seed crop failure from drought or post-harvest losses from prolonged rainfall in the absence of mechanical driers. A favourable policy environment is a prerequisite for seed market development.

Keywords: climate change, seed market development, seed systems

Introduction

The production of seed has been in the hands of the private sector for more than 10 years. The number of registered seed companies in Uganda has increased to 22; 10 of these were founded in 2009 (AGRA-PASS, 2010). The production of seed in many of the companies is carried out by contract growers who are supported by the seed companies and receive credit in the form of seed and sometimes fertilisers. Both men and women play an important role in seed production. However, women traditionally engage in food production while men work on cash crop production. Building on this tradition, Victoria Seeds Ltd is engaging female farmers in contract seed production of bush beans, soybean, groundnuts and sesame, which are grown on an average of 1–2 acres per household. Male farmers are engaged mainly in contract seed production of cereal crops; maize, sorghum, millet and rice, which are grown on an average of 5 acres or more per household. Overall, women contribute 55% of unpaid farm labour to crop production.

Despite efforts by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA) to harmonise seed policies and laws with the objective of increasing trade, seed companies can meet only 30% of Uganda’s annual seed demand, estimated at 35,000 tonnes (t) (MAAIF, 2012; Uganda Seed Trade Association, www.usta.ug). Factors limiting seed market development include:

- weak enforcement of the regulatory framework;
- limited access to trade finance because of stringent demands for collateral;
- limited capacity of seed companies to undertake field inspections and laboratory certification;
- absence of reliable seed market information;
- inadequate supply of breeder seed from the public sector for some crops;
- poor output crop marketing infrastructure for food security crops.

1 Victoria Seeds Ltd, Plot 2854 Namanve Industrial Park, PO Box 11913, Kampala, Uganda
Victoria Seeds, which was founded in 2004, is a good example of a start-up enterprise with limited capital that has succeeded in growing into one of Uganda’s leading seed houses, marketing over 90 seed varieties for cereal crops (maize, sorghum, rice and millet); legume crops (bush beans, cowpea and groundnuts); oil crops (soybean, sunflower and sesame) and vegetable and pasture seed. The company’s turnover is over 2,500 t, and it has expanded its product range into crop protection products.

**Victoria Seeds Ltd**

In the beginning, Victoria Seeds focused only on financial returns. As time went on, we realised that building a great company requires much more than good financial performance; we received validation from various entrepreneurs that when a business focuses on factors in addition to financial returns, the rewards are more sustainable and longer lasting. As a result, we incorporated an explicit social focus into our business model, which is to ‘empower rural women’. For instance, in our strategic profile statement, at least 70% of our supply-chain farmers must be women, which speaks to the values of what the company is all about. The role of our business, in the context of food security, has also evolved, so that we now find ourselves being involved in key policy decisions. The Government of Uganda and many development partners such as the World Bank, UK Department for International Development (DFID) and US Agency for International Development (USAID) often solicit our viewpoint. As such, we’ve had to learn how to articulate the issues and influence the right people so as to be successful policy advocates in these high-profile forums.

To achieve our objective of empowering women, Victoria Seeds provides:

- a revolving-input loan facility that enables rural women participating in seed production to access production inputs necessary to improve their production efficiency – credit for land, animal traction, irrigation equipment, seed, fertiliser and crop protection products;
- support for smallholder farmers participating in contract seed production and input loan schemes with an extension service throughout the active growth of their seed crop to ensure compliance with the minimum national standards and to realise optimum yield so they can make loan repayments;
- training that includes integrated pest management (IPM), soil management, agronomy, livestock management for effective animal traction, post-harvest handling and farming as a business;
- appropriate technologies for ploughing and post-harvest processing, ensuring at least 70% of supply-chain seed growers are women so they are developing their skills and generating income.

The company has worked with women’s groups since its inception in 2004. Bakusekamajja Women’s Group was the first group to sell certified maize seeds of Longe 1 and Longe 4 to Victoria Seeds in 2004. They received training from the National Agricultural Research Organisation (NARO) on seed production, then decided to form their own seed company.

Victoria Seeds has since engaged farmer groups from central, western and northern Uganda in contract production of seed. There are presently over 15 farmer groups producing the seed that the company markets. The majority of the farmers (75%) in the groups are women. These women, who produce 70–75% of agricultural output, are faced with time poverty and lack access to and control of productive household resources, which in turn limits their capacity to acquire productivity-enhancing inputs to improve crop yields and household food security. Northern Uganda has many female-headed households and the company gives them the opportunity to lead an economically productive life.
Women’s involvement in seed production

Victoria Seeds works with a total of 13 farmer groups in northern Uganda. These include Aketowanga, Ribeayeteko and Kwoyello, GWENET (Gulu Women’s Empowerment Network), Nyekopelonyi in Gulu district; Oryangopolacen, Opur cane and Canjertenge in Oyam district; and Ocanonotte in Apac district. In Lira, the farmer groups include Ogur seed growers, composed of farmers from Agweng, Ogur and Aromo seed growers. Each of these groups has 65 members on average; this translates into 845 members. As a requirement, 75% of members have to be women, which translates into 633 women. A third of all members in the leadership structure must be women to help steer them into decision-making positions and improve their leadership skills.

The farmers are trained in seed production basics, entrepreneurship, governance and post-harvest handling, and a host of other practices. Women were seen to be better learners and better placed to put their knowledge into practice than men.

Regarding the contracting growers, the company recruits women to make up 70% of its growers and marketing groups in the output market chain. Victoria Seeds is cognisant of the time poverty that women face: the 2007 Human Development Report shows that rural women spend up to 9 hours carrying out care activities while men spend just 1 hour doing the same activities (UNDP, 2007). Care activities include fetching water, collecting fuelwood, providing meals and nursing sick family members.

The company records show that some of our best seed producers are women. They exist in their own names and in their own rights. They obtain the seed loan, produce the seed crop, sell the seeds and are paid their dues. Sometimes both the wife and husband may be group members, but each will register separately and will have separate gardens. During inspections, it is common to see gardens belonging to each of them separately. Interestingly, women are the major producers of crops that are labour demanding and difficult to work on, such as sesame, millet, okra and groundnuts. The men prefer crops such as beans, maize, soybeans and sunflowers, which are less labour intensive.

Much of the hard work in seed production is done by women. First and second tillage, planting and weeding is done by both men and women. But women are the dominant participants from harvesting, to post-harvest handling activities, to pre-selling. They are more particular and pay more attention to detail than men. Hence they do a better job of threshing, sorting and bagging the seed.

Women are also actively involved in resource mobilisation and money pooling through village savings and loan schemes (bolicup). An examination of many bolicup shows that the majority of savers are women. In all groups with bolicup schemes, women save to buy seed, pay loans, and buy farm implements and animals, making them better savers. In almost all our producer organisations women are better team players, and group coherence in women groups is strong. Women pool labour and do their work in groups, however small. It is therefore not surprising that women always return cleaner and better-kept seed than their male counterparts.

Seed storage and seed store management is largely women’s responsibility. Women interact with stored produce almost on a daily basis. They sweep and clean the stores and are always the first to notice any infestation of pests in the store. They do a lot of work in maintaining the quality of the produce. Women could be viewed as better farmers than men, as they are involved in almost all seed production activities, from training, planning and production as well as marketing.
Involving women farmers in the lucrative regional seed industry has empowered them by increasing their incomes and standard of living. For example, a kilogram of soybean seed is purchased at UGX1,400 compared with UGX1,000 per kg in the open market, giving the farmer a return of UGX400 per kg. The mark-up is 40% higher than the open market price, and in all cases the price of the seed crop is at least 25% more than the market price.

It has been observed that engaging women in viable commercial enterprises such as seed production has led to a reduction in domestic violence. Households are food secure, acquire assets over a number of seasons, and can afford education for all their children including the girls. The women from such households have better clothing and are happier. These women have increased bargaining power in decision-making both at home and in the community.

**Conclusion**

Poverty means that there is a lack of working capital for rural production. Cash is required for seasonal or batch inputs, and for equipment and labour saving machinery such as tractors and post-harvest threshers. For the subsistence and emergent producers, access to credit has been the major constraint. The Uganda microfinance outreach plan was launched in 2003 as a vehicle for extending financial services to the rural poor, but it has not delivered owing to inadequate funding. Despite the reported success of the microfinance outreach plan, lending to smallholder farmers remains unattractive to most microfinance institutions (MFIs). The key factors that have negated lending include:

- concentration of demand for borrowing at the start of a growing season with long gestation periods during which repayments cannot be made;
- challenges of mobilising savings from agriculture, therefore MFIs opt to serve urban and peri-urban clients because the infrastructure and commodity markets in urban settings are more developed;
- low number of commercial and semi-commercial farmers;
- high cost of processing, monitoring and enforcing agricultural loans;
- tendency of farmers to default on their loans as Ugandan agriculture is rainfed and subject to the vagaries of the weather.

Smallholder farmers, like everyone else living in poverty, need a diverse range of financial services to assist them to become food secure and income secure, build assets and improve their standard of living. They need not just loans, but convenient financial services which are flexible and can be adapted to their needs.

Seed companies can bridge this gap by providing input loans in kind, such as seed, fertilisers, crop protection products and product machinery. However, the seed companies can only offer credit for inputs when the seed market is robust and their returns are guaranteed.

Women in much of sub-Saharan Africa are more active than men in food crop production, marketing and processing, but the incidence of poverty is highest among women compared with men. This is largely because they lack access to and control of productive household assets, and time poverty remains an intangible productivity constraint. Time poverty hinders women’s capacity to benefit from poverty-reducing programmes such as extension support services, market information, credit and educational activities.
Seed companies striving to address the challenge of time poverty and access to assets by women should be supported with grants to enhance their outreach programmes.

References


An integrated seed delivery system and seed research in Kenya: Case studies of pigeon pea, onion and dry bean

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Producing adequate and nutritious food for a population estimated to reach a billion people is the main challenge facing African countries in the twenty-first century. This demands increased utilisation of technologies designed to enhance crop productivity and quality, especially considering predictions in climate change and variability. Crop productivity is constrained by biotic and abiotic stresses, and by socio-economic factors, especially timely availability of affordable seed of improved varieties. The main limitation is a lack of integrated seed delivery systems linking key players in the seed value chains of most crops. Universities are key players in this system, a position recognised by recent policy change for Kenyan universities as described in the Universities Act (2012). The development of more than 18 new pigeon pea, onion and bean cultivars and of a seed delivery system at the University of Nairobi over the past two decades illustrates the potential of and challenges for implementing an integrated seed delivery system and defining the role of universities. This paper describes the current seed delivery system in Kenya, and proposes an integrated and sustainable seed delivery system and the functions of the key actors.

Keywords: seed systems, universities, varieties

Introduction
The principal challenge for African nations in the twenty-first century is to feed a growing population, estimated to reach over a billion people. During the last two decades of the twentieth century, only Africa recorded a decline in per capita food production, which was attributed to a rapid growth in population and a decline in agricultural production. For example, Kenya recorded one of the highest population growth rates, at nearly 4% in the mid-1980s and early 1990s, but it has now stabilised at about 3% in the past decade. The decline in agricultural production was associated with several biotic, abiotic and socio-economic factors. These include inability to replenish declining soil fertility, use of inferior and poor quality seeds, drought, inability to control heavy yield losses due to pest and disease attacks, limited access to and participation in local, regional and international markets, lack and/or poor implementation of supportive policies to boost agricultural production, and poor infrastructure. The result of the decline in production and rapid growth has been extreme poverty in some regions, widespread malnutrition, reliance on food aid and environmental degradation. However, in the past decade several African countries have registered impressive economic growth of more than 5% per annum, reduction in poverty and improved nutrition as a result of interventions by governments and development partners.

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Predicted food situation

It is predicted that between 1997 and 2020, Africa’s population will double to 1.1 billion. The demand for imported food (mostly cereals and legumes) will increase to 50 to 70 million tonnes (t) per year (Kimani and Kirkby, 2002). If the current situation persists, it is unlikely that food deficit nations will have the resources to purchase this huge volume of food on a commercial basis. Several countries have become regular recipients of food aid. To avoid a possible human catastrophe, it will be necessary to accelerate development and to implement strategies designed to increase productivity and commercialisation.

Major food crops produced in arable regions of Kenya include cereals, legumes, vegetables, root crops and fruit crops. Major cereal crops include maize, sorghum and millet. The main legumes, in declining order of importance, are bean, pigeon pea, cowpea, green gram and chickpea. Main root and stem crops include potato, sweet potato and cassava. Major vegetable crops include tomato, onion, cabbage and kale. These crops are grown by small-scale, resource-poor farmers for domestic consumption and income generation.

Low productivity has been attributed to several biotic, abiotic and socio-economic factors. Production is based on traditional varieties, which have low yield potential and are susceptible to common diseases and pests. Losses due to diseases and pest in the field and during storage are heavy, but severity of attacks varies seasonally. Due to continuous cultivation, an inability to replenish nutrients and a poor nutrient base, fertility has continued to decline. Soils are generally low in nitrogen and phosphorus. Moisture stress further reduces their productivity especially in arid and semi-arid (ASAL) regions due to the unreliable and low amounts of rainfall, low moisture retention and heavy losses due to evapotranspiration. Loss of ground cover due to drought and heavy grazing has exposed land to erosion and further degradation. In some ASAL areas, land has been lost to deep gullies, which are difficult to reclaim. Population pressure has led to fragmentation of land into small, hardly economical subunits.

Several socio-economic factors have also contributed to declining productivity. Although improved cultivars of several crops have been developed in the past two decades, their impact has not been realised because of inefficient, unreliable and often non-existent seed delivery systems. Seed companies have tended to focus only on a few crops produced for high-potential zones, where effective and reliable markets exist. Most companies produce and distribute maize, and to a lesser extent beans and other grain legumes. Because of the poor infrastructure, seed is delivered only to urban and shopping centres in more accessible areas. Seeds are often of low quality and are delivered late in the season.

Influences on seed delivery systems are not always socio-economic; sometimes they are technical in nature. For example, some crops, such as onions, carrots and other vegetables, may require vermalisation to stimulate flowering. This has constrained production of seed under the prevalent warm, tropical conditions in Eastern Africa. Furthermore, there has been limited breeding and seed science research in this region. Consequently, farmers have relied on imported and often expensive seed, e.g., for onions, runner beans, snap beans and other vegetables.

Breeding research is often poorly connected to the end users. As a result, improved varieties do not have the desired impact at the farm level. The main constraint is the lack of an effective seed delivery system capable of producing and disseminating adequate certified seed. Most Kenyan farmers still
use seed varieties that are more than 20 years old. There is a need for better links between researchers and users – not just discoveries, but innovations that are actually used.

**Implications**

Improved cultivars and a seed delivery system can only be part of the solution. In this paper we focus on seed delivery systems, and highlight three case studies of seed science research in Kenya.

**Seed delivery chain and variety development in Kenya**

A seed delivery chain can be defined as the integration of all activities, processes and actors involved in production, bulking, processing, labelling, storage, dissemination, promotion and marketing of seed or other planting materials to end users. The key elements of seed delivery include variety development and release; production of nucleus, breeder, pre-basic, basic and certified seed and other classes of seed; quality assurance, seed processing, storage and conditioning; promotion, distribution and marketing; variety maintenance; monitoring demand; and the overall coordination of activities and actors. The actors may be individuals, groups of individuals, institutions, public and private companies along the seed value chain, who provide the services or products, and the consumers of the end products.

**Variety development**

Variety development in Kenya is carried out within public institutions and private companies. The main public institutions involved in cultivar development are the Kenya Agricultural Research Institute (KARI; since renamed the Kenya Agricultural and Livestock Research Organization) and public universities. Private universities do not usually conduct breeding research. In 2012, the government enacted a new policy for public universities. There is an increasing demand on universities to play a more active role in national development – outside their traditional teaching and research roles (NACOSTI, 2013). This demand is known as the ‘third mission’ of universities. To achieve this mission, their interaction with industry, communities and policymakers has become ever more crucial, and efforts are now being made to make the universities occupy a more central place in the national innovation system. A few crops – maize, sorghum, millet, bean, pigeon pea, cowpea, chickpea and green gram – illustrate the variety development process in Kenya.

**Improved maize varieties**

Maize is the most important staple crop in Kenya and has the highest number of new releases (10-20) per year. Development of improved cultivars has been based on agro-ecological zones. The Kitale Programme, which started in 1955, focused on developing long-duration varieties for high altitude zones with a long growing season and high-input systems. This programme released the first synthetics soon after independence in 1964 (such as Kitale Synthetic I, II, III and IV) and hybrids (Harrison, 1970). However, the hybrid became so popular that synthetic production was stopped. Kenya’s leading 600 series hybrids, such as H612, H613, H614, H625 and H628, were developed at the Kitale Station. The Katumani programme was started in 1957 to develop short-duration, drought-tolerant varieties for semi-arid areas. The popular, short-duration Katumani composite B and, later, Makueni composite were developed from this programme. Hybrids for the medium-altitude zone were developed at the Embu programme, which started in the 1960s. They were crosses between the late maturing Kitale hybrids and early maturing Katumani composites. The best known hybrids from this programme are H511 and H512. Breeding maize for the hot, humid and disease-prevalent coastal lowlands started at Mtwaya in 1975. Important varieties developed from this programme include the Coast composite and Pwani hybrid. Although these improved varieties are widely grown in the
country, farmers also have made selections from the Kenya Flat White complex. This population originated from natural crosses and mixtures among introductions made since the sixteenth century from Caribbean maize such as Cuzco and Caribbean Flint by the Portuguese traders and settlers from South Africa and Zimbabwe early in the twentieth century (Harrison, 1970). Distinct varieties, such as Ukambani local, Katumbili, Githigu and Muratha, were selected by farmers from the complex. Although many new varieties have been released since 1992 when the market was liberalized, older-generation hybrids, composites and farmers’ varieties still dominate the seed delivery system in Kenya, partly due to the slow adoption of new varieties.

**Improved sorghum and millet varieties**

Development of improved sorghum varieties started in 1948 at Ukiriguru in Tanzania, and later at Serere in Uganda under the East African Agricultural and Forestry Research Organisation in 1958 (Dogget, 1970). In Kenya, sorghum improvement was initially based at Alupe and Kakamega in western Kenya and later at Katumani, starting in 1978. The main varieties developed from these programmes were Serena, Seredo, Dobbs Bora and Lulu. A new variety, Mtama 1, was developed and released through a collaborative programme between the Kenya Agricultural Research Institute (KARI), Katumani and the regional programme of the International Crops Research Institute for Semi-Arid Tropics (ICRISAT). Work on improvement of millet started recently at Katumani.

**Improved bean varieties**

Bean is a preferred crop for farmers because of its short growth cycle (90 days and less), resistance to drought and ability to mature on residual moisture. Kenya has the largest areas under bean cultivation in Africa, estimated at over 670,000 ha (Wortmann et al., 1998) and more recently, 1 million ha (MOA, 2012). Common bean is the most important grain legume. Its improvement started in 1977 at the University of Nairobi (UON) as part of the Bean Cowpea collaborative research support programme (CRSP). The Grain Legume Project (GLP) at the National Horticultural Research Centre, Thika, based partly on the materials developed at the UON, started in the late 1970s. At Katumani, breeding activities started in 1980 as part of a Food and Agriculture Organization (FAO)/United Nations Development Programme (UNDP) grain legume project. Breeding activities in Kenya expanded considerably with the formation of a regional network led by the International Center for Tropical Agriculture (CIAT) in 1985. The main objective of these programmes was to increase productivity through developing bean cultivars tolerant to biotic and abiotic stresses.

Several varieties have been released from these programmes. Six cultivars were released by the GLP in 1984. These were GLP 2 (Rosecoco or Nyayo), GLP 24 (Canadian Wonder), GLP 1004 (Mwezi Moja), GLP X-92 (Mwitemania) and GLP 585 (Wairimu, or Red haricot). Of these, Mwezi Moja and GLP X-92 were recommended for production in semi-arid areas. The sugar beans were also recommended for production in semi-arid regions. The Katumani programme released three cultivars in 1998 (KAT B1, KAT B2 and KAT B9). Another two cultivars, KAT X-56 (large red kidney) and KAT X-69 (a red mottled) type were released in 2001. KARI-Kakamega in collaboration with CIAT has released three bush cultivars tolerant to root rot (KK 8 or SCAM 80/15 CM, KK 15 or MLB 49-89a; KK 22 or RWR 719) which are adapted to western Kenya. Four early maturing sugar bean cultivars (Miezi Mbili, Kenya Early, Kenya Speckled Sugar and New Rosecoco) were subsequently developed by the UoN Bean Research Programme and formally released by the National Variety Release Committee (NVRC) in 2008 (Table 4). UON’s improved bean germplasm has been shared with over 33 countries in Africa, Asia, Australia, Europe, North and South America.
Improved pigeon pea cultivars
Pigeon pea is probably the most drought-tolerant grain legume grown in the semi-arid regions of Kenya. Often, it is the only thriving crop after severe droughts from which a harvest can be made. Pigeon pea improvement started in 1977 at the University of Nairobi and in 1980 at the National Dryland Farming Research Center, Katumani (Kimani, 2001; Kimani et al., 2001). The first improved cultivar, NPP 670, was released in 1983 (Jones et al., 2001; Mergeai et al., 2001). It became popular among farmers because it is early maturing, tolerant to drought, short in stature and determinate, and has the preferred large, white/beige seeds (Kimani, 1990). KAT 60/8 and ICPL 87091 were released in 1998. KAT 60/8 is of medium duration and indeterminate. ICPL 87091, originally developed by ICRISAT, is an early maturing and determinate variety. Another three cultivars have been recommended for release by the collaborative programme among KARI, University of Nairobi and ICRISAT. These are ICEAP 68 (medium duration), ICP 6927 (medium duration) and ICEAP 40 (long-duration and resistant to wilt) (Kimani et al., 2001).

Improved cowpea cultivars
Cowpea is grown by farmers in semi-arid areas as it is drought-tolerant. Its leaves are also consumed as a vegetable. Cowpea improvement in Kenya started in 1977 as a collaborative programme between the Ministry of Agriculture and the University of Nairobi/Cowpea-Bean CRSP project. Cowpea improvement at Katumani started in 1980. Two important varieties were released from these programmes, Machakos 66 (M66) and K80. M66 is a drought-tolerant, indeterminate, dual-purpose cowpea variety adapted to areas above 1,300 m. It gives an average yield of 1.3 t/ha. K80 is semi-spreading and drought-tolerant. It is best adapted to low altitudes (<1,300 m) and gives an average yield of 1.5 t/ha.

Chickpea and green gram
Although chickpea and green gram are important in the semi-arid areas of Kenya, limited work has been done to improve their productivity. Field experiments showed that green gram (also known as mung bean) is more drought-tolerant than cowpea. A small improvement programme was started at Katumani in 1980. KVR 26 was selected for its high-yield, determinate-growth green gram cultivar with large seeds (60.3 g/1000 seeds). It has since been released. Work on chickpea started early in 2000 in a collaborative programme between ICRISAT and KARI. ICCL 83110 was selected and recommended for release because of its high yield and tolerance to wilt and pests.

Delivery systems
Seed delivery systems operational in Kenya can be grouped into four categories: formal, informal, seed aid and mixed.

Formal seed systems
This category refers to the production, processing and packaging, labelling and marketing of certified seed by registered producers. This normally involves private or public seed companies with outlets in many parts of the country. Leading seed companies in Kenya include the Kenya Seed Company, East African Seed Company, Western Grain and Seed Company and Faida Seeds. Several multinational companies such as Syngenta, Bayer (East Africa Ltd), Seminis, Cargill, Pannar and Royal Sluis have started operations in Kenya directly or through subsidiaries. There are about 70 registered seed companies in Kenya, many of which are members of the Seed Trade Association of Kenya (STAK) based in Nairobi. Most of these companies produce seed of cereals, (especially maize, wheat
and barley) and legumes (especially bean) which are under mandatory certification (schedule II crops), and distribute imported vegetable seeds. These companies have country-wide distribution networks and offer modest national coverage. Except for maize, they account for less than 5% of the seed sown in ASAL areas. Very little certified seed of pigeon pea, cowpea, sorghum, millet or green gram is produced by private seed companies. With the exception of cut flowers, companies do not produce planting material of most vegetatively propagated crops. Private companies are profit driven and consider demand for the seed of other crops unreliable and expensive to produce and market. However, demand for seed of various crops is poorly documented. An issue often raised by seed companies is that, for self-pollinated crops, farmers will buy seed once and use farm-saved seeds in subsequent seasons. But the key question is why farmers save seeds for future planting or buy grain in open markets for use as seed. Farmers save and reuse seed because they are not assured of regular, timely availability of seed locally. This is a vicious cycle. If farmers were assured of timely availability of affordable quality seed near their locality, they would probably dispose of their produce and buy seed each season, as they do for crops such as maize. Studies have shown that farmers are willing to buy seed of self-pollinated crops such as beans at twice or more the grain price (Sperling et al., 2004; Rubyogo et al., 2007). A formal seed system is sustainable but tends to produce more expensive seed because of the additional certification and marketing costs.

Informal systems
This category refers to the production, processing, marketing and/or distribution of seed by unregistered seed producers. Seed produced is variable in quality and is not produced under a certification scheme. Production and marketing are often localised and based on low-input technology. Key players in this system include NGOs, farmers, farmer groups, researchers and community-based organisations (CBOs). In Kenya, this system has been producing seed of open-pollinated varieties of cereals, grain legumes and also of vegetatively propagated crops such as sweet potato and cassava for many years. Except for schedule II crops, no certification is required, although the situation is changing in favour of certification of more crops. It accounts for over 90% of the seed of most crops planted each season. Because it is based on rainfed cropping systems, it is highly vulnerable to drought stress, occasioning severe shortage of seeds. Producers have limited access to breeders’ and basic seed of improved varieties. The quality of seed is variable because there is no independent verifiable quality assurance process. However, it has potential for sustainability partly because it is derived from the traditional system and has limited demand for external inputs. It also offers opportunities for evolution into indigenous seed companies.

Seed aid
Also known as emergency seed, this is a relatively new development in Kenya, which started in 1992 as an effort to supply seeds to communities faced with acute seed shortage following drought-related stress. Seed aid started as a collaborative programme involving the government, NGOs, CBOs, farmers and other development agencies. In the past decade, considerable quantities of seed maize, bean, cowpea, sorghum, pigeon pea and green gram were acquired from seed companies or produced by communities for wider distribution. Although this was intended to be a limited, one-time intervention, it has become a regular source of seed for the affected communities, creating a dependency syndrome. Operations of seed aid are poorly linked with the formal research system. A survey evaluating the effectiveness of seed aid in Kenya found that both the government and NGOs delivered seed mainly of maize and beans, with smaller amounts of drought-tolerant crops such as cowpea, sorghum, millet and pigeon pea (Sperling et al., 2004). Maize and bean were the priority seeds for the
majority of farmers, even in situations where they were less adapted. Farmers expressed discontent with the timing (generally late), targeting (not transparent) and quantities received (too little). Often the wrong varieties were delivered. For example, seed of long-duration hybrids such as H614 was distributed to farmers in semi-arid districts. There was no evidence that seed aid per se strengthened farmers’ systems, and it is a costly intervention for farmers, governments and development agencies.

Mixed systems
This is a seed delivery system that combines elements from both formal and informal systems. It is operated by small seed companies and/or commercially oriented individual seed producers. They may or may not be registered. Part of the seed is produced locally under a certification scheme or imported and packaged locally. Such producers may provide seed for emergency aid, often by cleaning, dressing and packaging commodity that was not intended for use as seed. They have limited distribution capacity.

Developing and promoting an integrated seed delivery system
A wide range of improved crop varieties has been developed in Kenya. However, most have not reached their intended beneficiaries because of the lack of an organised seed delivery system. Because of the limited information available, often the wrong varieties are recommended to farmers, especially during emergency situations. Little promotion work has been carried out, and so few farmers and development agents know about improved varieties. Sometimes farmers may be aware of the improved varieties but do not know where to obtain the seed. This has contributed to low productivity reported in many regions.

To overcome the limitations associated with the current seed delivery systems and improve the availability of seed to farmers, we propose an integrated system with eight major components based on the seed value chain approach.

These are:
• variety development and testing;
• seed multiplication;
• quality assurance;
• promotion;
• distribution and marketing;
• variety maintenance;
• storage;
• monitoring and coordination.

This integrated system requires different actors at different stages, all of whom should be coordinated. Although most of the components exist in the current seed delivery system, there is very little vertical or horizontal integration, which reduces the effectiveness of the system. There is hardly any monitoring and coordination of activities of actors or clear delineation of responsibilities. Suggestions are made below on how these components can operate.

Variety development and testing is the primary source of improved varieties. This activity should be the responsibility of the national research organization, public universities, international centres and, to some extent, seed companies. They have the capacity, human resources, skills,
physical facilities and access to international genetic resources of many crops. They are also capable of producing high-quality breeder and basic seed for sale to companies and other seed producers on a regular basis. Necessary legislation for this activity is in place, and was revised recently to cater for a liberalised seed industry.

Seed multiplication is probably best carried out by seed companies, small independent producers or those contracted by seed companies. Few smallholder producers can be expected to meet the stringent, mandatory requirements legislated for the production of certified seed for crops. Informal producers, NGOs and other development agents have played key roles in seed multiplication, especially for areas that were not well served by seed companies. However, seed produced by unregistered seed producers is not certified. Consequently it is recommended that basic and breeders’ seed is produced by breeders or their institutions; certified seed is produced mainly by seed companies; and standard seed is produced by farmers, NGOs and CBOs. This is consistent with the harmonised regulations for the seed industry being promoted by the Eastern African Community and ASARECA.

Provision of high quality seed is an important component of an effective seed delivery system. Standards for quality seed, such as cultivar purity, germination capacity and moisture content, have been developed. This service, previously provided by the National Seed Quality Control Service (NSQCS) under KARI, is now a mandate of the Kenya Plant Health Inspectorate Service (KEPHIS). KEPHIS is responsible for seed certification in Kenya and provides internationally recognised seed certification and phytosanitary services. It conducts multi-location national performance trials (NPTs) to validate the performance of candidate varieties submitted by public and private breeders. KEPHIS also organises meetings for the NPT Technical Committee and the National Variety Committee on behalf of the Ministry of Agriculture. It maintains a register of released varieties and post-control plots, inspects seed crops, issues labels for certified seed, and regulates seed exports and imports in accordance with the Seeds and Plant Varieties Act (Chap. 326) – which was updated in 2006 and 2013 to maintain relevance to a rapidly changing seed sector. It is expected that the seed offered to farmers will be of the highest quality and will meet international standards.

Promotion of improved varieties is critical if growers are to provide a reliable market for seed producers. Limited promotion activity for the improved varieties has been carried out in Kenya. Most activities have focused on maize seed. Consequently, few farmers are aware of the availability and potential of varieties of other crops. Adoption has been slow. Seed should be regarded as any other commercial product. Demand is created by promoting a product. Many seed companies have argued that there is no demand for seed to justify production of the seed of grain legumes, traditional cereals and vegetable crops. Few of these companies have attempted any significant promotion campaign. Available evidence indicates that farmers purchase as much as 50% of their seed requirements from local markets, even for self-pollinated crops such as bean (Sperling et al., 2004). Promotion can be done through multiple channels such as on-farm trials, demonstrations, electronic and print media, field days, bazaars or community meetings, church announcements, and drama. Materials required for promotion should be well designed and informative. These include posters, leaflets and brochures for farmers and extension agents. Promotional activities require effective and functional partnerships among researchers, extension agents, NGOs, CBOs, farmers, community leaders, traders and stockists.

An effective distribution network is essential to ensure seed reaches farmers at the right time, in adequate quantities and in good condition. Such a network should involve seed companies, NGOs,
transporters, CBOs, farmer seed producers (or small-scale seed enterprises), and traders to serve communities in each of the target areas and others with suitable storage capacity. Delivery schedules should be worked out to ensure seeds are available before planting time. The costs of distribution and margins for the various players should be factored in during the development of price structures.

Except for maize, few breeders (or their institutions) maintain breeders’ seed of released varieties because of the high costs involved. Most of the improved varieties have been developed through short-term research projects. In addition, there is no regular demand from potential seed producers. In a liberalised seed industry, it is expected that breeders and/or their institutions should finance their variety maintenance activities from the proceeds of breeder and basic seed to commercial seed producers. Maintenance breeding is important if seed producers are to be regularly assured of high-quality breeders’ and basic seed. Contracts between seed producers and breeders are required to remove uncertainties associated with the production of seed, which cannot be disposed of.

Seed must be stored in good condition for variable duration after harvest to facilitate distribution to retail outlets and for sale to farmers for planting. The quantities stored will vary with the estimated demand in the target regions. Suitable storage facilities should be provided in an integrated seed delivery system. Seed may be stored to meet the regular demand by growers, or as strategic reserves. Storage of strategic reserves to meet unexpected shortages or to meet the needs of marginalised sectors of society is expensive, and is beyond the scope of private seed producers. The government should contract private companies to maintain strategic reserves based on anticipated demand.

Finally, an integrated seed delivery system cannot operate effectively unless there is a functional coordinating and monitoring unit. The functions of such a unit would be to provide a continuous situation analysis, monitoring levels and status of normal and strategic reserves, unclogging bottlenecks in the delivery system, and providing a consultative forum for planning and implementation of agreed activities by stakeholders. Such a unit should have wide representation, including policymakers, seed producers and merchants, and local and international organisations involved in the seed trade.

**Case studies**

**Pigeon pea seed production**

After the development and release of NPP 670 variety in 1983, the next challenge was to develop a seed delivery system (Kimani, 1990). Several seed production and dissemination pathways were evaluated. These included a revolving fund scheme operated by the Pigeon Pea Research Programme; production and dissemination of seed by contracting farmers by the Machakos Integrated Development Project (MIDP, 1984–90); farmer-to-farmer; extension officers; ICRISAT/KARI seed projects; supporting farmer seed entrepreneurs in Mbeere, Machakos and Kitui districts (now ‘counties’); and private seed companies such as the East African Seed Company, which has expressed some interest. Of these, support for farmer entrepreneurs in Mbeere district was the most successful, effective and sustainable seed delivery pathway (Kimani and Mbatia, 1993; Kimani et al., 1994a,b). NPP 670 was introduced to Mwea division, Mbeere district during a field day in Karaba location in August 1986. The field day was organised in a farmer’s field (Mr Joseph Mugweru) by the Pigeon Pea Research Programme of the University of Nairobi in partnership with the Ministry of Agriculture. Farmers from Karaba and adjacent areas participated. The new short-duration variety was nearing
maturity and was distinctly different from the tall, late maturing local varieties grown in this area, both of which were planted in adjacent plots. Demonstrations were conducted on production, crop protection, gross margin analysis, utilisation and availability of seed. Soon after harvest, the farmer sold all of his seed crop from his 1 ha plot and realised more than KES10,000 (about US$150), which he used to produce more seed. Very little additional support was provided by the project to the farmer. Several other farmers started producing seed for sale. Because of its good grain characteristics, farmer entrepreneurs found ready markets for their grain in local traders and major urban centres such as Nairobi, which stimulated expansion of the production area. A survey conducted by ICRISAT and the Overseas Development Institute (ODI) showed that this variety had become known to all farmers and was being grown by 68% within a period of 12 years (Jones et al., 2001). Three-quarters of farmers found out about the variety through observing it growing in the field, and obtained seed primarily from other farmers. Factors favouring the diffusion of the variety included its attractiveness as a cash crop; the ease with which it could be distinguished from other varieties; the low seed rate; and the relative ease with which growers were able to maintain seed purity. Farmers expressed a willingness to pay for fresh seed, which suggests that more effort needs to be made to involve the formal seed sector. Twenty-seven years since its introduction, the variety has spread to neighbouring counties of Kirinyaga and Embu among others, without any external injection of seed or funds.

Onion seed production

Although bulb onions (Allium cepa L.) have been grown in Kenya for more than 70 years, farmers have always relied on imported seeds as there is no local production. Bulb onions are biennial, producing bulbs during the first season and seeds during the second season. Vernalisation is required for the transition from vegetative to reproductive phase. Optimal vernalisation temperature is about 8–10°C for 2 months. While this poses no problem in temperate climates where low temperatures can be realised during the colder winter and spring months, it is a major constraint in tropical countries such as Kenya, because ambient temperatures range between 14 and 30°C in onion-growing areas. Five new onion varieties developed at the University of Nairobi, in partnership with Hebrew University of Jerusalem and Hazera Seed Company (Israel), were formally released in 1994 by the Ministry of Agriculture (Kimani and Kariuki, 1994; Table 1).

Table 1. Maturity, bulb size, bulb skin colour and yield of new onion varieties developed at the University of Nairobi

<table>
<thead>
<tr>
<th>Variety</th>
<th>Maturity</th>
<th>Bulb size</th>
<th>Bulb skin colour</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New varieties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KON 1</td>
<td>153–191</td>
<td>Large</td>
<td>Light brown</td>
<td>32</td>
</tr>
<tr>
<td>KON 4</td>
<td>158-198</td>
<td>Large</td>
<td>Light red</td>
<td>29</td>
</tr>
<tr>
<td>KON 6</td>
<td>154–205</td>
<td>Medium</td>
<td>Bright red</td>
<td>22</td>
</tr>
<tr>
<td>KON 7</td>
<td>154–205</td>
<td>Large</td>
<td>Yellow</td>
<td>34</td>
</tr>
<tr>
<td><strong>Old varieties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bombay Red</td>
<td>160–197</td>
<td>Small to medium</td>
<td>Red/purple</td>
<td>16</td>
</tr>
<tr>
<td>Red Creole</td>
<td>150–212</td>
<td>Medium</td>
<td>Red</td>
<td>18</td>
</tr>
<tr>
<td>Tropicana Hybrid</td>
<td>162–207</td>
<td>Large</td>
<td>Red</td>
<td>20</td>
</tr>
</tbody>
</table>

Sources: Kimani and Kariuki (1994); Kimani et al. (1994)
Studies were initiated to determine the potential of onion seed production under local conditions. Initial results indicated that onion seed can be produced by artificial vernalisation by storing bulbs in cold rooms at optimal temperatures for 2 months. However, this required large capital investment and operational expenses, which would translate into expensive and unaffordable seeds. The second option was to determine if natural vernalisation could be achieved by storing bulbs at ambient temperatures at high-altitude locations. Cured bulbs of the eight new varieties and three local checks were vernalised in a cold room at 5 or 10°C; in a well ventilated grass thatched potato warehouse at Njambini Farmers Training Centre (2,350 m.a.s.l., mean temperature 13.9°C), and room temperature at Kabete Field Station (1,820 m.a.s.l., 21.4°C). After 8 weeks in storage, treated bulbs were planted at four locations – Kabete, Njambini, Kibirigwi and Marigat. Results showed that interactions between location, variety and storage temperature were highly significant for days to flowering, stalk height, umbels per plant, 1,000-seed weight and seed yield. Varietal and vernalisation temperature were significant for seed germination rates. Bulbs stored at 10°C had the highest seed yield, followed (in order) by those stored at 13.9°C and 21.4°C (Table 2), except for Bombay Red, which produced higher seed yield at 21.9°C. Bulbs stored at room temperature at Njambini flowered at all locations for the 2 years. The results showed that commercial seed yield can be obtained in the tropics by vernalising bulbs at high altitudes and producing seed at lower altitudes.

Table 2. Effect of vernalisation temperature on seed yield of onion cultivars grown at four locations in Kenya

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Temperature (°C)</th>
<th>Seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kabebe</td>
<td>Kibirigwi</td>
</tr>
<tr>
<td>KON 1</td>
<td>5</td>
<td>272</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>726</td>
</tr>
<tr>
<td></td>
<td>14.4</td>
<td>582</td>
</tr>
<tr>
<td></td>
<td>21.9</td>
<td>130</td>
</tr>
<tr>
<td>KON 7</td>
<td>5</td>
<td>321</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>767</td>
</tr>
<tr>
<td></td>
<td>14.4</td>
<td>492</td>
</tr>
<tr>
<td></td>
<td>21.9</td>
<td>114</td>
</tr>
<tr>
<td>Tropicana</td>
<td>5</td>
<td>219</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>516</td>
</tr>
<tr>
<td></td>
<td>14.4</td>
<td>372</td>
</tr>
<tr>
<td></td>
<td>21.9</td>
<td>84</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>343</td>
</tr>
</tbody>
</table>

Source: Kariuki and Kimani (1997)

Bean seed production

In June 2008, 12 new bean varieties developed by the University of Nairobi were formally released by the NVRC. Nine were bush and three were climbing bean types (Table 3). To commercialise these varieties, the university had to overcome many challenges. Available nucleus seed of each variety was limited. Farmers were demanding seeds after the local print media highlighted the qualities of the new varieties, which included multiple resistance to diseases, earliness, drought tolerance, wide adaptation, highly marketable grain types, and better grain yield than any of the existing commercial
varieties. Seed laws demanded that only certified breeder, pre-basic, basic and certified seed could be sold to farmers, because dry bean, unlike pigeon pea, is a schedule II crop. Moreover, only registered seed merchants could produce certified seed. The university did not have expansive land tracts, the personnel to produce adequate certified seed, or a national seed distribution network.

Table 3. Growth habit, market class and yield potential of new bean varieties developed at the University of Nairobi

<table>
<thead>
<tr>
<th>Variety</th>
<th>Growth habit</th>
<th>Market class</th>
<th>Yield potential (kg/ha)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miezi Mbili</td>
<td>Bush</td>
<td>Speckled sugar</td>
<td>2,300</td>
</tr>
<tr>
<td>Kenya Early</td>
<td>Bush</td>
<td>Speckled sugar</td>
<td>2,150</td>
</tr>
<tr>
<td>Kenya Sugar</td>
<td>Bush</td>
<td>Speckled sugar</td>
<td>1,818</td>
</tr>
<tr>
<td>New Rosecoco</td>
<td>Bush</td>
<td>Red mottled</td>
<td>2,300</td>
</tr>
<tr>
<td>Kenya Red Kidney</td>
<td>Bush</td>
<td>Red kidney</td>
<td>2,800</td>
</tr>
<tr>
<td>Super Rosecoco</td>
<td>Bush</td>
<td>Red mottled</td>
<td>2,800</td>
</tr>
<tr>
<td>Kabete Super</td>
<td>Bush</td>
<td>Red kidney</td>
<td>2,470</td>
</tr>
<tr>
<td>Kenya Wonder</td>
<td>Bush</td>
<td>Red kidney</td>
<td>2,090</td>
</tr>
<tr>
<td>Kenya Umoja</td>
<td>Bush</td>
<td>Red mottled</td>
<td>2,300</td>
</tr>
<tr>
<td>Kenya Safi</td>
<td>Climber</td>
<td>Speckled sugar</td>
<td>3,000</td>
</tr>
<tr>
<td>Kenya Tamu</td>
<td>Climber</td>
<td>Red mottled</td>
<td>3,500</td>
</tr>
<tr>
<td>Mavuno</td>
<td>Climber</td>
<td>Red mottled</td>
<td>4,500</td>
</tr>
</tbody>
</table>

* Yield figures based on NPTs conducted by KEPHIS, 2005–07.

The majority (90%) of dry bean seed in Kenya has traditionally been produced and distributed mainly through informal channels since the release of the first varieties in 1984; only limited quantities were produced and marketed by the East African Seed Company and Simlaw Seeds Ltd.

To overcome these challenges, nucleus and certified breeder seed production was initiated at Kabete Field Station under the supervision of KEPHIS in 2008 and 2009. The university registered a seed company, UniSeed Ltd, through which certified breeder seed would be produced. At the same time, several seed companies expressed an interest in partnering with the Bean Research Programme in the production, promotion and marketing of seeds of the new varieties. A technology licensing agreement was negotiated with Simlaw Seeds Ltd, a subsidiary of Kenya Seed Company. In this agreement, the University of Nairobi would provide certified breeder seed of at least six varieties on a regular basis to Simlaw Seeds. It would also provide technical support during the production of pre-basic, basic and certified seed. The first consignment of certified breeders’ seed produced at Kabete Field Station was handed over to Simlaw Seeds in November 2010. To produce pre-basic and basic seed, smallholders (farmers who produce seed on at least 1 acre), medium-scale farmers (>2 ha) and large-scale farmers (>5 ha) were contracted in Naromoru, Meru, Kirinyaga, Isiolo, Naivasha, Nyeri, Murang’a and Bungoma. Although common bean is highly self-pollinated (99%), it was necessary to maintain the mandatory minimum isolation distances required by the Seeds and Plant Varieties Act (Chap. 326). This was a major constraint, especially for smallholder farmers with small land parcels. Moreover, it was important to organise the farmers into clusters to facilitate field inspection, and to reduce technical support, collection and other operating costs. Staking climbing bean varieties was a challenge for farmers who had traditionally grown bush type bean varieties. The farmers tested various staking options including the use of sisal twine, wire trellises and stakes. Growing climbing
beans in association with maize was not acceptable to regulatory agencies. The climbing beans were too vigorous and tended to strangle the maize plants, adversely affecting their productivity.

Table 4 shows the quantities and seed categories of the new dry bean varieties produced in various locations in Kenya during the short and long rainy seasons of 2011 and 2012. More than 9,000 kg of seed was produced during the long rainy season of 2011. Of this, 315 kg was nucleus seed stage I and II produced at Kabete Field Station. Nucleus seed goes through three stages under certification before it is used to produce breeder seed. Certified breeder seed delivered to Simlaw Seeds in November 2010 was used to produce 4,500 kg of pre-basic and basic seed at Naivasha, Isiolo and Kabete field stations. This implied that various categories of seed must be produced each season and advanced to the stage in subsequent seasons. Certified seed produced increased to 21.4 t during the short rainy season of 2011. More than 80 ha of seed crops were planted each season in 2012 and 2013. Certified seed was first offered for sale to growers during the 2013 long rainy season.

Table 4. Seed of new bean varieties produced in 2011 and 2012

<table>
<thead>
<tr>
<th>Season</th>
<th>Category of seed</th>
<th>Quantity (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long rainy season 2011</td>
<td>Nucleus</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>Breeder</td>
<td>4,129</td>
</tr>
<tr>
<td></td>
<td>Basic</td>
<td>4,562</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>9,041</strong></td>
</tr>
<tr>
<td>Short rainy season 2011</td>
<td>Nucleus</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>Breeder</td>
<td>8,000</td>
</tr>
<tr>
<td></td>
<td>Basic</td>
<td>12,667</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>21,467</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Season</th>
<th>Category of seed</th>
<th>Quantity (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long rainy season 2012</td>
<td>Nucleus</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Breeder</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Basic</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Certified</td>
<td>–</td>
</tr>
</tbody>
</table>

Although the initial certified seed production was largely carried out by the Bean Research Programme and Simlaw Seeds, a new partnership was formed in 2013 between the Seed Enterprise Management Institute (SEMI) of the University of Nairobi, Simlaw Seeds and the Bean Research Programme. In the new arrangement, SEMI would focus on the production of breeder seed; Simlaw Seeds would focus on the production of pre-basic, basic and certified seeds, and promotion and distribution of seeds through its country-wide network of retail agents; and the Bean Research Programme would focus on production of nucleus seed, variety maintenance, development of new varieties and technical support of its partners. In November 2013, a second company signed a technology licensing agreement with the University of Nairobi to produce and market new bean varieties that were not contracted to Simlaw Seeds. The companies insisted on exclusive licensing agreements.

**Lessons learned, future directions and conclusions**

Based on our experiences in developing improved crop cultivars and seed delivery systems for farmers in Kenya, and other countries in Eastern Africa over the past 20 years, we can offer some observations and conclusions.
• Maize and bean are the priority crops for ASAL farmers. However, these are not necessarily drought-tolerant, but may have features that make their production feasible in semi-arid regions. Thus Katumani composite is not a drought-tolerant variety per se but its earliness contributes to drought escape. Similarly, beans are adapted in these regions because of their short life cycles.
• Pigeon pea, green gram, sorghum, millet and tepary beans are drought-tolerant.
• Research focus to date has been on pigeon pea and beans. Less work has been done on cowpea, green gram and other drought-tolerant crops. There is growing interest in drought-tolerant maize among researchers in a collaborative programme between KARI and the International Maize and Wheat Improvement Center (CIMMYT). CIAT and its collaborators are developing drought-tolerant bean cultivars.
• The limited demand for seed of drought-tolerant crops is partly due to limited promotion and poor links to markets.
• There are four major seed systems in Kenya. All seed systems have merits and shortcomings. None is best under all conditions and for all crops. Each system has underlying technical, institutional and socio-cultural–economic–political issues that need to be taken into consideration to improve its effectiveness.
• The main components and key players in these seed systems are poorly integrated, hence ineffective; synergy is lost because of the lack of integration.
• Farmers have several coping strategies to meet their seed requirements. Their main seed sources, which include farmer-saved, local markets, extension, research, stockists and relatives, can be exploited in developing effective seed systems.
• Correct diagnosis of the causes of seed shortages is critical for appropriate interventions.
• Public universities have a key role in cultivar development and building capacities for seed research and delivery systems because of their large pool of trained (but underutilised) personnel, field and laboratory infrastructure, and recent policy change demanding their increased involvement in national development beyond their traditional teaching and research roles.
• No single institution has all the resources (human and non-human) needed to develop, promote and implement an effective seed delivery system.

Future directions
We suggest an integrated seed delivery system involving all key players and components.

The key components of an integrated seed delivery systems are variety development and release, seed multiplication, quality assurance, promotion, a distribution and marketing network, variety maintenance, provision of storage on normal and strategic reserves, and a coordination and monitoring unit. The possible actors and their roles are described in this paper.

Some functional principles for an integrated seed delivery system are to:
• identify roles and responsibilities of each partner based on the human and physical resources, skills and current legislation;
• plan, implement and receive feedback together;
• create and provide several options to beneficiaries;
• link seed systems with markets – local, national, regional and international – to provide the pulling force and motivation to increase productivity.
Conclusion

Integrated systems require commitment, effective partnerships and resources. If in place, the expected consequences are that:

- seeds of the right variety and quality, and in adequate quantity, will reach farmers faster, in time and transparently;
- few improved varieties will remain on the shelves;
- seed sales will improve;
- Kenya will have improved capacity to deal with seed stress;
- there will be enhanced crop productivity and commercialisation of research products;
- the number of food-insecure people will decrease;
- the numbers living below the poverty line will start decreasing;
- researchers and development workers will be less frustrated;
- better returns to investment in research and development will be seen.

References


Engaging universities in integrated seed sector development: Lessons from Mekelle University, Ethiopia

F. Abay

This paper describes the success of Mekelle University (MU) as a key implementing partner in seed sector development in Ethiopia. The university has been fuelling seed sector development through demand-driven and high-impact capacity-building programmes for practitioners and policymakers. MU works with farmers in participatory plant breeding (PPB), which aims to expand seed agro-biodiversity to develop new, locally bred varieties. PPB and varietal trials have been conducted in seven districts of Tigray under farmer management, including farmer-developed barley varieties. The Integrated Seed Sector Development (ISSD) programme has provided a platform for seed sector partners including Tigray Agricultural Research Institute (TARI), Ethiopian Seed Enterprise (ESE) and private investors. In effect, a consensus on ways to share tasks and responsibilities has been reached. The Seed Safety through Diversity project provided technologies for farmers to become directly involved in PPB and varietal selection. The process has enabled the release of three new, improved barley varieties (Felamit, Fetina and Hirity), which were released by the National Varietal Release Committee (NVRC). ISSD-MU disseminated the technologies to wider farmer communities through the formal channels and producer cooperatives. This shows that synergy among partners can help to develop integrated seed systems. In 2012, Felamit had reached 5,000 farmers through farmers’ networks and seed cooperatives. The adoption rate has been increasing – by 50% in 2013 and by 66.7% in 2014 – a 60% overall adoption rate. Currently the new barley varieties have reached about 60,000 farmers. The lessons from MU suggest that public universities can work to ensure synergistic integration of the formal and informal systems. For the benefit of smallholder farmers, this initiative should be given institutional and policy support and recognition.

Keywords: adoption, participatory, varietal

Introduction

Low crop productivity in sub-Saharan Africa (SSA), including Ethiopia, is due to limited use of seeds of improved varieties by smallholder farmers. The supply of certified seeds of grain crops in Ethiopia is estimated to be about 10% of the annual seed planted (Spielman et al., 2010). Seed is a divisible and scale-neutral technology that can be adopted by different types of farmers – from resource poor to resource rich. Farmers’ access to seeds of varieties of modern landraces adapted to their agro-ecologies is critical in increasing their food production (Feder et al., 1985). However, deficiencies have been observed in improved seed supply due to low prices, the seed varieties demanded and quantities required, and untimely seed delivery (Bishaw and Turner, 2008; Sahlu et al., 2008).
There is an acknowledged need for policy and institutional support for integrated seed system development (ISSD) that helps smallholder farmers to re-appropriate their seed. This can be done by introducing a favourable legal environment for agricultural biodiversity, based on the varieties capable of evolving and adapting to their local areas, and on participatory varietal selection (PVS) to improve local varieties. Mekelle University (MU) is the key implementing partner for the ISSD programme in the Tigray region of Ethiopia, where farmers rely heavily on the traditional seed system. MU works with farmers, consumers, other public institutions and private companies to develop interventions using seeds of local crops, instead of the improved varieties such as hybrid maize that are favoured by commercial enterprises in the formal seed sector.

Lack of access to improved seed and planting material

As outlined in recent FAO reports, over 90% of the fields in Ethiopia are still planted with farmers’ varieties and farm-saved seeds (Neate and Guei, 2011). In the informal seed system, individual farm households carry out all seed functions, including variety selection, multiplication, processing and marketing, while the formal/commercial system comprises specialised organisations with distinct roles in supplying seeds of new varieties. Unfortunately, there is limited collaboration between stakeholders in the formal and informal seed sectors. This means that many farmers often do not have access to early generation seed of new, improved varieties for a range of food crops or high-value fruit and vegetables. Building horizontal linkages between the informal and formal sectors at each functional level, such as research, development and seed production, is critical in facilitating transformation of the seed industry. The public sector, including universities, research organisations and extension, has a vital role to play in this process.

Several factors limit access to improved seed for African smallholders, including the following.

- **Poorly developed infrastructure.** Long distances between farmers’ fields and seed outlets, poorly maintained roads, high transportation costs and inadequate storage arrangements have a negative impact on seed production, quality and affordability.

- **Inadequate extension services.** In many countries, extension services are not readily available or easily accessible (Spielman et al., 2011). Farmers often need such services to guide their decision-making on production and use of quality seeds and to understand the benefits.

- **Inadequate seed policies.** In some countries, seed policies encourage investment to support the development of integrated and quality seed systems, whereas inadequate or inappropriate policies in others can serve as disincentives to further seed development. Seed regulations should facilitate the development of a heterogeneous, competitive group of seed producers, while protecting the rights of all producers and customers. In many African countries, stringent variety release procedures, plant breeders’ rights and plant variety protection laws favour formal seed sector enterprises. Removing compulsory seed certification and restrictive trade licensing requirements for open-pollinated crops such as maize and sorghum would permit the production of quality seed by smallholders, and its sale among neighbouring farmers. Involving smallholders in contract seed production would enable seed companies to benefit from existing informal, farm-level seed systems. The specific objectives are to promote pluralistic seed regulation and varietal registration laws in order to support crop diversity-based farming systems that build local seed exchange.
MU seed programme
Mekelle University is the key implementing partner for the ISSD in the Tigray region, where farmers rely on the traditional seed system. A strong farmer–researcher linkage group was established in 2004 (through Seed Safety through Diversity, a bilateral project supported by the Government of Norway) in which the importance of farmer-breeders is recognised. Farmers’ right to full access to varieties and to partial ownership of breeding rights (including the recognition of farmer-selected and officially released varieties) was secured from the start. The Ethiopian Plant Breeders’ Right Proclamation also recognises farmers’ rights. The objective of the MU seed programme is to enhance agricultural biodiversity for farmers using varieties that are adapted to their local environment.

Figure 1. Improved local barley variety demonstrated in a farmer’s field

Key intervention areas include:
- awareness creation, and working closely with the key stakeholders who play a significant role in the development of the seed sector;
- improving farmers’ access to seed, and enhancing adoption rate of varieties by the community, through facilitating and supporting the involvement of private investors, public seed enterprise, public schools and seed producer cooperatives in the production of early generation seed;
- encouraging cooperatives to realise the common good and promoting farmer-to-farmer transfer of better techniques for seed production and marketing;
- promoting autonomous cooperative growth to tackle farmers’ problems and encourage the use of locally available materials in the seed production process;
- motivating member and community contributions to strengthen their sense of ownership – members of the cooperatives contribute 50% in labour and other resources;
- building local knowledge and strengthening the technical capacity of seed producer farmer enterprises in quality seed production, post-harvest processing, storage and marketing;
- promoting the diversity of crop portfolios and varieties;
• promoting gender-sensitive cooperative growth (where at least 40% of the member of the cooperatives should be women) and encouraging women to participate actively in various committees;
• encouraging market-led/commercial production orientation, thereby guaranteeing local seed enterprise development;
• strengthening private sector seed producer development, especially in foundation seed production as a means of achieving access to early generation seed in the region;
• conducting research on areas concerning seeds and varietal development, and undertaking participatory varietal selection through joint experimentation with local farmer groups;
• encouraging farmers to produce and maintain on-farm seed stocks for improved crop varieties and support them to improve their traditional community-based production.

Results
The major results to date are summarised below.

Participatory plant breeding (PPB)
Through the combined efforts of breeders in MU and local farming communities, three high-yielding barley varieties with improved nutritional qualities (β-glucans, iron and zinc) were developed and officially released by Ethiopia’s national variety releasing committee (Abraha et al., 2013a,b). The PPB work was farmer-led and demand-driven, and aimed at increasing yields and nutritional value while enhancing the tolerance of local varieties to biotic and abiotic stresses. Farmers also regained access to endangered local barley varieties in PVS trials. Farmers at almost all of the sites have a substantial share of the local market for the seeds they are producing (Abay et al., 2011). This demonstrates that plant breeding with locally adapted varieties may have much to offer the farmers of Tigray (Abraha et al., 2013a,b).

Shared experience
A joint vision was developed and a regular discussion forum was established. Senior officials facilitated and participated in study visits to other African and Asian countries in order to learn about the need for regional quality assurance and certification; regional seed quarantine systems (to isolate seeds that may have been exposed to a contagious or infectious disease); seed quality laboratory facilities; quality control systems; and the participation of private investors in the seed sector.

Collaborative seed multiplication and distribution
Collaboration among stakeholders for the multiplication and distribution of early generation seed (includes breeder and pre-basic seed) was strengthened to mitigate the problem of basic seed shortage in the region. MU conducted discussions with the various stakeholders to reach consensus on ways to share tasks and responsibilities. Partners included Tigray Agricultural Research Institute (TARI), the Ethiopian Seed Enterprise (ESE), and private investors. In 2011, the breeding department of MU released a barley variety known as Felamit. Felamit was released by the NVRC. It was developed through PVS involving interested farmers from Atsbi-Womberta and Emba-alage and breeders and agronomists from MU. All the trials and demonstrations were carried out in the farmers’ fields. In 2012 the multiplication of the first released farmer-developed variety (FDV) reached 5,000 farmers. It was distributed to the farmers mainly through cooperative and village networks. The adoption rate of the variety was recorded every year so as to monitor access of the seed (the numbers of farmers who use the variety have been increasing since 2012; for instance the number was increased from 2,500 in 2013 to 5,000 in 2014). MU also produced early generation seed in village schools. During
the multiplication, two rural schools from Adishu Woreda participated by renting their lands. A total of 25 quintals of Felamit were produced. The seed was distributed to 250 model farmers on a contractual basis, who returned the seed after harvesting and sold the rest to the local community. Each farmer received 10 kg and farmers returned equivalent amounts of seed (to what they had received), according to the contractual agreement.

**Variety development and registration of barley**

Three barley varieties (Felamit, Fetina and Hirit) were released by the National Varietal Release Committee (NVRC). The Seed Safety through Diversity project targets cooperatives in accessing these improved varieties. Using the same model, the plant-breeding team of MU has expanded into sorghum and finger millet breeding and seed dissemination in Tigray.

**Capacity building**

Capacity building at several levels has been supported by: (1) providing PhD scholarships abroad in addition to co-funding PhD research within the country; (2) providing short-term training for experts, development agents working with local seed businesses (LSBs), and other stakeholders in the seed production; (3) preparing a seed production and marketing training manual; (4) promoting research studies with potential for a tangible impact in empowering LSBs in their quality seed multiplication, storage and distribution; and (5) sponsoring MSc students to conduct thematic research, and designing training and capacity-building programmes to empower LSBs.

**Improvement of local food products by women**

Improvement of local food products by women using second-grade seeds for product processing has enabled LSBs to diversify their business and better target consumer preferences for particular varieties and crops. A case in point is the increased demand for lentil and chickpea by women’s cooperatives, which led to a partnership of MU breeders with Holetta and Debrezeit legume breeders. This in turn led to increased interest in linseed, both as a rotation crop and for its nutritional value. The demand for these and other crops attracted the interest of the NAS Food Company, which began preparing various products from food security crops such as finger millet, sorghum, lentil and chickpea. The company produced biscuits from a mix of finger millet, sorghum and barley, and this mix blended with wheat. The women’s food science project in MU has been promoting these products through exhibitions and food fairs.

**Seed-cleaning machines**

Seed-cleaning machines were provided in 2012 to Hiwot and Hirit-Mekhan LSBs through the Seed Safety through Diversity project. The recipients are members of the two cooperatives. The machines are expected to clean seed of the LSBs and of the local community at a reasonable price. This will save time, boost productivity, generate income, guarantee clean seed and promote competence in the seed business.

**Dissemination**

Flyers, brochures, newsletters, billboards, T-shirts, caps, posters, calendars and the internet (e.g. www.ISSDEthiopia.org) were used to share experiences and promote results.
Conclusion
Universities, with their wealth of highly qualified academic staff and potential for agricultural research, are currently recognised more for their teaching role than for their research role. Their linkages with actors of the national agricultural research and innovation system (NARIs) are generally weak, and need to be strengthened to enhance agricultural performance. Universities can establish and strengthen multidisciplinary teams, facilitating and supporting multidisciplinary collaboration among institutes that are devoted largely to specific problem-solving research in the fields of food, agriculture, agricultural economics and rural development. Such teams and institutes, while maintaining a high level of autonomy, would remain firmly linked to teaching and postgraduate research, as well as conducting targeted research. For example in Ethiopia, Hawassa and Mekelle Universities established the Institute of Environment, Gender and Development Studies (IEGDS) with donor support. Currently, both institutes are conducting multidisciplinary research.

Public universities need to consider how to:
- assist seed-insecure subsistence farmers who may be unable to purchase seed available in the formal market, but could benefit significantly from access to high quality seeds of local varieties with improved drought and disease resistance developed through an improved informal system;
- better identify and distribute improved varieties of smallholder crops in which there is little commercial interest.

Seeds of new varieties could be distributed on credit terms, and farmers could return the seed in kind, not in cash. Through the establishment of LSBs and PPB programmes, farmers can be integrated in every aspect of the seed system as active participants in seed research, the release process, seed production, and seed distribution through farmer-to-farmer seed exchange networks. Some may become independent seed entrepreneurs producing seed for the local market, or may work as contract seed producers or seed traders for private or public seed companies.

The lessons from MU suggest that the enhanced role of public universities in seed systems that benefit smallholder farmers can work. The achievements of MU in integrating the formal and informal systems can be a take-home lesson for other public universities that must be supported through the legal and institutional mechanisms. Our findings confirm the policy recommendations described by Bocci et al. (2014). According to the authors, there needs to be a range of seed certification processes undertaken by public bodies. The basis of seed certification needs to ensure there is a wide range of seed that meets all markets, and to ensure it is of suitable quality (free from disease and weeds etc. and meeting a minimum quality standard). We recommend that farmers’ seed exchange are viewed as a particular type of seed marketing, and the inclusion of superior local varieties/mixtures in the national listing, allowing farmers and seed savers to ensure sustained and increased crop productivity.

References


Integrated seed sector development in Malawi: The role of Lilongwe University of Agriculture and Natural Resources (LUANAR)

V. H. Kabambe, W. Mhango and Y. Tembo

Lilongwe University of Agriculture and Natural Resources (LUANAR; formerly Bunda College of Agriculture of the University of Malawi) has a mandate for teaching, research, outreach and consultancy, and has expertise in the fields of agriculture and natural resources. This paper reports on a study conducted between December 2012 and April 2013 to analyse the involvement of LUANAR staff in integrated seed sector development (ISSD) in Malawi. The ISSD sector has been classified into farmer-saved (informal), formal and mixed seed systems. Three case studies are used to demonstrate LUANAR involvement. The university has been active in bean breeding since the 1970s, with over 15 varieties released, most of them in the 1990s. In 2011, a cowpea variety was released. LUANAR has also been involved in dissemination of mushroom, cassava and other seeds of horticultural crops. In the past 10 years the university has produced 10 publications, including two books, policy briefs, fliers and journal papers related to seed production and seed systems. Following a SWOT analysis, strategies for enhancing the role of LUANAR in ISSD were discussed at a stakeholder symposium, and are presented. Supporting the coordination of key players and activities for improving synergy and infrastructure development are recommended. It should also establish a medium-scale seed processing facility to handle the gap in neglected self-pollinated crops, provide seed cleaning and treatment services for small- and medium-scale entrepreneurs and farmer groups, and at the same time provide valuable experiential learning for its students. The university should test models for forecasting seed requirements and seed dissemination.

Keywords: synergy, seed systems, experiential learning

Introduction

Agriculture is the most important sector in Malawi, employing about 80% of the country’s workforce, and providing 39% of gross domestic product (GDP) and more than 80% of export earnings (Malawi Government, 2009; GoM, 2011). The development of agriculture is the first of the country’s nine priorities for 2011–16 (GoM, 2011). The key output is to increase yield per unit area. Thus a well developed and efficient seed sector is key to achieving this goal.

The Malawi seed sector is relatively well developed with a broad range of players. These include smallholder farmers; input suppliers; and regulatory, marketing and knowledge-based institutions. The seed industry is regulated by the Seed Act of 1988, which was revised in 1996. Over the past
15 years, the government has been a key player through its Farm Input Subsidy Programme (FISP) initiated in 2005 (MoAFS, 2007; Dorward and Chirwa, 2011). FISP enables smallholder farmers to access seeds and fertiliser at highly subsidised rates. The seed supported includes maize, groundnuts, soybeans and cowpeas (MoAFS, 2007; Dorward and Chirwa, 2011).

The Malawi seed market has been valued at US$10 million (Wekundah, 2012). Maize is the staple food of Malawi and dominates the land committed to agriculture as well as the seed sector. In the 2010–11 season, maize was grown on 1,732,371 ha of land, with hybrids occupying 41%, open pollinated varieties (OPVs) 31%, and local varieties 29% (MoAIWD, 2012). Pulses (beans, cowpeas, pigeon peas, soybeans) occupied 678,232 ha, while groundnuts occupied 308,094 ha and cassava 200,139 ha. Other crops such as tobacco, cotton, cassava, potatoes, other cereals and spices occupied a total of 582,870 ha (MoAIWD, 2012). The diversity in crops provides opportunities for crop rotations and the implementation of a range of activities along the various stages of the seed value chain and involving multiple stakeholders for providing seeds of improved varieties. In order to improve the seed sector further, an assessment and classification of the sector is important to enable value chain actors to identify their niche and improve their capacity.

There is an active commercial seed sector in Malawi, led by the Seed Traders Association of Malawi. The Association’s membership grew from 7 to 17 between 2004 and 2013, and it is involved in national programmes such as the FISP. Most classifications have grouped seed systems into two classes: traditional seed systems and formal seed systems (Cromwell et al., 1992; Almekinders et al., 1994; Dalton et al., 2010). These categories have been further subdivided into five specific seed systems: farmer-saved seed systems, NGO/farmer associations, public/private sector, multinational companies, and closed value chains.

There is a general perception that universities play a small role in the development of the seed sector and usually are not included in major policy reviews. However, there is little documentation of the role universities play in variety development, seed production and dissemination. Documented case studies can assist policymakers and other decision-makers in universities to review their expertise, research and policy involvement, and their curricula, syllabuses and laboratory capacities, to train and conduct research that will contribute to national goals.

**Evaluating the role of LUANAR in ISSD**

A national seed sector assessment was undertaken by the National Task Force of Malawi of the integrated seed sector development (ISSD) Africa II programme, coordinated by the Centre for Development and Innovation of Wageningen University (Zidana et al., 2012). This set the stage for the study to assess the role of LUANAR in ISSD, which was supported by the Technical Centre for Agricultural and Rural Cooperation (CTA), and conducted between December 2012 and April 2013 at LUANAR.

The study benefited from existing information on the activities of various university departments, units or projects made available during university field days and other open-day events when departments display their activities to the public. Additional information was obtained by reviewing annual reports. At the time of the study, LUANAR had three faculties (Agriculture, Development Studies and Environmental Sciences). The departments under the Faculty of Agriculture were Basic Sciences; Crop and Soil Sciences; Agricultural Engineering; Animal Science; and Home Economics and Human
Nutrition). The departments under the Faculty of Development Studies were Extension; Agricultural and Applied Economics; Agribusiness Management; and Agricultural Education and Development Communication. The departments in the Faculty of Environmental Sciences were Aquaculture and Fisheries Sciences; and Environmental Science. University staff engaged in ISSD were interviewed to obtain further details of their involvement in related projects, and were requested to provide their published outputs.

Three projects were selected as case studies (Annexes 1–3). The first was the bean seed multiplication project – a good example of a multidisciplinary research project that released varieties and backed them up with support for seed production and dissemination of both seed and knowledge, engaging and empowering farmers in the process (Annex 1). The second case study covered a mushroom project, which provides an upstream service of oyster mushroom seed multiplication, and supports farmers and farmer groups in spawn production, training and marketing (Annex 2). The third case covered the contributions from the Centre for Agricultural Research and Development (CARD), focusing on the involvement of one economist in ISSD (Annex 3). Data were collected through interviews with the relevant university staff using unstructured questionnaires.

The assessment was complemented with a SWOT (strengths, weaknesses, opportunities and threats) analysis, and draft strategies for strengthening the role of LUANAR were then developed. The results of the assessment, the SWOT analysis and draft strategies were presented to stakeholders involved in the seed value chain at a workshop held on 8 March 2013 in Malawi. This was attended by 21 participants comprising: government research scientists, private company directors, university faculty, government seed extension officers, an export trading company, CGIAR scientists, government seed regulatory officers, non-governmental organisations (NGOs) and seed association representatives.

Figure 1. Participants in the university seeds workshop held on 8 March 2013, Lilongwe, Malawi
Results and discussion

Role of LUANAR in integrated seed sector development

The major asset of LUANAR is its expertise in support of seed value chain development, including plant breeding, crop husbandry, plant health, plant biotechnology, policy analysis, agribusiness and marketing (Annexes 1-3). The contribution of the university to the five categories of seed system as identified through the assessment undertaken under the Malawi ISSD II Africa programme is summarised in Table 1; these are followed by highlights of the university’s roles with respect to the seed value chain.

Table 1. Types of support provided by LUANAR to different seed systems in Malawi

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<th>Seed system</th>
<th>Role of university</th>
<th>Example</th>
<th>Source of information</th>
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| Farmer-saved seed               | Capacity building of extension, crop, land management, policy and agribusiness specialists | • First degree training in extension, agronomy and natural resources  
• MSc in seed science and technology  
• Diploma in seed technology  
• Short courses | • Curricula and syllabuses  
• Crop Science Department annual report, 2008 |
| Capacity building of farmers    | Project training farmers in grain legume production and quality declared seed for integrated soil fertility management (ISFM) | • Lungwena pass-on initiative  
• Farmer and staff-training in various projects  
• Bean and cowpea seed production for sale to Association Smallholder Seed Multiplication Action Group (ASSMAG) and NGOs  
• Oyster mushroom seed production for sale | • Kabambe et al. (2008)  
• Mhango (personal communication)  
• McKnight Best Bets Project, 2013 |
| NGOs/farmer associations        | • Seed production, pass-on seed programmes, seed out-grower schemes and capacity building  
• Basic & breeder’s seed sales | • Variety evaluation for release  
• Variety evaluation (or national performance trials for Monsanto candidate varieties) | • Collaborating scientist (Department of Crop and Soil Science) |
| National public/private seed schemes | • Capacity building                                                                 | • Degree training for staff  
• University annual reports  
• Ministry of Agriculture reports | |
| Multinational companies         | • Variety evaluation for release                                                                 | • Compliance with biosafety regulations  
• Confined evaluation of Bt cotton | • Collaborating scientist |
| Closed value chains             |                                                                                                           |                                                                                                                                         | |

Capacity building

The most significant contribution of the university to the seed sector in Malawi has been through capacity building. This is because nearly all of the professionals and technocrats in the Ministry of Agriculture, at the Seed Services Unit at Chitedze (the regulatory wing), most breeders, research scientists, seed company production managers and extensionists were trained at the university. In addition to degree programmes, there are short courses offered by arrangement. LUANAR faculty staff continually train staff and farmers as they undertake activities in various projects across the
country. However, these should best be done in collaboration with existing research institutions, as there are few university staff.

**Basic research**
The university has expertise in genetics, plant physiology, plant biotechnology and tissue culture to enable it to conduct basic research for the development of appropriate varieties for industrial and home consumption.

LUANAR is currently involved in a project to regenerate clean seeds of potatoes for wider dissemination. It is also involved in the confined evaluation of Bt cotton, in compliance with the National Biosafety Act under the supervision of Public Biosafety Services. This is a collaborative effort between the Departments of Forestry and Horticulture, Crop and Soil Sciences at LUANAR; Department of Environmental Affairs, Ministry of Agriculture; Chancellor College of the University of Malawi; and Monsanto.

Through postgraduate student research, LUANAR has perfected a system to produce clean seeds of potato through micropropagation and induction of tuberisation using an aeroponics system. LUANAR is leading in studies to identify root traits that are related to drought and low fertility tolerance, which will help in the speedy screening of lines for these important traits.

**Applied research**
LUANAR has developed and released 15 new bean varieties through an interdisciplinary bean/cowpea project supported by a collaborative research support programme (CRSP). These include Kanzama, Kalima, Nasaka, Bwenzilana, Bunda 93, Napirira, BCMV-B2 and BCMV-B4. Some of these, particularly Kalima, have been widely disseminated in Malawi. Recently, Mkanakaufiti, a cowpea variety with resistance to the parasitic weed *Alectra vogelii*, was released in another collaborative project between LUANAR, Department of Agricultural Research Services (DARS) and the International Institute of Tropical Agriculture (IITA).

The university maintains and multiplies seed of oyster mushrooms and sells it to individual farmers and outreach groups. An International Development Research Centre (IDRC)-supported project carried out by postgraduate students is currently assessing the seed delivery systems for bambara nuts, sorghum and sweet potatoes.

Considering the multiple mandates of the faculty, its best niche appears to be in basic research that is more knowledge intensive; results can be validated by the public agricultural research system. LUANAR scientists are currently focusing on applied research because of a lack of adequate infrastructure. This has complemented public research, especially in filling research gaps that have not been prioritised by DARS due to staff vacancies and for other reasons. Involvement in applied research has given the faculty better understanding and experience with seed systems and seed value constraints. Moreover, university scientists are required to publish their work as part of their knowledge, innovation and dissemination mandates.

**Seed production and promotion**
LUANAR produces and sells seed to relevant stakeholders. LUANAR’s Bunda Farm produces certified seed on contract with major seed companies such as Monsanto, Seed Co Limited and Demeter.
Over the past 10 years, the Forestry and Horticulture Department has been engaged in multiplying and selling seed of mineral-rich indigenous vegetables such as amaranth and okra, forest tree seedlings and fruit trees. A cowpea improvement project supported by the McKnight Foundation maintains the newly released variety Mkanakaufiti (2011), and sells breeders’ and basic seed to individuals, NGOs and private firms. By December 2012, more than 1,000 kg of breeders’ seed was sold, of which 500 kg was sold to a private seed firm. The outreach activities for mushrooms are discussed under the case studies.

Other projects involve training extension staff and farmers in legume seed production with the aim of increasing legume seed for soil fertility improvement activities. These include an ongoing McKnight Best Bet Project, and the Soil Fertility Consortium for Southern Africa (SOFEC-SA) project in Lilongwe and Zomba. These two projects promoted farm-saved seed using certified or basic seed injected into the system by the projects. A similar project supported by the Government of Norway, promoting cassava, cowpeas, green gram and bambara nuts, has concluded in Lungwena, Mangochi district. Another project supported by the IDRC is directly involved in helping farmers select, multiply and use landraces of ‘orphaned’ crops, such as sorghum, bambara nuts and sweet potatoes.

Regulatory services and policy
LUANAR does not provide regulatory functions, but its staff are involved indirectly in various activities and projects that interface with policy. For example, in August 2009 the Best Bets Project, along with other partners, organised a consultative policy workshop focusing on ISFM and seed systems in Malawi. Among others, the workshop recommended that the government should consider quality assured seed categories and decentralised seed production for open-pollinated crops. Currently, one member of LUANAR is involved in a task force to review the Seed Act in Malawi.

LUANAR chaired the country team for the regional three-year (2011–13) project on Seed Policy Enhancement for African Regions (SPEAR). The project is advocating and facilitating streamlining of the variety release systems towards the Southern African Development Community (SADC) protocol. SPEAR drafted and tabled to government a ‘Genetic Access Transfer Scheme’ (GATS) and a ‘Variety Licensing Policy’. Among others, GATS has made the following recommendations:

- establishment of a variety release committee to critically evaluate varieties before release;
- establishment of the National Seeds Authority to investigate variety development and flow of seed to the farming community, and to provide expertise in seed business enterprises.

The variety licensing policy proposes a transparent policy with motivation and royalties to breeders, and increased funding for public breeding systems.

Outreach and knowledge dissemination
Most knowledge dissemination has been undertaken jointly with applied research and technology promotion projects. The university has performed reasonably well in developing publications to disseminate ISSD-related research results and general information for technocrats and farmers. Some of these outputs are listed in Box 1. In addition, the university has regularly participated in, and won awards at, national fairs and related events to showcase its technologies and activities.
Box 1. Some related publications by LUANAR faculty in the past 10 years (names of LUANAR faculty in bold) in support of seed sector development

Brochures, fliers and briefing notes


Journal papers, published reports


Swot analysis

The results of the SWOT analysis (Annex 4) indicate that LUANAR’s main strengths are its expertise and capacity building capacity which also provide opportunities: its main weaknesses are limited modern infrastructure, poor linkages with industry and limited funding. The university can contribute effectively to the development of the seed value chain and ISSD through the available expertise and capacity building of scientists, technical staff and farmers. Its experience in seed production and post-harvest management for selected enterprises are valued. It can also build on and strengthen existing collaboration with the government, NGOs, international organisations and development partners on seed systems programmes and agricultural innovations. However, it needs address infrastructure development, and attract financial support for seed systems research and outreach activities.

Suggested strategies to strengthen LUANAR’s role in ISSD

Breeding and seed systems

An efficient seed system requires adequate production of high-quality seed of different varieties to meet farmer preferences and to be adaptable to various agro-ecologies. The following actions are suggested.

• Seed production: conduct a national inventory of seed production facilities or resources for various enterprises, and make appropriate recommendations for improving quantity and quality in the national value chain.

• Seed types: explore licensing opportunities for improved crop varieties adapted to different agro-ecologies, variable environments (biophysical and socio-economic) and farmer preferences. Currently LUANAR, through the bean/cowpea CRSP, has produced up to 15 varieties of beans with different characteristics to meet farmer preferences and with adaptations to different agro-ecologies. Other seed production activities include oyster mushroom; and the cowpea variety
resistant to *Alectra* weed recently released in collaboration with the DARS and IITA. Such efforts should be intensified by LUANAR or other value players; seed can be distributed through NGOs and agro-dealer networks.

- **Seed quantity:** seed shortage is one of the major constraints to increased crop production. The university should work with existing seed production enterprises to assess the demand for specific crops and varieties and develop strategies to fill the seed gap (by LUANAR or the national value chain).
- **Genetic resources:** construct facilities for conservation of genetic resources. Establish and empower committees in various aspects of seed systems, such as variety development, variety release and extension systems, to fully engage and use the human and physical infrastructure.

**Commercial model enterprises**

Bunda Farm or the Crop and Soil Science Department should establish a medium-scale seed enterprise to scale-out its own varieties, improved landraces and seeds of orphaned crops, taking advantage of the institutional provision of recycling funds. In addition, the commercial plant will:

- train students, new entrepreneurs, farmer groups and seed personnel in seed handling and processing, mainly for neglected or orphaned crops such as bambara nut, green gram and sorghum; and neglected traits such as tolerance to drought, salinity and acidity, which are not widely picked up by international seed companies;
- provide facilities and equipment for seed production handling, cleaning, drying and storage for the above groups.

**Seed policy and seed dissemination model research**

Seed policy: staff of LUANAR need to be conversant with the relevant seed policy and be encouraged to document and analyse case studies so the best policies can be rolled out extensively. Policy experts should work closely with seed systems experts in the strategies identified above.

Seed distribution: improve information and communication channels for new seed varieties, and develop seed distribution networks for peri-urban and rural communities.

**Seed quality certification systems**

Certified and quality declared seed or certified seed 2: approval of certified seed required specific guidelines and inspection procedures by the Seed Services Unit (SSU). This may not be affordable for most smallholder farmers because of the associated costs. However, some farmers are involved in production of seed through community-based seed multiplication and pass-on programmes and, if properly trained and supported, the seed produced can be of better quality with local supervision. This is particularly applicable to self-pollinated crops that require affordable isolation distances.

There is a need to test and adopt models to reduce the cost of seed inspections and approval procedures while maintaining standards for high-quality seed. Such seed can be packed into small bags and sold in the local area through local agro-dealers.

**Teaching and research**

Improve the capacity of infrastructure for teaching and research in seed systems-related programmes at the university.
Strategic plan
Develop a strategic plan regarding the university’s role in the seed sector.

Conclusions
LUANAR is involved at several stages of the integrated seed system value chain in Malawi. This is necessary for a knowledge institution, which needs to continuously build staff capacity and produce competent students with skills that are in demand. However, for strategic purposes at national level, there is need for LUANAR to find a niche of excellence. Such a niche could be in basic research, and in piloting technologies for which closer scientific observation is needed, rather than extensive field evaluations.

As a semi-autonomous institution, LUANAR can recycle funds and reinvest into a medium-scale seed plant that can focus on crops neglected by the commercial sector. This is already happening with mushroom and beans, and could be expanded to include other crop species not bred at LUANAR, for which a licence can be obtained. Advantage may be taken of the commercial farm, and development of contract production agreements with local smallholder farmers. Currently the university has a good track record of publishing its work. This should continue, with an emphasis on informative, policy and technical briefs.

References
Annex 1. Case study – Bean improvement project and bean seed multiplication project at Bunda College of Agriculture (now LUANAR)

Context
Which seed system? Formal and informal, mainly servicing farmer-saved seed and NGO/farmer associations.

Problems addressed: (i) lack of good quality, high-yielding, drought-resistant, disease- and pest-resistant bean seed; and (ii) absence of a system to move released varieties with higher yields and above desirable traits.

Where? Bunda College of Agriculture (now LUANAR) under the Departments of Crop Science and Extension, extending nationwide through partnerships.

Coping strategy
Objectives: i) to breed varieties for improving yield and resistance to biotic and abiotic production constraints; and ii) to disseminate as widely as possible the bean varieties developed and released.

Specific activities
Breeding varieties of beans from germplasm collected from different parts of the country and from CIAT. Work started in the greenhouse, then took place in on-station field trials followed by evaluation in farmers’ fields in different agro-ecological zones in the country. The utilisation component was tested by human nutrition scientists to determine bean cooking time and palatability. Selected lines were submitted to the Agricultural Technology Release Committee of the Government of Malawi for release.

Two models of improved variety dissemination were used: (i) the project multiplied and sold seed; (ii) the project engaged farmers in an outgrower scheme. Farmers were trained in production skills to ensure high yield and quality. The project participated in local, district and national fairs to create awareness of the varieties. Brochures were distributed to various agriculture offices and NGOs, and to people during open days and agriculture fairs and trade fairs.

With whom? Breeding was done in collaboration with Michigan State University and CIAT Malawi. Farmers were involved during acquisition of germplasm lines. Dissemination was carried out by the Department of Extension at Bunda College and by NGOs who bought seed from the project and distributed it to farmers in different areas in the country.

When? Bean seed improvement started in the 1970s; by 1995 several varieties had been released. Seed multiplication under model (ii) is ongoing; breeder seed is being maintained by the project.

Results
15 varieties of beans were released. Seed bred by the project team was disseminated to many districts in the country. Many farmers are growing the seed and marketing it either through the project or individually.

Several NGOs and private organisations have bought seed from the project for further increase and dissemination. In the 2007–08 season, the following seed sales were made: Total Land Care (1,120 kg), Chia Lagoon Watershed (2,490 kg), Concern Worldwide (900 kg), School of Agriculture Operation (54 kg), Seed Tech Company (130 kg) and World Vision (46,500 kg).
Farmers lacked the capacity to identify markets, so the project helped farmers by bulking seed from different farmers and identifying markets. The seeds were treated against storage pests.

**Constraints**

Difficulty in producing certified seed: there were too many farmers for inspections and fees for registration and inspection were not affordable for the project or farmers. Therefore only quality declared seed was produced, which was not ideal for some clients.

The project could not pay farmers before markets could be found. This led to many complaints and to some farmers dropping out because sometimes it took more than five months before their produce could be sold.

**Recommendations**

To engage large-scale farmers who can pay for registration and inspection of certified seed.

**Impact**

Seed is still available in the country, as farmers who initially obtained it have saved their own seed and are still using it. The NGOs distributing the seed have made it more widespread in the country.

**Role of the university**

Expert capacity in development of new, better-quality crop seed varieties; in farmer training in seed multiplication; in seed information dissemination and marketing.

*Role in seed sector innovation:* Improvement of seed quality, making bean seed available, creating farmer awareness of good quality seed production and storage.

**Sources of information**

Bean breeder, Prof. J.M. Bokosi; extension specialist, Dr C. Masangano; bookkeeper, Mrs Kadzanja.
Annex 2. Case study – Mushroom project in the Department of Forestry and Horticulture

**Context**

*Which seed system?* Informal.

*Problems addressed:* (i) limited income sources of small-scale farmers; and (ii) no provider of mushroom spawn (seed) in central region of Malawi

*Where?* Communities around Bunda and later nationwide in Malawi

**Coping strategy**

*Objectives:* (i) to multiply mushroom spawn and make it available to smallholder farmers; and (ii) to improve small-scale farmer income and reduce unemployment.

*Intervention strategy:* Oyster mushroom production and marketing.

**Specific activities**

Train farmers how to grow mushrooms using crop residues, plastic bags and simple traditional houses combined with plastic sheet houses. Produce mushroom spawn (seed) and sell to farmers. Disseminate technology to others through participation in national trade fairs and open days.

*With whom?* Work of forming farmer clubs was done in collaboration with the Department of Extension at Bunda College; NGOs who loan initial capital to farmer clubs and/or individuals to start mushroom farming, including Foundation for Irrigation Development (FISD), Irrigation, Rural Livelihoods and Agriculture Development (IRLAD) project, Good Neighbours Young Advocates.

*When?* From 2000. Collaboration with IRLAD was in February 2013, and with FISD and Good Neighbours Young Advocates at 2 years.

**Results**

A total of 12 farmer clubs or groups were serviced, six in Lilongwe district and others in Dowa, Kasungu, Balaka, Nkhotakota and Blantyre districts. The farmers have a reliable source of seed.

**Constraints**

Three seed batches failed to germinate; demand sometimes exceeded supply.

**Impact**

Improvement of farmers’ livelihoods e.g., to build better houses, pay for school fees and buy livestock.

Farmers near Bunda have adopted the technologies and continue to grow mushrooms even without the intervention of the extension personnel. They come to Bunda to buy seed. However, sometimes the demand for seed is higher than the project can provide. More farmers are willing to join.

The project at the university is still capable of supplying seed.

The demand for button mushrooms is big, hence further research on button mushroom has started.

**Role of the university**

To produce mushroom spawn under sterile conditions and maintain a supply to farmers.

It has brought in diversification of agriculture seed and formalised its availability.

**Sources of information**

Mr Kafulatira, Forestry and Horticulture Department and Mr Chimombo, Extension Department.
Annex 3. Case study – Policy studies on seed marketing through a voucher system and policy reviews

Context
Which seed system? Public–private partnership

Problems addressed: There was donor partner questioning of the efficiency of seed marketing through the voucher system.

There was a need for Malawi to align its seed policy to the SADC protocol.

Where? Throughout Malawi.

Coping strategy
Objectives: (i) to study efficiency of the voucher system in seed marketing in order to perfect it for distributing various types of seed; (ii) policy intervention in building capacity in the seed sector.

Intervention strategy: Monitoring seed marketing through voucher system.

Specific activities
The university was involved in a review of the seed policy and Seed Act of the Government of Malawi.

A study was conducted to study the market points, how the vouchers were being handled, and whether quality seed was given.

The university is participating in the harmonisation of seed policy within SADC, looking the current situation in Malawi and how it can be improved.

With whom? NGOs (FANRPAN, Concern Universal), Government of Malawi, Self Help Africa, Action Aid.


Presently taking place: SADC seed policy formulation.

Results
Improved adoption of certain improved crop varieties. Better awareness of seed varieties, created through the voucher system, increased adoption compared with the past (without interventions).

The system was monitored and farmers were able to buy the seeds they wanted.

Policy briefs informed top-level policymakers, who have maintained the voucher system in the nationwide FISP.

Diploma in seed initiated to fill the human resource gap identified; the first group has now graduated.

Role of the university
To provide expertise in policy analysis through the social economic studies conducted.

Source of information
Mr Kachule, economist with CARD, LUANAR.
### Annex 4. SWOT analysis of LUANAR’s role in ISSD

#### Strengths
Multidisciplinary expertise (natural and social scientists – breeding, biotechnology, agronomy, crop protection, extension, agribusiness, economics) to support different components of the seed system, ensures development of high-quality improved seeds and on-farm experimentation; social scientists play a role in awareness, marketing and promotion of these varieties.

Seed production programmes for selected crops already in place e.g., common beans, cowpea.

Formal and informal interactions with different stakeholders act as a platform for creating awareness and access to new crop technologies (e.g., new varieties): the university interacts with stakeholders in different ways, such as field (open) days when stakeholders are invited to learn about the different programmes and research activities; research and outreach activities with farming communities; and scaling-out of technologies.

Involvement in collaborative research with partners from government and NGOs on seed systems-related research.

Well set for capacity building of farmers and scientists at various levels in the seed value chain.

#### Weaknesses
Limited infrastructure:
- to support seed production;
- to support post-harvest management of seed e.g., drying, cleaning, grading and packaging;
- for storage of seed to minimise post-harvest losses and maintain seed quality
- to support research and capacity building of scientists and technical staff in seed science and technology.

A modern seed lab is required for research and training.

Inadequate resources to support outreach activities to scale-up and scale-out existing and new technologies.

Limited number of seed of crops and/or varieties: focus is on limited number of crops or varieties in current breeding programmes (except for common beans).

Weak links between university expertise and other players in the seed system.

Legal framework for seed production at university level not well established.

Seed certification systems are expensive and hard to access.

#### Opportunities
Availability of natural and social scientists to support various aspects of the seed value chain (e.g., production of high-quality seed, storage, marketing, awareness, seed policy, capacity building of scientists and farmers).

Collaborative research with government and NGOs in national seed systems and other seed-related forums and international organisations.

Research and outreach activities with farming communities on new technologies provide access to high-quality seed (informal seed sector).

#### Threats
Natural factors (e.g., drought, floods) have negative effects on seed production; loss of seed in storage.

Current expansions in programmes and student numbers may overstretch staff mandate for teaching, research, consultancy and outreach.
There is high demand for seed of various crops that meet various agro-ecological conditions.

University faculty members have opportunity to access funding from different donors that can be used to support seed systems research and outreach.

Existing network of agro-dealers in various areas, including rural areas.

Seed production of some crops during off-season under irrigated conditions.
The role of the University of Burundi in support services for integrated development in the seed sector

N. Pierre

The objective of this study was to review the role of universities in the development of an integrated seed sector in Burundi. The University of Burundi is particularly active in improving varietal selection; quality control of seeds; disseminating innovations in rural areas; and reinforcing skills at various levels in the seed sector. In a project supported by the Belgian Development Agency (BTC), the university led the development of improved rice varieties adapted to the swampy conditions at medium altitude of up to 1,700 m when this type of culture was previously limited to the Imbo Plains. The varieties developed through this project, which started in 1986, have been widely adopted by farmers. Rice varietal development activities are also being implemented through the IRRI-Burundi project, supported by the International Rice Research Institute (IRRI) based at the Faculty of Agronomic Sciences, University of Burundi. To reinforce the role of the universities in the development of an integrated seed sector, priority should be given to increasing support for research in general and for the seed sector in particular, strengthening links between researchers and farmers, and enhancing the skills of stakeholders in the seed sector – academia, private–public partnerships, farmers and other actors along the seed value chain.

Keywords: innovations, adopted, value chain

Introduction

The University of Burundi (UB) has been a member of the Integrated Seed Sector Development in Africa (ISSD Africa) project since September 2012. UB plays an important role in the development of the seed sector through its Faculty of Agronomic Sciences (FACAGRO), founded in 1976. Its objectives are both academic and scientific. Its scientific mandate was to address the challenges rural populations face by conducting practical and appropriate research. In a country where 90% of the population is rural, an effective agronomic faculty is a great advantage (Khelfaoui, 2009).

FACAGRO’s specific objectives are to:
• conduct innovative agricultural research adapted to the needs of society, with emphasis on challenges facing the rural areas;
• disseminate the new technologies throughout the country;
• support national development by conducting relevant studies, direct on-site interventions, capacity building of government and private organisations, farmers’ associations and non-governmental organisations (NGOs);
• collaborate with other national and international stakeholders in research for development.

1 Faculty of Agronomic Sciences, University of Burundi, Bujumbura, Burundi
A review of these objectives revealed some shortcomings. These included a lack of graduate courses on crop improvement and seed production systems compared with those at Sokoine University of Agriculture in Tanzania, Makerere University in Uganda, and most South African universities. There is a low level of involvement by UB in seed policy development.

An assessment of seed systems in Burundi was conducted in August 2012 by a consultant (Astère Bararyenya) in collaboration with two researchers from the International Fertilizer Development Center (IFDC) in Burundi (Alexis Ntamavukiro and Cyriaque Simbashizubwoba). They were assisted by Peter Gildemacher of the Royal Tropical Institute (KIT, the Netherlands). Following a survey conducted with various stakeholders in the seed sector, a consultative workshop was held on 31 August 2012. This workshop brought together representatives from the public and private sectors, seed producers’ associations, NGOs and international organisations. Participants discussed the draft report developed by the National Task Force. The major seed systems in Burundi and the characteristics of each system were identified (Table 1). The results of the assessment were subsequently presented at round-table discussions with seed sector stakeholders.

Table 1. Components of seed systems in Burundi

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Description</th>
<th>Seed quality</th>
<th>Distribution and marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal</td>
<td>Family</td>
<td>Conservation by the family</td>
<td>Conservation by the family, local exchanges and market</td>
</tr>
<tr>
<td></td>
<td>Seed conservation by the family, bartering and sale at local markets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humanitarian</td>
<td>Production, purchase and distribution of seed to those in need</td>
<td>Commercial certified and non-certified</td>
<td>Free or subsidised distribution</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Community</td>
<td>Commercial non-certified</td>
<td>Local distribution and marketing</td>
</tr>
<tr>
<td></td>
<td>Community production for local use and market</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progressive farmers</td>
<td>Individual and group entrepreneurs starting to specialise in seed production</td>
<td>Commercial certified and non-certified</td>
<td>Contracts and direct marketing</td>
</tr>
<tr>
<td></td>
<td>Specialised businesses that meet commercial and humanitarian market needs</td>
<td>Commercial certified and non-certified</td>
<td>Contracts and direct marketing</td>
</tr>
<tr>
<td></td>
<td>Specialised businesses that meet commercial and humanitarian market needs</td>
<td>Commercial certified and non-certified</td>
<td>Contracts and direct marketing</td>
</tr>
<tr>
<td></td>
<td>Production and distribution of tea and coffee plants by companies</td>
<td>Non-certified</td>
<td>Public and private</td>
</tr>
<tr>
<td>Formal</td>
<td>Formal public–private</td>
<td>Certified</td>
<td>Government contracts and distribution</td>
</tr>
</tbody>
</table>
Assessing the Role of the University of Burundi

To determine UB’s contribution to the various seed systems, a survey was conducted among researchers working in relevant departments. The results of the survey (Table 2) showed that UB was actively involved in the integrated development of the seed sector, particularly through FACAGRO. Its activities are centred mainly on applied research, including varietal improvement and selection (rice, potato); crop adaptability under various ecological conditions in the country (sorghum, maize and potato); the production of foundation seeds (edible mushrooms, potato, banana and yam), quality control of seeds (virus indexing and germination testing for cereals), and virus eradication (banana and yam). The faculty is also involved in the development of training programmes and training farmers in seed storage systems.

Table 2. Types of support provided by the University of Burundi towards the development of an integrated seed system for the country

<table>
<thead>
<tr>
<th>Seed system</th>
<th>Role of UB</th>
<th>Example</th>
<th>Source of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td>• Training and supervising</td>
<td>• Training farmers in new techniques</td>
<td>Survey by the author</td>
</tr>
<tr>
<td></td>
<td>• Raising awareness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Facilitating innovation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humanitarian</td>
<td>• Quality control</td>
<td>• Germination testing of food seeds</td>
<td>Survey by the author</td>
</tr>
<tr>
<td>Community</td>
<td>• Varietal improvement</td>
<td>• Upland swamp rice</td>
<td>Reports</td>
</tr>
<tr>
<td></td>
<td>• Research on seeds</td>
<td>• Implementation and management of rural mini-laboratories</td>
<td>Survey by the author</td>
</tr>
<tr>
<td></td>
<td>• Skills upgrading</td>
<td></td>
<td>Mushroom project</td>
</tr>
<tr>
<td>Progressive farmers</td>
<td>• Varietal adaptability</td>
<td>• Potato cultivation at low altitude, hybrid maize</td>
<td>Survey by the author</td>
</tr>
<tr>
<td></td>
<td>• Quality control</td>
<td>• Associations education</td>
<td>IRRI-Burundi project</td>
</tr>
<tr>
<td></td>
<td>• Skills reinforcement</td>
<td>• Training for researchers and technicians</td>
<td>Mushroom project</td>
</tr>
<tr>
<td>In vitro micro-propagation</td>
<td>• Quality control</td>
<td>• Viral indexing</td>
<td>Survey by the author</td>
</tr>
<tr>
<td>(commercial)</td>
<td>• Production and distribution of clean <em>in vitro</em> plants to private laboratories and farmers</td>
<td>• <em>In vitro</em> micro-propagation of banana, taro, cassava, pineapple, potato, sweet potato</td>
<td><em>In vitro</em> culture project</td>
</tr>
<tr>
<td>Perennial cash crops</td>
<td>• Sector study</td>
<td>• Studies on coffee, banana, oil palm, tea and cotton sectors by FACAGRO researchers</td>
<td>Survey by the author</td>
</tr>
<tr>
<td></td>
<td>• Quality control</td>
<td></td>
<td>Consultancy report</td>
</tr>
<tr>
<td></td>
<td>• Assessment of value chains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal (public and private</td>
<td>• Quality control</td>
<td>• Viral indexing of potato plants before disseminating in rural areas</td>
<td>Reports</td>
</tr>
<tr>
<td>sector)</td>
<td>• Assessment of value chains</td>
<td>• Healthy starters to private laboratories</td>
<td>Survey by the author</td>
</tr>
</tbody>
</table>

A SWOT analysis of the role of UB in supporting integrated seed sector development was also done and the results are presented in Annex 1. The level of UB involvement in ISSD is insufficient, due to the fact that funds allocated to this type of research are often limited and liaison levels between university researchers and farmers are not very high. Much more remains to be done to make the role of UB more effective in the development of the seed sector in Burundi. This includes replacing old equipment, upgrading researchers’ skills, and strengthening links between researchers and farmers, the seed end-users.
UB’s role in seed sector development was further assessed using the case study of the Development Of Swamp Culture Rice Varieties For Medium Altitude Areas Of Burundi. There are three types of rice production system in Burundi: irrigated rice culture at low altitude; rain-fed rice culture; and swamp rice at medium altitude. The first is found in the Imbo Plains and the valleys of Moso. The second covers the foothills of the Mumirwa natural region. The third is located in the swampy central highlands at medium altitude and was developed by researchers at FACAGRO (Gahiro, 2011).

Figure 1. Development of swamp rice varieties for medium-altitudes areas of Burundi

The varieties used for these production systems come from both the private and the public sector. For most farmers in the Imbo Plains, the Imbo Regional Development Corporation (Société Régionale de Développement de l’Imbo, SRDI) supplies growers with seeds. But in the low altitude swamps, farmers increasingly use seeds from their own saved seed. Therefore rice seed systems are semi-formal.

Until the 1980s, rice was cultivated in the Imbo Plains only as irrigated rice. Only one variety, (Yunnan 3), introduced by the Agricultural Research Institute of Burundi (Institut des Sciences Agronomiques du Burundi, ISABU) was available for medium altitude areas. However, its productivity was constrained by infertility and poor seed set due to low night temperatures and diseases such as bacterial blight (Pseudomonas fuscovaginae) and the blast disease caused by Pyricularia oryzae (Tilquin, 1988). Intervention was thus necessary to preserve this upland swamp rice variety.
A new project, ‘Varietal improvement of medium altitude swamp rice culture’, was then developed. Its objectives were varietal diversification, because this culture was based on a single variety, and development of rice varieties resistant to major biotic and abiotic constraints prevalent in the region (Detry and Tilquin, 1992; Bouharmont, 1998). ISABU and FACAGRO were responsible for selecting and disseminating rice varieties adapted to medium altitude areas.

Interventions for this research were conducted as follows (Tilquin et al., 1996).

- Collection of breeds (genitors) combining the required characteristics for cross-breeding. Approximately fifty genitors (50 parental lines) with very diverse origins were collected at local and international levels [Madagascar, China, Korea, Japan, India, Nepal, IRAT (Institut de Recherches Agronomiques Tropicales) and IRRI].
- Selection through cross-breeding to allow a recombination of characteristics. Hybrids were then multiplied in the Imbo Plains (altitude 800 m). The method of hybrid populations (bulk populations) was used at this level for the rest of the selection.
- Natural selection in the pilot swamp at medium altitude (Akagoma, Ngozi). At this level, the varieties of rice obtained were cultivated under natural conditions to test the pressure of harsh conditions.
- Multi-location trials in different environments. These trials were conducted in the swamps of Akagoma (Ngozi), Mishia (Cankuzo) and Muramba (Kirundo) by FACAGRO graduating students to determine which varieties were kept for validation with farmers.
- Confirmatory trials undertaken with farmers for those varieties displaying strong performances.
- Dissemination of the best varieties in the selected regions.

The project has provided satisfactory results that are now operational and profitable to farmers in provinces at medium altitude in Burundi. Varietal diversification has been confirmed in swamps at medium altitude in Burundi (below 1,700 m). Table 3 shows the best varieties created through the crossbreeding conducted by FACAGRO (Nizigiyimana and Nimenya, 2002).

The provinces of Kirundo, Makamba, Ngozi, Cankuzo, Muyinga, Gitega and Karuzi benefited from the improved varieties, and authorised bodies are currently disseminating the best suited varieties in each province The project has had a significant impact on food diversification and household incomes have improved. Furthermore, national rice production rose from 12,000 tonnes (t)/year in 1985 to 78,432 t/year. Area under rice cultivation increased from 5,000 ha in 1985 to 22,210 ha in 2009. Average yield increased from 2.6 t/ha in 1985 to 3.5 t/ha in 2009 (Gahiro, 2011). Research on rice varietal improvement with FACAGRO was a success because (prior to Belgian funding) activities continued, with financial support from FAO, on further evaluation and dissemination of the varieties created. From 2009 to date, a new project funded by IRRI has been working on varietal creation. Two new varieties of rice (Vininzara and Rwizumwimbu) have been developed through this programme.
Table 3. Rice varieties developed by FACAGRO, University of Burundi

<table>
<thead>
<tr>
<th>Variety</th>
<th>Pedigree</th>
<th>Origin of parental lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facagro 18</td>
<td>Shua-Nan-Tsan × Tatsumi Moshi</td>
<td>North Korea, Japan</td>
</tr>
<tr>
<td>Facagro 46</td>
<td>IR9202-6-1-1 × YR2379-79-2</td>
<td>IRRI, Korea</td>
</tr>
<tr>
<td>Facagro 56</td>
<td>IR9202-33-4-2-1 × RP19848-54-2-3-1</td>
<td>IRRI, India</td>
</tr>
<tr>
<td>Facagro 57</td>
<td>IR24312-RR-19-3-B × B2980b-Sr-2-6-3-2</td>
<td>IRRI, Indonesia</td>
</tr>
<tr>
<td>Facagro 59</td>
<td>NR10041-66-3-1 × B2980b-Sr-2-6-3-2</td>
<td>Nepal, Indonesia</td>
</tr>
<tr>
<td>Facagro 71</td>
<td>IR15579-24-2 × K288</td>
<td>IRRI, India</td>
</tr>
<tr>
<td>Facagro 420</td>
<td>K288x RP1848-54-2-3-1</td>
<td>India</td>
</tr>
<tr>
<td>Fac 422</td>
<td>IR22623-RR-4-3 × IR9202-33-4-2-1</td>
<td>IRRI, IRRI</td>
</tr>
<tr>
<td>Fac 430</td>
<td>IR24312-RR-19-3-B × IR5716-18-1</td>
<td>IRRI, IRRI</td>
</tr>
<tr>
<td>Fac 441</td>
<td>YR2379-47-2 × IR15636-b-3</td>
<td>Korea, IRRI</td>
</tr>
<tr>
<td>Fac 906</td>
<td>Kirundo 3 × Kirundo 9</td>
<td>Burundi</td>
</tr>
<tr>
<td>Fac 907b</td>
<td>Kirundo 3 × Ambalava</td>
<td>Burundi, Madagascar</td>
</tr>
<tr>
<td>Fac 908a</td>
<td>Kirundo 9 × YR1641-GH59-7</td>
<td>Burundi, Korea</td>
</tr>
<tr>
<td>Fac 909</td>
<td>Yunnan 3 × Facagro 57</td>
<td>China, Burundi</td>
</tr>
</tbody>
</table>

Source: Nizigijimana and Nimena (2002)

Conclusion

The University of Burundi has played an important role in the development of new rice varieties. It has made a significant contribution towards the breeding of locally developed varieties, and in adaptability studies of introduced varieties through multi-localational trials in various upland swamps in Burundi. The university has played a unique role in designing the crosses and developing the selection and evaluation procedures. It is responsible for providing foundation seeds to other research institutions, such as ISABU, for multiplication and dissemination. FACAGRO was the first to develop rice varieties adapted to harsh biotic conditions (bacterial blight and blast disease) and abiotic conditions (low night temperatures) in the medium altitude swamps of Burundi.

In terms of innovation in the seed sector, UB is a centre for research and remains the ‘bread basket’ of research protocols, especially with regard to applied research. Academia remains the best area for developing innovations and transferring them to end-users (smallholder farmers). The university is involved in various aspects of the development of the Burundian seed sector, from varietal development to dissemination in rural areas of agricultural innovations.

This paper demonstrates UB is contributing to the integrated development of the seed sector but certain weaknesses have to be addressed.

- Intervention by UB at the level of seed policies remains low. Seed research is dependent on external financing because of the low budget allocated to this sector by the government via UB.
- Most research projects are short-term; donors dictate their implementation period. Certain stages of the research, such as the level of innovation adoption, are usually not assessed.
- Links between UB researchers and other stakeholders in the seed sector, including farmers, are weak. This reduces complementarity and may result in duplication because of poor information exchange.
• Certain crop species, known as ‘neglected crops’ or ‘orphan crops’, are not included in the research agenda and therefore remain underdeveloped.

UB can play a central role in the development of a vibrant seed sector in Burundi.

Acknowledgements
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References


Although UB conducts interventions at all levels of the seed sector, including research, capacity building and dissemination of innovations, the degree of intervention in most cases is low because of various constraints. These constraints can be grouped into four categories.

- Insufficient financial resources for research. The Research Department at UB does not provide enough funds for agronomic research. It finances only small research projects. Research is thus limited and depends on external funding.
- High staff turnover. Researchers are poorly motivated due to low salaries. Consequently there have been frequent departures to other sectors such as international organisations, NGOs, politics or the private sector.
- Low level of collaboration among stakeholders in the seed sector.
- Weak links between researchers and farmers, and between other actors in the seed sector. Poor communication of research results to farmers and other end-users contributes to the low level of dissemination of research results. This is further complicated by a failure to translate research results into languages spoken by farmers. Consequently, farmers do not benefit fully from the innovations developed at UB.
For UB to play a major role in the development of the integrated seed sector development in Burundi, a number of strategies to meet these challenges have been identified by participants during a seminar held at the university on 26 March 2013. These are:

- increase financial support for agronomic research in general, and for seed research in particular, to facilitate sustainable research and provide motivation to reduce researcher turnover;
- mobilise external financial sources to compensate for the low economic power of Burundi, which prevents it from providing finance for research at the university;
- create and develop strong links with other seed sector stakeholders, including farmers;
- reinforce communication and knowledge-sharing among stakeholders in the seed sector, and encourage researchers to develop fact sheets in the national language (Kirundi);
- enhance the capacity of existing analysis laboratories through provision of specialised equipment and qualified, motivated human resources – in return, researchers should provide concrete outputs including publications, demonstration plots and participation in seed fairs;
- create a seed research centre at UB to enable sustainable research in the seed sector;
- integrate the UB into innovation platforms on seed research, which would enable researchers to work more closely with other stakeholders;
- increase UB’s level of involvement in building capacities of all stakeholders in the seed sector.
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About this publication
This unique publication ‘Seed Systems, Science and Policy in East and Central Africa’ provides insights into the various seed systems that exist in sub-Saharan Africa, the policy environment as well as the challenges faced and the contributions made by governments, universities, private sector, farmers, women’s groups and regional organizations in their efforts to assure that quality seeds are made available and Africa can increase its share of the global seed trade. It is the direct output of the CTA/ASARECA “Seed science and policy learning writeshop”, which was held in conjunction with the 2nd ASARECA General Assembly and Scientific Conference, in Burundi in December 2013.

About CTA
The Technical Centre for Agricultural and Rural Cooperation (CTA) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). Its mission is to advance food and nutritional security, increase prosperity and encourage sound natural resource management in ACP countries. It provides access to information and knowledge, facilitates policy dialogue and strengthens the capacity of agricultural and rural development institutions and communities. CTA operates under the framework of the Cotonou Agreement and is funded by the EU.

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