

Seeding an African Green Revolution

The PASS Journey



AGRA's Program for Africa's Seed Systems

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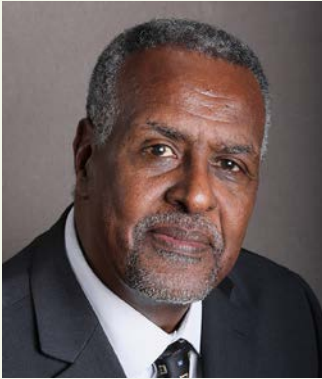
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Foreword



Gebisa Ejeta
Distinguished Professor
Purdue University

In the summer of 2006, I was granted a sabbatical leave from Purdue University, and chose to spend it at the Nairobi, Kenya base operations of The Rockefeller Foundation. I had previously served as an advisor to The Rockefeller Foundation’s program “Biotechnology, Breeding and Seed Systems for African Crops”, and wanted to undertake a study of the African seed system to support the Rockefeller Foundation program.

Just before I arrived Nairobi in October 2006, I found out that plans had already changed. I received a call from Gary Toenniessen, Director of Food Security at The Rockefeller Foundation, informing me of an agreement that had just been signed with the Bill & Melinda Gates Foundation to establish a new organization, the Alliance for a Green Revolution in Africa (AGRA), and asking if I could join the team to engage in planning this new initiative. Of course, I was thrilled to get the invitation to participate.

From the beginning, there was widely shared enthusiasm for the new program among those involved. Based on the vision that would quickly emerge and the strong backing from two of the world’s largest and most determined philanthropies, we all felt that this new initiative could become a game changer for Africa’s agricultural development.

While AGRA would eventually include a number of thematic programs, it would start with a deep commitment and focus on seed supply through the “Program for Africa’s Seed Systems” (PASS), under the leadership of Joe DeVries, then Deputy Director of Food Security at The Rockefeller Foundation. Our year-long study would eventually recommend an ambitious roll-out of PASS activities in 13 countries.

PASS was configured to provide solutions to key bottlenecks to agricultural development in Africa. The program had four sub-components: tertiary education (to train African plant breeders); strategic research (to develop new crop varieties); the creation of private seed companies (to produce and market seeds); and the establishment of agro-dealerships (through training of rural African shop-keepers in small villages to stock seeds and fertilizers) to increase access to agricultural inputs by smallholder farmers. The vision for PASS programming was sound. In the absence of functional extension systems or effective public seed programs, the PASS vision looked like it had all the elements of success. PASS programs also creatively mimicked the successful US Land Grant University model, with its tripartite functions of education, research, and extension for the creation and dispensation of agricultural technologies for impact.

For me, personally, the year with the AGRA team helped strengthen and reaffirm my own sense of purpose and will. It also gave me a chance to contribute to the creation of AGRA and the rolling out of PASS, and to share thoughts on how to address certain recalcitrant challenges in smallholder agriculture. We learned a lot from each other through impromptu debates in hallways and intense, five-minute meetings in farmers' fields and airport lounges. Long drives to and from seed production fields and research stations afforded us the luxury of analyzing the forces affecting seed supply in Africa down to the finer details.

Even with our new-found excitement, we knew that this was going to be a long and grueling journey, but we also knew that the team was well chosen, with highly committed and open-minded practitioners who looked capable of going the distance, giving us the hope that success would be likely. We knew it was going to be a marathon, not a sprint; that it required teamwork and was not a solo effort; and that it would be characterized by mutual benefits and partnerships with national and international agricultural research organizations, national policy makers, donor agencies, and the private sector. All in all, it was an exhilarating time to be on the ground in Africa.

Ten years later, I believe that the PASS team and their associates have reason to feel good about what they have accomplished. The numbers support their pride and sentiment. AGRA reports that 131 PhDs and 228 MSc graduates were trained;

and that 600 new crop varieties of major African crops were bred and released by PASS-supported breeding programs. PASS helped establish more than 100 local, private seed companies and trained nearly 20,000 agro-dealers. Together, these entities have been involved in the production and distribution of some 578,000 metric tons of seed. The greater impact will, of course, ensue when these accomplishments are made sustainable and smallholder farmers find it profitable to routinely get into the market for seed and fertilizer to boost their production and incomes.

The good news is that crop yields in several countries are increasing for the first time in decades. In some countries, such as Ethiopia and Rwanda, the evidence is clear that Africa's smallholder farmers are using new and improved hybrid seeds and fertilizers in large numbers, leading to sharper upward trajectories in crop productivity and food supply than ever before. So much more remains to be done, but now there is a proven way forward.

The indispensable power of science, technology, innovation, and the marketplace premised in the creation of PASS and AGRA now appear prominently on the agenda of Africa's governments and donor agencies alike. Country-led initiatives are becoming a mainstay. More and more young African professionals are drawn to opportunities in agricultural business and entrepreneurship. The prospects for a truly African Green Revolution are brighter than ever.

Gebisa Ejeta

Distinguished Professor
Purdue University

Preface



Dr. Agnes Kalibata
President
AGRA

AGRA's Program for Africa's Seed Systems (PASS) was initiated in 2006 with funding from The Rockefeller Foundation and the Bill & Melinda Gates Foundation. Over a period of 10 years, PASS operated in 18 African countries with funding from these donors, plus additional support from the United States Agency for International Development, the Howard G. Buffett Foundation, the Embassy of the Netherlands in South Sudan, the Government of Korea, and the African Development Bank. Establishing a viable system for the supply of quality, high-yielding seed is an essential component of agricultural transformation, and has proven to be the most elusive goal for many governments in Africa. The generous support of these donor agencies, plus co-financing for many activities by African governments, allowed PASS to venture further than perhaps any group

had previously gone into the challenging world of building sustainable seed systems for Africa's smallholder farmers.

Through more than 300 individual grants to local institutions and private agri-businesses, PASS helped to develop and strengthen more than 100 African seed companies, develop nearly 20,000 agro-dealers to serve as a sustainable distribution network for new seed and other agricultural inputs and services, and ultimately catalyze the production and sale of over 600,000 metric tons of certified seed of a wide range of staple food crops. Equally important, it allowed AGRA and its partners to demonstrate that Africa's smallholder farmers are not bound by tradition to continue living in a subsistence mode, but are in fact eager adopters of new technologies, provided they are relevant to their needs and are made available locally at affordable prices. It is therefore not surprising that AGRA's work on seeds has catalyzed over 200 million dollars of private investment in the seed sector across the continent.

The work of PASS was complemented by parallel interventions by AGRA in the areas of soil health, improved markets, better agricultural policies, stronger farmer organizations, and innovative finance, plus many other useful initiatives implemented by partner organizations. Together, these initiatives are contributing to a new image of African agriculture that is far from the scenes of low productivity and widespread rural poverty of previous decades. Today in many African countries crop yields are increasing,

populations are becoming better-nourished, and people in rural areas are diversifying their economic activities.

But we cannot stop here. In order to better capture the synergies between the adoption of improved seed, increased use of fertilizers, growing commodity markets, and more dynamic public and private institutions, AGRA has developed a new, integrated approach to agricultural transformation. Increasing the supply of improved seed will continue to play a crucial role in this strategy, but will be made more sustainable, we believe, through the development of the entire value chain, more forward looking policies and stronger regulatory institutions.

Agnes Kalibata

President
AGRA

This book serves to document the rich and varied experience in the development of seed systems gained by the PASS team of specialists, the whole of AGRA, and our partners, as a result of the bold actions taken by our supporters beginning in 2006. It is our hope that those who learn about this experience will likewise feel emboldened to take new actions to ensure that Africa is able to feed its growing population and even contribute to feeding the rest of the world. There remains much to be done to achieve inclusive agricultural transformation broadly across Africa, but the experiences and lessons described within these pages show that Africa's farmers, scientists, agri-business leaders, and public servants are ready to work together to carve out a new future for the African continent.

Acknowledgements



Joe DeVries
Vice President
Program Development
and Innovation
AGRA

First and foremost, the PASS team wishes to thank those who provided the financial support to make this work possible, especially those who bought in from the very beginning: the leadership of The Rockefeller Foundation and the Bill and Melinda Gates Foundation.

The concept for PASS was first described to Roy Steiner by officers of The Rockefeller Foundation. Roy gave it his enthusiastic support and travelled to several proposed program countries to see the work on the ground with the then director of agriculture at the Gates Foundation, Rajiv Shah. Over dinner one night in early 2006, at the Norfolk Hotel in Nairobi, Raj proposed to expand the scope of the original set of ideas and soon visited and spent time in the field with Melinda Gates, who walked through many rows of new maize

hybrids developed by Kenyan scientists and then pronounced that the Gates Foundation was “on board”. Judith Rodin, then president of The Rockefeller Foundation, proposed an even broader agenda for the organization that would implement the PASS strategy, later to become AGRA. Bill Gates and Jeff Raikes likewise spent time with the PASS team in Northern Nigeria, and gave us encouragement at a critical point in the program’s implementation.

To these original backers, who had vision and took a risk by investing hundreds of millions of dollars in a plan that would be carried out by a group of unknown crop scientists, as well as to our original mentors at The Rockefeller Foundation – Gary Toeniessen, Gordon Conway, Peter Matlon, Akin Adesina, and Bob Herdt – we wish to express our deep sense of gratitude.

We likewise wish to express special appreciation to Gebisa Ejeta, who worked side-by-side with us in formulating the PASS work plan, and introduced us to many sincere and influential individuals in his home country of Ethiopia. We are also extremely grateful to Yvonne Pinto and Yilma Kebede for their support and advice, as well as their willingness to travel to many remote worksites on the PASS map.

To the past and present AGRA presidents – Namanga Ngongi, Jane Karuku, and Agnes Kalibata – as well as to all the AGRA board members, especially Kofi Annan, Strive Masiyiwa, Moise Mensah, and Monty Jones, who provided guidance and who worked hard to ensure the mission of PASS could be carried on for a full ten years, we are tremendously grateful.

To Howard Buffett of the Howard G. Buffett Foundation, Johan de Waard of the Dutch Embassy in South Sudan, Seliatou Kayode-Anglade of the African Development Bank, and Cho Gyoung-rae of the Korea/Africa Food and Agriculture Cooperation Initiative, who got what PASS was about from the beginning and who bet on PASS to make a difference in farmers' lives in some of the most challenging places, we also wish to express our sincere appreciation.

To the senior officers of USAID – Julie Howard, Mark Huisenga, and Charles Jackson – we are grateful for your service, support and partnership.

To our highly experienced seed business consultants, Aline O'Connor, Dave Westphal, Dilip Gokhale, Ashington Ngigi, and Simon Kimani, who brought their decades of experience and achievement in seed business from other parts of the world, and embraced without hesitation the idea of an independent, private African seed sector led by local entrepreneurs, we thank you for your diligence and commitment.

To the seed specialists of the Seed Science Center of Iowa State University, especially Yuh Shyy,

CIMMYT seed specialist John MacRobert, and Agnes Mwang'ombe and her team at the University of Nairobi, we are sincerely grateful for your dedication and hard work in making the Seed Enterprise Management Institute a success.

To all of the hundreds of PASS grantees and investees, who worked together to educate young African scientists, breed new and better crop varieties, create and grow new seed enterprises, raise farmers' understanding of the value of improved seed, and make the seed available at village level, and to the many public officials of the 18 countries in which PASS operated – the people who opened up to the idea of a vibrant, competitive African seed sector and created a seed revolution in Africa – we are deeply grateful for your contributions and wish you every success in the future.

This book is dedicated to the farmers of Africa, who daily demonstrate their courage and expertise in feeding the continent, and who have committed their precious time and hard work to cultivating the new seed delivered to them by the collective efforts of all those cited here.

Joe DeVries

Vice President

Program Development and Innovation

AGRA

Acronyms

ACCI	African Centre for Crop Improvement	AT Uganda	Agriculture Trust Uganda
AfricaRice	Africa Rice Center	AU	African Union
AGRA	Alliance for a Green Revolution in Africa	AVRDC	Asian Vegetable Research Development Center
AGMARK	Agricultural Market Development Trust	BDS	Business Development Support
AGRIFOP	Agribusiness Focused Partnership Organisation	BRITEN	Building Rural Incomes Through Enterprise
AGRIMERC	Agricultura e Mercados Organização para Desenvolvimento Sustentavel (Sustainable Development Organization for Agriculture and Markets)	CAADP	Comprehensive Africa Agriculture Development Programme
AGRODIA	Association des Grossistes et Détaillants d’Intrants Agricoles du Burkina (Association of Wholesalers and Retailers of Agricultural Inputs)	CAMP	Comprehensive Agricultural Master Plan
AMPU	Autonomous Mobile Processing Unit	CAVS	College of Agriculture and Veterinary Sciences
APA	African Potato Association	CBSD	Cassava Brown Streak Disease
ARI	Agricultural Research Institute	CEB	Contribution A’L’Education de Base
ASA	Agricultural Seed Agency	CGIAR	Consultative Group on International Agricultural Research
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa	CIAT	International Centre for tropical Agriculture
ASIF	African Seed Investment Fund	CIALCA	Consortium for Improving Agriculture-based Livelihoods in Central Africa
ASPRODEB	Association Senegalaise Promoting Development at the Base	CIMMYT	International Maize and Wheat Improvement Center
ASTI	Agricultural Science and Technology Indicator	CMD Ug	Cassava Mosaic Disease-Uganda
		CMS	Cytoplasmic Male Sterile
		CNFA	Citizens Network for Africa
		COMESA	Common Market for Eastern and Southern Africa
		CORAF	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles

CRI	Crops Research Institute	GADD	Ghana Agro-Dealer Development
CSIR	Council for Scientific and Industrial Research	GCAm	General Combining Ability (male)
DADTCO	Dutch Agricultural Development and Trading Company	GCAf	General Combining Ability (female)
DAICK	Deepening Agro-dealer Impact in Coastal Kenya	GES	Growth Enhancement Scheme
DARS	Department of Agricultural Research Services	GIS	Geographic Information System
DRC	Democratic Republic of Congo	Ha	Hectare
DTMA	Drought Tolerant Maize for Africa Initiative	IAR	Institute of Agricultural Research
DUS	Distinctiveness, Uniformity and Stability	IAR/T	Institute of Agricultural Research and Training
EAC	East African Community	ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
EACI	Education for African Crop Improvement	ICT	Information and Communications Technologies
ECCAS	Economic Community of Central African States	IER	Institut d'Economie Rurale
ECOWAS	Economic Community of West African States	IFAD	International Fund for Agricultural Development
EDS	Enterprise Development Services	IFDC	International Fertilizer Development Center
EIAR	Ethiopian Institute of Agricultural Research	IFPRI	International Food Policy Research Institute
ENSA	Ecole Nationale Supérieure d'Agriculture	IGAD	Intergovernmental Authority on Development
EU	European Union	IIAM	Instituto de Investigação Agrária de Moçambique
FAO	Food and Agricultural Organization	IIL	Injaro Investments Limited
FIACC	Fund for the Improvement and Adoption of African Crops	IITA	International Institute of Tropical Agriculture
FIPS	Farm Inputs Promotion Services	IMCDA	Improved MSc in Cultivar Development for Africa
GAABIC	Ghana Agricultural Associations Business and Information Center		

INERA	Institut de l'Environnement et de Recherches Agricoles de Burkina Faso	NGO	Non-Governmental Organization
INRAN	Institut National de la Recherche Agronomique du Niger	PASS	Program for Africa's Seed Systems
IRRI	International Rice Research Institute	PBRs	Plant Breeders' Rights
ISU	Iowa State University	PICS	Purdue Improved Crop Storage
ISRA	Institut Sénégalais de Recherche Agricole	PPPs	Public-Private Partnerships
KALRO	Kenya Agricultural and Livestock Research Institute	PRA	Participatory Rural Appraisal
KEPHIS	Kenya Plant Health Inspection Services	ProGRA	Program for a Green Revolution in Africa
KNUST	Kwame Nkrumah University of Science and Technology	PSCL	Pearl Seed Company Limited
MALIMARK	Mali Agricultural Market Trust	RCDC	Rochdale Cooperative Development Consult Plc
M&E	Monitoring and Evaluation	RFLP	Restriction Fragment Length Polymorphism
MIRA	Micro-Reforms for African Agribusiness	RUFORUM	Regional Universities Forum
MLN	Maize Lethal Necrosis	RUMARK	Rural Market Development Trust
MT	Metric Ton	SAA	Sasakawa Africa Association
NAT	Nutri-Aid Trust	SADC	Southern African Development Community
NaCRRI	National Crops Resources Research Institute	SARI	Savannah Agricultural Research Institute
NAFSN	New Alliance for Food Security and Nutrition	SARS	Sotuba Agricultural Research Station
NARI	National Agricultural Research Institute	SCARDA	Strengthening Capacity for Agricultural Research in Africa
NARO	National Agricultural Research Organization	SEMI	Seed Enterprise Management Institute
NARS	National Agricultural Research Systems	SEPA	Seed Production for Africa
NCRI	National Cereals Research Institute	SLARI	Sierra Leone Agriculture Research Institute
		SMEs	Small and Medium Enterprises
		SROs	Sub-regional Research Organizations

SSTP	Scaling Seeds Technologies Partnership	VBA	Village-Based Agricultural Advisors
TEEAL	The Essential Electronic Agricultural Library	VCU	Value in Cultivation and Use
UEMOA	West Africa Economic and Monetary Union	WAAIF	West Africa Agricultural Investment Fund
UNADA	Uganda National Agro-input Dealers Association	WAAPP	West African Agricultural Productivity Program
UNESCO	United Nations Educational, Scientific and Cultural Organization	WACCI	West African Centre for Crop Improvement
USAID	United States Agency for International Development	WECARD	West and Central African Council for Agricultural Research and Development
USD	United States Dollar	ZMW	Zambian Kwacha



1 The Vision

Joe DeVries¹

Africa's farmers are smart, hard-working people. While their energy, focus and intelligence are too often masked by poverty, they are in reality members of a highly-specialized profession with a deep knowledge of soils, weather patterns, market dynamics and other factors on which the lives of their families depends.

As Africa's population has grown, the pressure on local farmers to meet both the nutritional needs of their families and demand from local markets has increased dramatically. The populations of most African countries have more than quadrupled over the past five decades, creating a need for ever-greater supplies of staple foods. It is a scenario which calls for urgent action, focused on ensuring that Africa's farmers have the best technologies and the best marketing opportunities possible in order to maximize their output. Yet, due to a collective failure to deliver these, Africa's farmers have continued to struggle, mostly depending on the same methods used by their parents, grandparents, and countless generations before them. As a result, hunger and poverty have become rampant, the continent's grain imports have soared, and the quality of life enjoyed by farmers has changed little. While much of the rest of the developing world has gone on to enjoy the benefits of the IT revolution, owning a car and household appliances, Africa's farmers have remained mired in poverty, unsure of whether they will be able to provide tomorrow's food, a decent education for their children, or medicines to heal their illnesses.

The main limiting factor in this scenario is not a lack of capability. Nor is it a lack of drive among smallholder farmers to increase their yields. Nor is it a preference for traditional methods. It is not even the lack of government extension support.

It is the seed.

To put it more precisely, the main limiting factor in agricultural productivity growth in Africa has historically been a failure to provide Africa's farmers access to higher-yielding seed, without which little else done to assist them can have much effect. Because in all crop production systems it is primarily the seed that sets the upper limit on what farmers can achieve.

Throughout history and around the world, the intensification of local farms and national food supply systems has been catalyzed by the introduction and distribution of seed of improved, higher-yielding crop varieties. While traditional crop varieties embody a number of traits that allow them to grow reliably under local conditions, they also, with few exceptions, embody very low yield potential, usually leveling off at less than two metric tons per hectare.² They likewise lack the ability to respond to most improved crop management practices such as irrigation and the application of fertilizers. This is why a farmer in Africa who plants seed of a centuries-old landrace variety with fertilizer and irrigation still fails to achieve much yield increase, and may even lose money due to the low return on investment that is common to such landraces.

¹ Vice President, Program Development and Innovation, AGRA

² All references to tons in this publication indicate metric tons; i.e. 1,000 kilograms. The spelling 'tonnes' is not used.

The most urgent priority for African agriculture, then, according to the authors of this book, is simple: Africa's governments, donor agencies, and all concerned groups need to work together to ensure that Africa's farmers have access to the seed that can, and eventually will, enable them to become the efficient, productive suppliers of food that they can be.

Historical context

Modern crop varieties are bred for a range of improvements, including maximum response to inputs and crop management, high yield, resistance to locally important pests and diseases, and adaptation to local growing conditions. In the 1930s in the United States, a new era of productive farming, mechanization, and grain exports was set in motion by the introduction of seed of higher-yielding hybrid maize. In Latin America and the Indian Subcontinent, short-stemmed, disease-resistant wheat varieties bred by Norman Borlaug and his team in Mexico in the 1950s sparked a Green Revolution that earned him the Nobel Peace Prize. Soon thereafter, high-yielding varieties of rice developed by scientists at the International Rice Research Institute in the Philippines liberated hundreds of millions of Asians from hunger.

For decades following the Green Revolutions in maize, wheat and rice in other regions of the world, conventional wisdom held that in Africa the challenge was different. Africa's soils were too poor and washed-out to produce bumper harvests even with improved varieties, it was said, and in any case African farmers were not interested in new technologies. Emphasis was instead placed on natural resource management, public extension systems, the building of roads, and the forming of farmer cooperatives and NGOs.

Yet despite these investments, average crop yields in Africa barely budged, and in many cases declined.

In the late 1990s, The Rockefeller Foundation commissioned an informal study aimed at providing clues to a simple, basic question: *Why has there been no Green Revolution in Africa?* Why, despite the expenditure of billions of dollars on agricultural research, extension and rural infrastructure, were the vast majority of Africa's farmers continuing to harvest less than one metric ton per hectare, and as a result living in impoverished, subsistence conditions?

The study's implementers traveled from country to country, holding conversations with people working in various fields of agriculture, asking them why, in their view, yields on local farms continued to lag far behind those of farmers elsewhere in the world.

Unexpectedly, most conversations soon turned to the chronic lack of seed of higher-yielding, locally adapted crop varieties as the one missing element that could motivate farmers to invest in their crops to achieve bigger harvests. While a number of breeding efforts had produced good varieties, these were far too few. And even in countries where improved varieties were available, seed supply at village level was lacking. Crop genetic improvement in Africa at the time was mostly limited to the efforts of a few breeders working at stations belonging to the various centers of the Consultative Group on International Agricultural Research (CGIAR) in Mali, Nigeria, Zimbabwe, and a few other locations. These scientists would routinely send samples of improved varieties for testing at national research stations around the continent, but the official release of new varieties were rare events, and production and distribution of seed of these varieties was very limited.

A second key observation made by the study was that African cropping systems, in contrast to Asia's and Latin America's, were extremely diverse, divided into many small, rain-fed agro-ecologies which were planted to a wide range of crops. Each of these ecologies imposed a different mix of limitations on crop growth. The conclusion reached was that seed supply in Africa needed a decentralized, more locally-driven approach. Centralized, top-down supply schemes were unlikely to serve most farmers' needs. Given the regularity with which Africa's public seed schemes had already collapsed into "white elephant" status it seemed clear that a new approach was needed, one that could be locally maintained, and remained in close communication with farmers.

In retrospect, the pinpointing of breeding and seed as the root cause of low yields in Africa now seems logical. Seed contains the DNA (the genetic blueprint) for the form and growth pattern a crop will eventually display (tall or short, early- or late-maturing, many or few grain-bearing tillers) and determines whether it will resist impediments to growth such as heat, pests, diseases, drought, or floods, or succumb to them. Moreover, the combined work of plant breeders and seed suppliers, though time-consuming and complex, had previously been proven to be effective in improving the productivity of farmers.

Still, the suggestion that a narrow focus on improving seed supply could improve food security broadly across Africa sounded radical to many. Hadn't breeding been tried in Africa – and hadn't it failed – to deliver the expected results? Even if many new varieties were bred, how could they possibly be delivered to farmers? Plant breeders working at public breeding stations are, at best, able to produce only a few tons of seed per year, yet even a medium-sized African country requires many thousands of tons of healthy seed

to be delivered on-time to farmers every year. To achieve change on a large scale Africa's farmers need access to hundreds of thousands of tons of quality seed every season. Many people also doubted that African smallholders would go to shops to buy the new seed. Africa's farmers, it was said, were far too impoverished and tradition-bound to exchange precious cash to buy new, unknown seeds.

Equally important, the research teams needed to conduct modern crop breeding were absent in many African countries. In others, qualified researchers were present but unable to conduct basic breeding activities for lack of funding. And in almost none of the countries visited was there a functioning breeding program linked to a seed delivery system that could operate at scale, delivering fresh seed of higher-yielding varieties to farmers on a year-in, year-out basis, as is the case throughout the rest of the world.

In a book entitled *Securing the Harvest* (DeVries & Toennissen 2001), the study's principals proposed a radical new approach to attaining higher crop yields in Africa. The primary constraint, they stated, was a lack of seed of improved, locally adapted crop varieties. It would be necessary, they contended, to train large numbers of crop breeders and technical staff, and then to fund them to conduct the breeding of higher-yielding, locally-adapted varieties of Africa's major food crops. They also argued that it would be necessary to create a private and competitive African seed industry that could deliver the seed of these new varieties to farmers on an ongoing basis. This latter proposal was controversial because previous Green Revolutions elsewhere had been led by public seed delivery, and seed supply in Africa up to that point had likewise been dominated by government parastatals that often acted as

monopolies. But the world had changed since those days, the authors argued, and government coffers were mostly empty. Moreover, maize, and more precisely *hybrid* maize, looked poised to be Africa's principal Green Revolution crop, and the seed of hybrid maize could only be produced and delivered through private seed systems. Farmers, they asserted, know a good thing when they see it, and they would do the rest.

A competitive grants program was established and managed from The Rockefeller Foundation's offices in Nairobi, with support and oversight from its headquarters in New York. The program had a three-pronged approach:

- 1) Fund programs aimed at breeding higher-yielding, locally adapted varieties of Africa's staple food crops (including maize, beans, cowpea, rice, sorghum, millet, cassava, sweet potato, soybean, and others);
- 2) Train a new generation of plant breeders to join the ranks of those already employed; and

- 3) Link these breeding groups to emerging seed companies in several East African countries in order to get large amounts of seed of the best varieties to farmers.

From the outset, the program faced major hurdles. Crop breeding is notoriously slow to deliver results, and many national-level breeding programs literally had to start from scratch. Moreover, years of neglect of national agricultural research institutes meant that the infrastructure available to breeders was dilapidated and out of use. Local seed companies that could multiply, harvest, clean, package, and market the seed of new varieties were few and far between, and even when present were often led by inexperienced, first-generation entrepreneurs. As a result, few farmers had ever tried new seed on their farms, and building awareness of the benefits of improved varieties was a labor-intensive, farm-by-farm process. Finally, The Rockefeller Foundation itself, despite its far-reaching ambitions, had limited resources.



Breeding of improved, adapted crop varieties, as conducted through this rice breeding program led by Fousseyni Cisse in Mali, contributed to breakthroughs in farmer demand for improved seed across the PASS program area.

Nevertheless, there was cause for hope:

A new generation of disease-resistant, hybrid maize varieties developed by Dr. Jane Ininda of the Kenya Agricultural Research Institute and CIMMYT for the mid-altitude ecologies of Kenya had begun to reach the market and quickly gained popularity with farmers. Rain-fed rice varieties developed by Dr. Monty Jones of the Africa Rice Center had found a niche in Uganda, and were marketed widely by a few local seed companies. And climbing beans with resistance to root diseases developed by Augustine Musoni of the Rwanda Agriculture Board and CIAT had become highly popular with Rwandan farmers, and were quickly replacing older land races. The first generation of graduates in plant breeding from a PhD training program at the University of Kwa-Zulu Natal in South Africa began filtering back to their posts brimming with confidence and determination to succeed as developers of new plant types that were both higher-yielding and locally adapted.

Equally important, several local entrepreneurs showed promise as seed company owners, and were soon joined by new entrants into the market. Meanwhile, also working with Rockefeller Foundation support, private input supply specialists began to fan out across the countryside, training and financing new inputs shop owners and linking them to suppliers. Everywhere, the small investments made by The Rockefeller Foundation were re-doubled by pent-up ambition and the joy that comes with new opportunity. With all these parts now in motion, a new model for catalyzing an African Green Revolution began to take root in the minds of a growing community of practitioners.

Then in late 2005, the Bill and Melinda Gates Foundation announced that it would

establish a major new program focused on ending hunger in Africa and South Asia. In September, officers from both the Rockefeller and Gates Foundations met in London to discuss possibilities for working together in crop breeding and seed supply. That meeting was followed in January 2006 by field visits to Kenya and Malawi that revealed the capability and inventiveness of a new generation of local actors, and during a visit to Nairobi in March, Melinda Gates declared that the Gates Foundation was “on board with this.” By June 2006, a basic framework for the greatly expanded program, which would be called the Program for Africa’s Seed Systems (PASS) and would be implemented by a new organization called the Alliance for a Green Revolution in Africa (AGRA), was agreed upon and detailed planning was initiated.

On September 13, 2006, the New York Times ran an article that read:

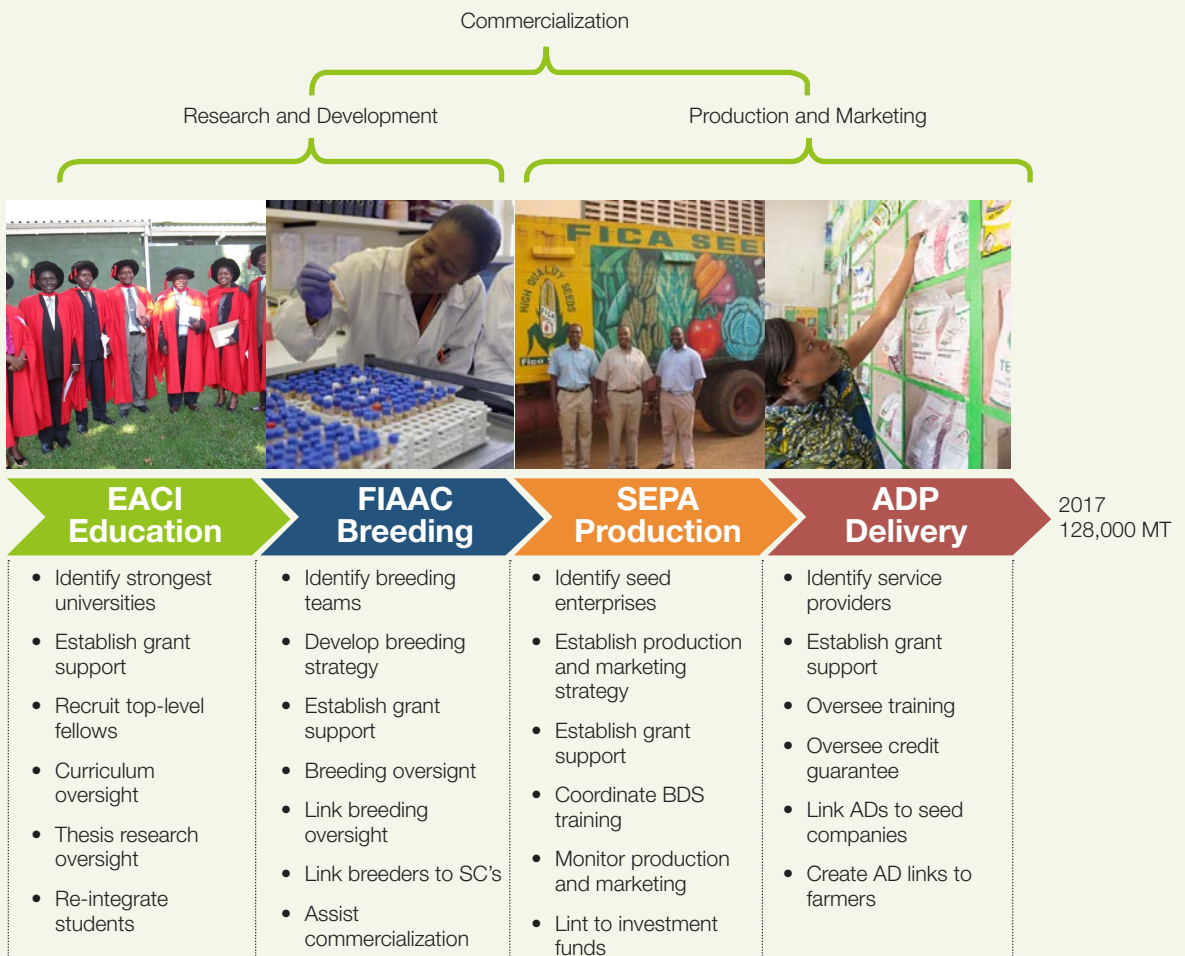
“The two foundations will make an initial investment of USD 150 million - USD 100 million from Gates and USD 50 million from Rockefeller – to increase access to seed that produce higher crop yields. That will entail developing new varieties of seeds, training African crop scientists and retooling seed distribution systems.”

A driving belief behind PASS from the start was that Africa’s farmers wanted, and would purchase, high-quality seed of higher-yielding crop varieties. A second key belief was that African crop breeders were capable of developing those crop varieties using a rich mix of local knowledge, scientific methods, local germplasm, and modern breeding lines available from CGIAR institutes and elsewhere. A third belief was that seed businesses, while demanding and risky, could be effectively managed by local entrepreneurs who had received hands-on

training and who were equipped with vision, some working capital, and links to breeders (for obtaining new varieties) and to agro-dealers (for selling their products). A fourth, less obvious, contention among PASS staff was that they could coax public crop breeders and private seed entrepreneurs into fruitful collaborations that would allow seed markets to grow to scale and result in new, positive benefits for millions of farmers.

The final plan for an initial, 5-year phase of work in 13 countries, budgeted at USD 150 million, was accepted in January 2007, and recruitment of

staff began. Six highly experienced crop scientists and one agricultural economist were hand-picked from around the continent for their proven abilities in the area of breeding and seed systems. PASS began operations on the first day of April 2007, making investments across 13 countries focused on four main themes: 1) educating a new generation of African crop breeders; 2) the breeding and official release of new crop varieties; 3) helping local seed entrepreneurs establish companies; and, 4) building agro-dealer networks to sell improved seed and other inputs to local, smallholder farmers. A diagram depicting the structure of the PASS initiative is shown below.



PASS hit the ground running. Crop breeding strategies proposed by former PhD fellows who had recently graduated and were back in their home stations, were read, critiqued, and funded. Seed entrepreneurs were trained and financed to increase the size of their operations. Included in that first flurry of investments were grants to newly-established local seed businesses. These included:

- Nafaso in Burkina Faso;
- Faso Kaba in Mali;
- Alheri in Niger;
- Seed Project in Nigeria;
- Dryland Seed in Kenya;
- Tansed International in Tanzania; and
- Funwe Farms in Malawi.

PASS engaged several seasoned seed company executives from the US and India to make regular site visits to seed companies throughout the program area. They dispensed practical advice on seed production, seed business management, and seed marketing to the companies' management teams, and reported back to PASS management on the things they were observing. The excitement they showed for what they saw fueled hopes for success.

Further upstream, PASS replenished the student pipeline of its PhD fellowship program, the African Center for Crop Improvement (ACCI) based at the University of KwaZulu Natal, and initiated a new fellowship program at the University of Ghana, known as the West African Centre for Crop Improvement (WACCI). Teams of students and professors, brimming with ideas stimulated by problems confronting farmers around the continent, began formulating scientific procedures to overcome those problems, and got to work.

By the end of its first year the program had invested USD 36.8 million in 11 countries, all aimed at getting better seed to smallholder farmers. In its second year of operation the program invested an additional USD 37.7 million. Most of the recipients of the funding were groups who had never before received support from donors. Very few were based in capital cities.

Soon after, the Howard G. Buffett Foundation joined forces with PASS, eventually allowing the program to be extended into Liberia, Sierra Leone, South Sudan, and DR Congo. In 2013, the United States Agency for International Development agreed to provide USD 47 million to take the supply of seed and other technologies to scale in six countries.

The first sign that PASS was onto something big came from the seed companies. Most of them were selling out all their seed, and unable to meet demand. Many seed companies reported anecdotally of farmers who were lining up outside their warehouses and agro-dealer shops, waiting to purchase their higher-yielding seed. Hence, early on in the program's history the PASS team was confident that their vision was not a mirage. If they helped Africa breed and supply more seed, farmers would use it.

Along the routes traveled by the team to monitor seed activities there was a noticeable difference in the physical appearance of the fields: maize, rice, sorghum, cassava and bean plantings all appeared more productive and better managed. The farmers had responded.

The PASS initiative operated for 10 years and eventually grew to include 18 countries. In all, approximately USD 300 million was expended toward developing sustainable seed supply systems in Africa.

Did PASS succeed? The answer to that question gets us ahead of the story. But taking stock of some of the key indicators:

- Within two years, certified seed production by PASS grantees went from zero to over 12,000 metric tons per year, enough to plant over half a million hectares of farmland. At the end of 10 years, 114 African seed companies were producing over 120,000 tons of certified seed annually.
- After 10 years, public crop breeding teams operating with support from PASS developed and released 600 new crop varieties. Over 400 of these were at some stage of commercialization.
- 493 crop breeders had been enrolled in MSc and PhD fellowship programs and 360 had graduated. The vast majority of these returned to their home countries and are gainfully employed.

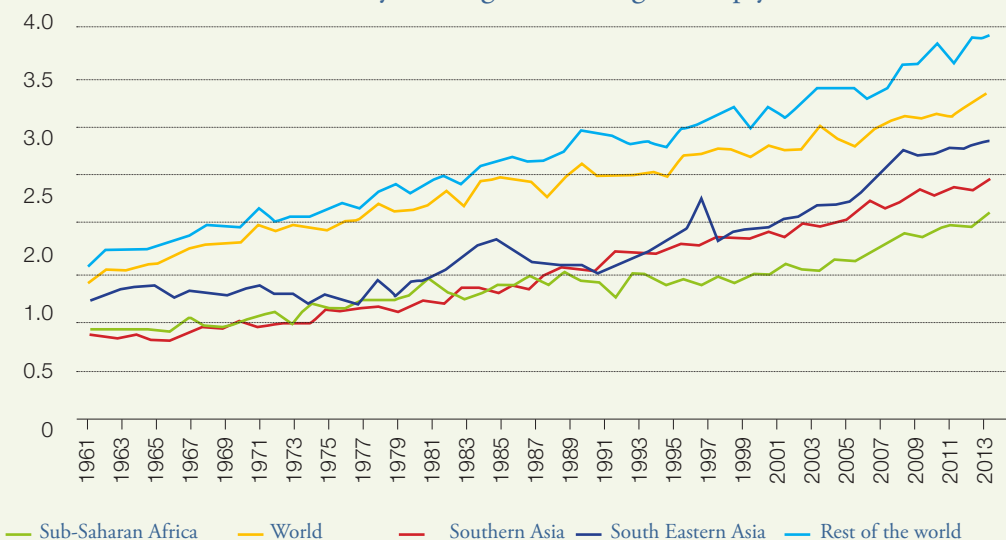
- Approximately 25,000 agro-dealers had been trained and certified for operation as private input suppliers.

Meanwhile, official data show that crop yields in Africa are increasing.

The story of PASS provides a lesson in the power of taking action on big challenges even when the outcome is unclear, even if the questions can't all be answered. Unexpected discoveries that occurred along the way which accelerated progress include:

- The establishment of agro-dealers in villages removed a huge physical barrier that had prevented farmers from using improved seed by making it available in shops open to the public, where farmers could see it, handle it, ask questions about it, and take an informed decision;
- Private, local seed companies that successfully marketed maize seed often went on to expand their range to include seed of improved legumes, sorghum, rice, and other crops;

Africa is finally moving towards higher crop yields



Data source: FAOSTAT downloaded on 18th May, 2017. Average yields for wheat, maize, barley, mixed grain, oats, rice, sorghum, rest of the world include: Oceania, Americas, Europe, northern Africa, western, central and eastern Asia

- Efficient, low-cost modular seed processing equipment manufactured in China had reduced a key barrier to growth;
- The marketing of products in small packages and sharing free samples – common practices aimed at gaining new customers of consumer goods – could as well be applied to seed;
- Electronic libraries, internet access, and many forms of instant communication allowed students of plant breeding to create better crop varieties quicker.

In the years since the beginning of PASS, dramatic changes have not occurred everywhere. The emergence of vibrant, competitive seed sectors has often taken longer than expected. The list of factors that need to be in place is extensive:

- Private-public partnerships to supply seed require understanding from governments and policies that allow for freedom-to-operate by both public breeders and seed companies.
- Nevertheless, private seed companies need to be held to quality standards by an impartial regulatory systems.
- Public breeding teams need funds to allow for continual improvement of existing varieties.
- Private, local seed companies need to be able to access, produce, and market seed of publicly bred varieties.
- The supply of adequate stocks of quality foundation seed is beyond the capabilities of government, and needs to be assured through a combination of public and private suppliers.
- Seed companies need to be allowed to package, brand, and price their seed freely, and sell it directly to farmers.

- Seed companies need access to affordable capital for growth.

In countries where this basic set of conditions has not been met, the impact of PASS has been reduced.

PASS, too, made its own share of blunders. One mistake was in assuming for too long that improved varieties, once bred, would somehow naturally find their way into seed production. But after four years of operation, the program recognized that far too many of the new varieties were still “on the shelf”, awaiting a seed commercialization agent to get them into farmers’ fields. Likewise, the program underestimated the complexities involved in foundation seed supply, and continues to struggle to fill this gap in most countries. In many instances, the program tended to operate in a somewhat insular fashion, failing to build bridges to other, similar efforts that would create opportunities for its collaborators. On the other hand, the work spearheaded by PASS has inspired other investors with an interest in seed systems to support different activities, since seed is now seen as an important area worth investing in, and returns on investments are evident. Even non-traditional investors such as commercial banks are beginning to come on board.

This is the story of a journey deep into the heart of African agriculture and the lives and dreams of Africa’s farmers, African businesspeople, and young, aspiring African agricultural scientists. The authors hope that it will serve as a three-dimensional, full-color depiction of the immense potential of the continent, beginning with its farmers.

Africa’s Green Revolution was never going to be of the “Big Bang” type – its farming environment is too diverse and its political landscape is too varied for that. But across a large portion of the continent, things are now changing.

African agriculture is on the move, powered by access to new seed.



2 Catalyzing Capacity for African Crop Improvement

Rufaro Madakadze¹ and Caroline Adala-Oremo²

The African continent is vast and diverse. Farming conditions range from near-desert ecologies in the northern Sahel to tropical rain forest near the West African coast, where average annual rainfall is more than four meters, to chilly highland plateaus in East Africa with two separate rainy seasons per year. Crop varieties that perform well in one environment might produce nothing in another. Furthermore, African agriculture is nearly all rainfed, with no recourse to irrigation in the short or medium term. This diversity and uncertain conditions have major implications for increasing crop yields across a broad area of the continent. Different crop varieties with higher-yield capability must be bred for each distinct environment, so that the time to maturity of the crop matches the period during which the rains are falling; so that the crop resists locally-prevalent diseases; and so that the crop embodies the taste, texture, and color preferences of local markets. Even if one variety works in several regions, extensive testing must be carried out to verify it.

Rural, isolated farming communities faced with supplying the bulk of their dietary needs through their own harvests have historically cultivated a wide range of crop species which occupy different niches within a single farm. Moreover, men and women by tradition often have responsibilities for the production and marketing of different crops. As such, it rarely suffices to offer farmers only one improved variety of one of the crops they grow.

Offering farmers better options for the crops they grow is the work conducted throughout the world by plant breeders. In most modernized agricultural sectors, the bulk of the seed planted is produced and sold by large seed corporations conducting operations around the globe. But these corporations were absent in most of the 13 countries where PASS commenced operations in 2007, and where they were present, their total sales comprised only a small fraction of the total seed requirement. In seven of these countries, neither private nor public seed companies existed. Hence, if farmers were to ever plant seed of improved crop varieties, breeding had to be initiated within public agricultural research institutes.

Recognizing this critical lack of qualified plant breeders in Africa, PASS conceptualized a training program for plant breeders in 2007. The program built on previous efforts by The Rockefeller Foundation and others over the last few decades of the 20th century. Despite these initiatives, however, fewer than 500 plant breeders were working in the 13 sub-Saharan African countries surveyed by PASS in 2007. Moreover, many of these scientists had been trained overseas on commodities and approaches not always relevant to Africa, and were therefore unable to make much impact in their home countries (Madakadze et al. 2013). The data shown in Table 2.1 include agronomists, plant pathologists and other scientists with plant breeding responsibilities, as well as non-active plant breeders.

1 Program Officer, Capacity Building, AGRA

2 Associate Program Officer, Education & Training, AGRA

The national research systems of Africa therefore needed better-trained staff, with broader and enhanced skills, to ensure that a steady stream of improved varieties with farmer-preferred traits were developed, released, multiplied and made accessible to smallholder farmers. Only by significantly increasing the number of plant breeders could these problems be effectively addressed.

A compilation of Agricultural Science and Technology Indicator (ASTI) data collected by the International Food Policy Research Institute (IFPRI) in sub-Saharan Africa indicated that the share of public sector researchers was less than 30%, most of whom were MSc-level scientists and below (IFPRI 2001 and 2008). More recently, data on the national agricultural research systems (NARS) in East and Southern Africa indicated that NARS were constrained by the low critical mass of

qualified personnel/scientists available to effectively conduct priority research and outreach (Methu et al. 2011) (Table 2.2).

PASS – Addressing the Problem

Realizing this inadequacy, PASS established the Education for African Crop Improvement (EACI) sub-program to train African scientists in plant breeding and other crop improvement disciplines in African institutions. The aim of the initiative was to both increase the number of relevant scientists working in Africa and build institutional capacity to conduct post-graduate and other types of training.

At the time of the inception of PASS in 2007, very few dedicated MSc and PhD training

Table 2.1: Plant breeders at PASS inception by country, 2006

Country	Trained MSc scientists	Trained PhD scientists	Total
Burkina Faso	6	12	18
Ethiopia	144	52	196
Ghana	25	12	37
Kenya	30	53	83
Malawi	15	3	18
Mali	15	7	22
Mozambique	9	2	11
Niger	10	3	13
Nigeria	14	25	39
Rwanda	-	15	15
Tanzania	18	14	32
Uganda	10	9	19
Zambia	-	-	No data

Adapted from PASS Country Studies, 2006.

Table 2.2: Research staffing in ASARECA member NARS, September 2010

Country	Total research staff	PhD holders (% of total)	MSc holders (% of total)	BSc holders (% of total)
Kenya	549	27	52	21
Uganda	270	25	46	29
Tanzania	294	18	56	26
Ethiopia	572	17	41	43
Rwanda	85	7	40	53
Burundi	68	3	72	25
Sudan	614	22	44	34
Madagascar	118	17	67	14
Eritrea	78	1	28	71

Source: Methu et al. 2011: ASARECA.

ASARECA = Association for Strengthening Agricultural Research in Eastern and Central Africa.

programs in plant breeding existed at African universities in sub Saharan Africa. The exception was the African Centre for Crop Improvement (ACCI) at the University of KwaZulu-Natal, initiated by The Rockefeller Foundation in 2002. Most other universities offered MSc degrees in crop science to only one or two students per year who conducted their thesis research in plant breeding or crop improvement. PhD programs had little or no coursework components.

The mission of EACI was to provide PhD and MSc fellowships in breeding and related disciplines and offer short-term training courses to plant breeding technicians and seed company personnel. The technicians were trained on

research methods, practical breeding and research ethics and integrity. Seed company personnel were trained on all aspects of seed business including seed production, processing and storage, business, marketing and enterprise management. Since the EACI intervention, a total of 493 fellowships have been funded at the post-graduate level. In addition, 1,112 seed company personnel have undergone technician and/or short-term training courses (Table 2.3). This has been made possible through partnerships between NARS, CGIAR centers, and the active engagement of other international partners, including Cornell and Iowa State University (Madakadze et al. 2016).

Table 2.3: Total PASS-funded graduates, 2007-2016

Training level	Total funded	Graduated
PhD	152	106
MSc	341	228
Short-term training of seed company personnel and plant breeding technicians	1,112	-

Program Components

PhD training at the African Centre for Crop Improvement and the West African Centre for Crop Improvement

PhD training programs were initiated in two universities in sub-Saharan Africa: The University of KwaZulu-Natal (which already hosted ACCI) and the University of Ghana, which was selected to host the West African Centre for Crop Improvement (WACCI). AGRA took over support for ACCI in 2006, and after assessing several universities in sub-Saharan Africa selected the University of Ghana, which began admitting students in February 2008. At both ACCI and WACCI, funding was provided to hire more academics to teach and supervise students, to increase practical exercises, and to improve infrastructure.

WACCI admits students from West and Central Africa, and thus far has trained students from Burkina Faso, Cameroon, Ghana, Mali, Niger, Nigeria, Senegal and Sierra Leone. ACCI mainly admits students from East and Southern Africa (Ethiopia, Kenya, Malawi, Mozambique, Rwanda, South Africa, South Sudan, Tanzania, Uganda, Zambia and Zimbabwe) with a few outliers (Burkina Faso and Nigeria).

Under the EACI sub-program, both ACCI and WACCI collaborated with Cornell University in curriculum improvement and provision of library services. Professors from Cornell taught some of the more specialized modules, supervised some students, and reviewed student proposals for thesis development (Pell et al. 2010). Also available to the students was the use of Cornell's "The Essential Electronic Agricultural Library (TEEAL)", a collection of journals for agricultural and related sciences, thus broadening the students' knowledge base and research skills.

The ACCI/WACCI model for PhD training comprised one or two years of intensive coursework and thesis proposal development, followed by three years of thesis research, covering a relevant topic in plant genetics and breeding, in the student's home country. The PhD students were mainly recruited from national agricultural research institutes (NARIs) of the 18 PASS focus countries. Most of them returned immediately to their home countries after completing their degrees. A crucial aspect of the fellowships funded by PASS and implemented by the respective universities was that student thesis research had to focus on significant crop improvement-related constraints of important food crops of each student's home country. As such, the three years of breeding research conducted as part of the qualification for a PhD often led to the development of useful, finished crop varieties in the following several years.

The courses taught included a wide range of topics in plant breeding, related plant sciences, management, the conduct of both scientific and social science research, and data collection and analysis. Each student was assigned three supervisors – two from the university and one from their own NARI. In the first year of study, each student worked with their supervisors to develop a thesis proposal that was reviewed and critiqued by the faculty of their respective university, as well as by the plant breeding faculty of Cornell University. Each student's field work was conducted in his/her home country, where they worked with such institutions as the Consultative Group on International Agricultural Research (CGIAR), other universities and gene banks. Although the students mainly worked with local supervisors, the university supervisors also visited the

students at critical stages of research at least twice a year. The students started writing their theses as soon as their data was collected, and many of them published two or three papers before completing their theses.

To accurately focus their research on topics of genuine interest to farmers, PhD students first conducted participatory rural appraisals (PRAs) to determine the farmer-preferred traits of the crop under investigation and, together with farmers, to identify the major priorities to be addressed. The students' breeding objectives were then designed to incorporate the farmers' priorities and preferences. In this way, the adoption levels of the varieties developed could realistically be expected to be high. The next steps – making the varieties available through local seed companies and adopting good

agricultural management techniques – may well trigger the Green Revolution so long awaited in Africa.

After completing their research, the students returned to their universities to complete their theses, working closely with their supervisors.

The training supported by PASS aimed to be highly relevant to farmers' needs by being conducted in local environments, often using local varieties as parental materials in crosses with improved, exotic breeding lines. Another aim was to ensure that students would be able to continue with the breeding activities they initiated during their training long after graduation, eventually resulting in the official release of new varieties. Graduates thus emerged



New models for training of plant breeders in Africa, developed by ACCI at the University of Kwa-Zulu Natal and WACCI at the University of Ghana, combined advanced scientific learning with practical, field-based studies on the genetics and breeding of key traits of African staple crops and led to a new generation of crop breeders capable of developing improved varieties at national level. This cohort included graduates from Zimbabwe, Uganda, Zambia, Tanzania, and Malawi.

from training already fully integrated into the overall agricultural system. Over 70% of the students continued their breeding programs with funding from another PASS sub-program, the Fund for the Improvement and Adoption of African Crops (FIACC). This helped to ensure immediate inclusion of the training germplasm into a breeding pipeline.

PASS has funded 99 PhD students at ACCI and 53 at WACCI. The two institutions had successfully graduated 73 and 35 students, respectively, by March 2017. This unique

model demonstrates that high-quality training in plant breeding can be achieved in Africa. The trained scientists have so far developed and released 136 varieties of a wide range of crops, including maize, rice, sorghum, finger millet, cassava, groundnuts, beans, cowpeas and pigeon peas, of which 89 had been commercialized by March 2017. They have also published over 250 scientific articles in peer-reviewed journals, including *Crop Science* and *Euphytica*, as well as in Africa-based journals, thus contributing to the body of knowledge on these crops.



PASS was committed to training a large number of African plant breeders, especially women, reflecting the dominant role of women in African agriculture. Safiatu Sangare, above, of Mali, was awarded her PhD in plant breeding by studying the genetics and breeding of early-maturing, drought-tolerant maize for the northern Guinea Savana Zone of West Africa.

Achievements of ACCI and WACCI

These two centers set out to develop a world-class PhD course in plant breeding, for the benefit of Africa's farmers. In order to do so, the curriculum had to be unique. No other plant breeding fellowship program had yet been developed within Africa that embodied the best of what was available from the top universities and research institutions. Makerere University in Uganda has since adopted similar approaches.

As of November 2016 there was 100% retention of graduates in Africa. Equally important, the programs proved to be incubators of many new and useful crop varieties. After graduation, students continued the breeding programs to develop improved varieties, rather than simply dumping their thesis research results on the table and walking away, as had been the case for far too long.

The international appeal of the WACCI model became apparent when, in 2009, the Chicago Council on Global Affairs endorsed WACCI in a major publication – *Renewing leadership in the fight against global hunger and poverty* – as a model that could be replicated in Africa and Southeast Asia. WACCI has attracted funding from the Generation Challenge Program, the World Bank, and the Association of African Universities. The governments of Sierra Leone, Liberia, Togo and Senegal, have funded training of their own nationals at WACCI through the West African Agricultural Productivity Program (WAAPP). The Agricultural Research Council of Nigeria has adopted the WACCI model for replication at the Ahmadu Bello University's Centre for Crop and Animal Breeding.

ACCI/WACCI students have started breeding programs for 18 staple food crops, using African germplasm. Crop species include:

- *Cereals*: maize, rice, wheat, sorghum, pearl millet, finger millet, tef
- *Legumes*: dry bean, faba bean, cowpea, pigeon pea, soybean, groundnut
- *Tubers*: sweet potato, potato, cassava
- *Matooke*: banana

In 2002, the total number of senior plant breeders needed in Southern and East Africa was estimated to be about 440. This number was calculated from a premise that one PhD breeder is required per crop per agro-ecology. Given 10 crops and 4 agro-ecologies in 11 countries, the total comes to 440. The 99 breeders trained at ACCI will therefore supply about 23% of the regional needs (Laing 2013, personal communication).

No estimate was made as to how many plant breeders were needed in West Africa, but at the outset of PASS the situation was even more dire than that of Southern and East Africa. Notwithstanding, WACCI did train the first fully qualified maize breeder from Mali and the first sweet potato breeder from Burkina Faso. Clearly, the situation would be far worse without ACCI and WACCI graduates filling critical gaps.

A Sampling of PASS PhD Graduates Working in Their Home Countries

African Centre for Crop Improvement –
University of KwaZulu - Natal

Dr. Jimmy Lamo – Rice breeder, National Crops Resources Research Institute, Uganda

Dr. Lamo graduated from ACCI in April 2010 and is now based at the National Crops Resources Research Institute in Uganda.

Concerned by the arduous process of removing rice florets (emasculation) during plant breeding, Dr. Lamo, guided by his supervisors, Professors Tongoona and Derera of the University of KwaZulu-Natal, developed a device that uses an ordinary household vacuum cleaner to provide suction pressure to remove the anthers in rice flowers. Over the years, rice plant breeders have employed two types of emasculators that use suction force to forcefully pull off the anther from the stigma.

The first emasculator, a prototype, was developed by the International Rice Research Institute (IRRI). The second type, a modification of the IRRI prototype, was made with a view to reducing the cost of the power unit. Dr. Lamo's design is simple, efficient and cost-effective. It has already been adopted by several breeding programs in Ghana, Uganda, Tanzania and South Africa (Lamo et al. 2010). The Lamo model, according to 2008 estimates, costs USD 850, while the IRRI prototype costs USD 2,100, excluding freight.

Dr. Lamo also developed an instrument to test for shattering in rice (Lamo et al. 2011). Shattering causes the rice grains to fall to the ground, making a proper harvest impossible. Timing the harvest to avoid shattering is therefore crucial. Identifying varieties that mature with little or no shattering is equally important because they can remain in the field longer while the grains mature properly with little artificial drying, thus reducing yield loss. The instrument developed by Dr. Lamo will enhance studies on shattering, a trait that has thus far been difficult to quantify.

Dr. Lamo continued the rice breeding program he started during his PhD studies with further funding from AGRA. He has so far developed nine rice varieties for release. The varieties are high-yielding (3.2– 4.0 MT/ha), have good resistance to blast, and are drought-tolerant.

Dr. Amade Mutaliano Muitia – Groundnut breeder, Instituto de Investigação Agrária de Moçambique (IIAM), Nampula, Mozambique

Dr. Muitia's PhD studies at ACCI were funded by AGRA. He works for IIAM, the national agriculture research center. He focused on groundnut breeding for his PhD thesis and graduated in April 2012. Upon completion, he obtained a grant from AGRA to continue breeding groundnuts in northern Mozambique where he is based.

Dr. Muitia was responsible for developing and releasing one improved variety within a year of his graduation. He continues to breed groundnut from his base at the IIAM station in Nampula, and has several other groundnut varieties in the pipeline for release. He works with several seed companies and NGOs to commercialize his variety and ensure that smallholder farmers have access to the varieties he breeds. He also mentors several MSc students from Eduardo Mondlane University.

West African Centre for Crop Improvement – University of Ghana

Dr. Abamadou Issaka – Millet breeder, Institut National de la Recherche Agronomique du Niger (INRAN), Niger

Dr. Issaka was funded by AGRA for his PhD at WACCI in 2008. He graduated in July 2012 and has returned to INRAN where he is now INRAN's principal millet breeder.

Dr. Issaka's thesis topic was the genetics and breeding of downy mildew-resistant pearl millet for Niger. During his thesis research, he conducted a PRA to obtain information from farmers on constraints and traits that needed to be incorporated in new varieties of pearl millet, Niger's staple food crop. The result of his investigation indicated that farmers needed varieties with resistance to downy mildew, head miner and stem borer, tolerance to seedling-destructive rainstorms and drought, as well as the preferred traits of high grain yield, good taste and early maturity.

He developed cytoplasmic male sterile (CMS) lines to produce the first F₁ hybrid pearl millet

varieties in Africa. Hybrid millet is common in Asia and North America but virtually non-existent in Africa. Currently, Dr. Issaka has secured four different grants for research:

- A 3-year grant to reduce the risk of crop failure for poor farmers through enhancing traditional seed systems in Sahelian West Africa;
- A grant to bring the benefits of heterosis to smallholder sorghum and pearl millet farmers; and
- A grant to develop top cross pearl millet hybrids in Niger.

Dr. Beatrice Ife – Maize breeder, Nigeria

Dr. Ife was funded by AGRA to conduct her PhD at WACCI. She graduated in July 2014 and was immediately awarded a lectureship position at WACCI and placed in charge of the maize breeding program.

Working on *Striga* and low soil nitrogen in maize inbred lines, Dr. Ife conducted her thesis research at the International Institute of Tropical Agriculture (IITA) under the supervision of Dr. Badu Apraku. Aware that *Striga* and low N are the most important constraints to maize production and productivity in West Africa, she developed inbred lines with superior positive male (GCAM) and female (GCAF) effects for grain yield under *Striga* infestation. These inbreds will serve as an important resource for breeders and the scientific community for the genetic improvement of germplasm for *Striga* resistance. Dr. Ife identified two F₁ hybrid

lines as the most stable and high yielding for extensive testing and promotion for adoption and commercialization. The hybrids remain in Dr. Badu Apraku's maize breeding program at IITA and are being evaluated for possible release. This initiative will contribute significantly to improved maize productivity and food security in the sub-region.

Dr. Stanley Nkalubo – Bean breeder, Uganda

Dr. Nkalubo is a Plant Breeder employed by the National Agricultural Research Organization (NARO) and is based at the National Crops Resources Research Institute (NaCRRI) in Namulonge. He was awarded a scholarship by the African Centre for Crop Improvement (ACCI) to pursue a PhD in plant breeding at the University of Kwazulu-Natal-South Africa. The ACCI was established with funding from the Rockefeller foundation, and AGRA funded the center from 2007. Stanley's research work on bean anthracnose led to the production of over 400 beans lines that had varying levels of resistance to the disease. After obtaining his PhD, he applied for and won two consecutive three-year projects (2007-2013) from AGRA to breed and popularize anthracnose disease-resistant beans in Uganda.

Through a participatory variety selection technique, he advanced his bean lines and initially released two new early-maturing, anthracnose-resistant, and high-yielding bean varieties, NABE 15 and NABE 16, in

April 2010. He has since released seven other varieties suitable for many agro-ecologies in Uganda.

Stanley worked with farmer groups, seed businesses, schools, NGOs and government agricultural institutions [such as the National Agricultural Advisory Services (NAADS)] to produce seed of the released varieties. Together with the Uganda National Bean Development Program staff, he initiated a campaign to equip farming communities with knowledge on seed production and marketing techniques. He also undertook training in these communities in four major aspects of bean seed production, including: a) bean variety description and maintenance of genetic purity; b) agronomic practices of bean seed production; c) group dynamics/management; and d) record keeping.

The demand for the nine improved varieties (NABE 15 through NABE 23) has tremendously increased throughout the country because they mature early, produce high yields, are resistant to various diseases, and have qualities preferred by consumers. To date, the project has managed to directly reach over 20,508 farmers, of which over 60% are women in 19 districts and 56 sub counties. By working with Ugandan seed companies, NGOs and the NAADS program, bean varieties developed by Dr. Nkalubo have reached about 30% of all bean growers in Uganda. This has been achieved using farmer groups, working with individual farmers, and forming partnerships with

other projects (such as the “*Utilization of Bean Innovations for Food Security and Improved Livelihoods in Eastern and Central Africa*”, funded by ASERECA). Delivery has also been facilitated through a seed distribution mechanism of the Tropical Legume II (TLII) seed systems project funded by ECABREN. In addition, Stanley has managed to engage seed companies to produce and market some of the released varieties, and as a result the new bean varieties NABE 15, NABE 16 and NABE 17 are now being provided by these seed companies. Also, due to the early maturing ability of these new varieties, international NGOs have seen the advantage of growing them in areas that have limited rainfall, such as Karamoja, and they are requesting tons of seed.

Dr. Mamadou Mory Coulibaly – Maize breeder, Institut d’Economie Rurale (IER), Mali

Mory was funded by AGRA for his PhD at WACCI and is the first PhD maize breeder in Mali. He popularized a maize hybrid called Tieba. Tieba is early maturing (100-105 days), high yielding (7-8 MT/ha), drought tolerant, and otherwise well adapted to growing conditions in the country. Dr. Mamadou Mory Coulibaly is currently serving as the project manager

of a project aimed at the development of intermediate and early maturity maize hybrids tolerant to drought and *Striga* in Mali (USD 191,800 in funding). With this grant he developed and released three hybrids and two open pollinated maize varieties by July 2016 for various agro-ecologies in Mali. He is also responsible for complementary breeding activities of the DTMA Project, as well as the production of breeder and pre-basic seed activities for the country that are supported by another small research grant.



Dr. Mamadou Coulibaly conducting his PhD thesis research at IER in Mali.

Unique Discoveries: Technologies and Findings from Students' Research

Dr. Koussao Some – Sweet potato breeder, Burkina Faso

Dr. Some, a WACCI-trained plant breeder, has taken sweet potato breeding to the next level. Currently a plant breeder with the *Institut de l'environnement et de Recherches Agricoles* (INERA), Burkina Faso's national agriculture research center, Some's main focus is on sweet potato. The potential of this crop to address food security, malnutrition and poverty has long been recognized, and varieties that combine yield and quality in Burkina Faso have been developed. Farmers' production constraints and trait preferences were first gathered in a participatory rural appraisal and the varieties developed with these traits will be the first developed in Burkina Faso. Recognized for his accomplishments, Some has been appointed as a representative of West Africa for the African Potato Association (APA). He has been awarded a three-year grant (August 2014 to July 2017) by AGRA to fund his research project on farmer-focused participatory breeding of orange-fleshed sweet potato adapted to the Savannah and Sahelian environments of Burkina Faso. Some is also the principal investigator of a sub-regional project entitled *Jumpstarting orange-fleshed sweet potato in West Africa through diversified markets*, which is being implemented in Ghana and Nigeria, as well as Burkina Faso. This groundbreaking project is funded by the Bill and Melinda Gates Foundation for three years (April 2014 to March 2017). Dr. Some also trains MSc students at the University of Ouagadougou and extension workers on sweet potato production in the country.

Dr. Joseph Kamau – Cassava and sweet potato breeder, Kenya

Dr. Joseph Kamau was funded by the Rockefeller Foundation to obtain his PhD in plant breeding at the ACCI. He graduated in April 2008 and was funded by AGRA to continue the breeding program. He developed novel clones of cassava that are ready to harvest in 9-12 months, compared to the two years required by popular landraces (Kamau et al. 2010). This development effectively doubled the yield of cassava in the semi-arid regions of Kenya. Kamau released nine cassava varieties and four sweet potato varieties, which he worked with farmer groups to popularize. These varieties were also tested by farmers for taste and cooking performance, helping to ensure adoption by the farmers. Formerly with the Kenya Agricultural Research Institute (KARI) at Katumani, Kamau now works with Kenya's Ministry of Agriculture.

Dr. Geoffrey Kananji – Bean breeder, Malawi

Dr. Kananji was funded by the Rockefeller Foundation to pursue his PhD at ACCI, from which he graduated in April 2008. He discovered new genes for bruchid resistance in bean landraces in Malawi that had never been previously documented. These genes can provide complete protection for harvested beans from storage pests, where post-harvest losses are typically 40-70%. Kananji is responsible for the release of seven bean and two pigeon pea varieties tolerant not only to bruchid but also most of the leaf spot diseases affecting these crops. Previously employed by Chitedze Research Station, he is now AGRA's Scaling Seeds Technologies Partnership (SSTP) representative in Malawi.

Dr. Frank Kagoda – Maize breeder, Uganda

Dr. Kagoda, a Ugandan national, was funded by AGRA to obtain his PhD in plant breeding from ACCI. He developed a new technique to quickly culture the nematode genus *Pratylenchus* (using carrots) as part of his PhD thesis. This groundbreaking research will facilitate studies on breeding for resistance to nematodes in maize and other crops (Kagoda et al. 2011). Kagoda is now breeding mid-altitude maize varieties for Uganda's National Agricultural Research Organization (NARO).

Dr. Jean Baptiste Tignegre – Cowpea breeder, Burkina Faso

Dr. Tignegre, who was funded by the Rockefeller Foundation, received his PhD from ACCI in 2010. In his thesis, he reported the discovery of new genes for resistance to *Striga gesneroides* in cowpea in Burkina Faso (Tignegre et al. 2013). After graduation, he was funded by AGRA to continue the cowpea breeding program he started during his PhD research, during which he developed four *Striga*-resistant cowpea varieties adapted to the Sahel. All four have been released and are grown by farmers all over Burkina Faso. Formerly with INERA at Kamboinse, Tignegre now works with the Asian Vegetable Research Development Center (AVRDC) in West Africa.

Dr. Kiddo Mtunda – Cassava breeder, Tanzania

The first Tanzanian student to receive a PhD from ACCI, Dr. Mtunda graduated in April 2010. Her studies were supported by the Rockefeller Foundation. Dr. Mtunda was funded by AGRA to continue the cassava breeding program to develop varieties for Tanzania that combined earliness (9-12 months to harvest), complete resistance to both cassava mosaic disease and cassava brown streak virus, and good taste and cooking performance. Four varieties resistant to Cassava Mosaic Virus and Cassava Brown Streak Disease were released and are in the process of commercialization. She now works at the Sugarcane Research Station at Kibaha, where she continues her breeding program with funding from AGRA.

MSc Training in Plant Breeding and Other Plant Sciences

The second mandate of EACI was to roll out MSc training programs in several universities in sub-Saharan Africa. The initial training target of 170 students was surpassed. Since its inception, MSc training programs were established in 13 universities, all of them in sub-Saharan Africa:

- Eduardo Mondlane University (Mozambique)
- Lilongwe University of Agriculture and Natural Resources (Malawi)
- University of Zambia
- Sokoine University of Agriculture (Tanzania)
- University of Nairobi (Kenya)
- Makerere University (Uganda)
- Haramaya University (Ethiopia)
- University of Ibadan (Nigeria)
- Ahmadu Bello University (Nigeria)
- Kwame Nkrumah University of Science and Technology (KNUST) (Ghana)
- University of Ouagadougou (Burkina Faso)
- Moi University (Kenya) and
- University of Nairobi (Kenya)

Most of the MSc programs were regional, serving two to three countries. The exceptions were Haramaya and Eduardo Mondlane Universities, mainly due to language barriers. Although

lectures are held in English at Haramaya, administrative communication is in Amharic, making it difficult for foreign students to fit in. At Eduardo Mondlane University, lectures and communication are in Portuguese.

Each of the universities was funded for full scholarships, curriculum review, and significant infrastructural improvements.

The infrastructure components, which comprised 30-40% of the grant funds, enabled the institutions to purchase computers, strengthen Internet connectivity, and to refurbish buildings, irrigation equipment and laboratories to enable the programs to function efficiently and to enhance practical work. For example, at Makerere University, the grants enabled the refurbishment of irrigation facilities, tissue culture and biotechnology laboratory blocks, lecture rooms and student accommodation. At the Kwame Nkrumah University of Science and Technology, post-graduate student offices and greenhouses were refurbished with internally generated funds, while new biotechnology and seed science laboratory equipment improved the laboratories. At the University of Ouagadougou, the grants were used to purchase plant genetics laboratory equipment and to refurbish facilities at the Gampela Research Station to enable irrigation in research plots on three hectares for post-graduate student research.

The MSc training programs were very successful and attracted students funded by other donors, governments, and even self-sponsored students, indicating inroads to sustainability of the programs. Table 2.4 shows the number of students funded by AGRA, as well as by others, at three different institutes.

MSc training model

The MSc training programs typically lasted two years, with year one comprising course work and thesis proposal development and year two focused on research and thesis writing. Most of the students (>90%) were attached to national agricultural research stations or CGIAR centers to conduct research, which generally reflected national research program priorities. Largely because their research training lasted for only one year, the MSc students conducted their thesis research in the country where they were enrolled. Also, most of the universities only had one or two plant breeders on their faculties, so attaching students to breeders in the NARS or CGIAR centers increased the number of persons training (and supervising) the students, thus ensuring that they tackled pertinent aspects of the research while learning first-hand how to run a breeding program in a research center.

New and improved MSc degrees in plant breeding

The standards of training in the 13 fellowship programs varied greatly, despite initial attempts to ensure that the curricula were reviewed and relevant. Although the practical exercises in most of the universities were an improvement over non-funded programs, they were still inadequate for supplying the practical hands-on exercises the students needed to be able to work in isolated stations without other plant scientists to help.

Most of the students had never been exposed to the private seed sector and were trained for working in the public sector with no concept of product development or breeding pipelines.

To address this problem, in 2013 PASS introduced a special program funded by the Bill and Melinda Gates Foundation called the Improved MSc in Cultivar Development for Africa (IMCDA). The objective was to train 90 MSc students using new breeding methodologies and equipping them to work in both the public and private sector. This new MSc program was housed in three universities pre-selected as regional centers to cover East, Southern and West Africa: Makerere University in Uganda, University of KwaZulu Natal in South Africa, and KNUST in Ghana.

This represented an enhancement of the previous plant breeding MSc programs at these universities, which targeted the training of public sector plant breeders. The new program undertook to produce breeders trained in cultivar development who could develop improved varieties with farmer-preferred traits using up-to-date technologies. The idea was to equip them to create unique, high-quality product lines that could be easily commercialized, a component not fully covered in the previous curriculum. Certain aspects of the training would be delivered through e-learning, using modules jointly developed with Iowa State University to complement the existing curriculum.

Table 2.4: MSc students trained as of November 2016

Institution	Total funded by AGRA	Graduated	Funded by other donors
KNUST	85	53	Over 40
Makerere University	67	35	Over 30
University of Ouagadougou	23	23	24

MSc Program Success Stories

Kwame Nkrumah University of Science and Technology (KNUST), Ghana

In 2008, KNUST received the first grant from AGRA to train 10 MSc students in plant breeding and seed science and technology. This was followed by other grants leading to the funding of 85 students and the graduation of 53 students by March 2017 (see Table 2.4). The students were recruited from five countries – Ghana, Liberia, Mali, Niger and Sierra Leone. KNUST gave assurance that all the students would complete their degree programs, including examinations, within two years. This is not always possible in most African universities, but KNUST has a very transparent examination process where all internal and external examiners are required to submit thesis marks promptly and to attend the oral theses examinations which are scheduled in advance.

Various governments have appreciated the performance of KNUST graduates because of the high quality of the training the students received. Because of the program's success, KNUST attracted funding from several governments in the sub-region – Gambia, Ghana, Liberia and Sierra Leone all sponsored their nationals for the MSc and MPhil programs with their World Bank facilities within the West African Agricultural Productivity Program (WAAPP). Funding from the Howard G. Buffett Foundation permitted the training of 14 MSc-level plant breeders from Liberia and Sierra Leone. In the 2013/2014 academic year, the Department of Crop and Soil Sciences admitted 60 MSc/MPhil students. AGRA funded 9 of the 19 MSc students in plant breeding and 4 of 9 students in seed science and technology.

Additionally, KNUST forged strong collaborations with the various agricultural research institutions in Ghana – the Crops Research Institute, the Savannah Agricultural Research Institute, and the Ghana Grains and Legumes Development Board.

KNUST graduates have either been employed as research scientists in research institutions, lecturers in universities, joined NGOs and/or are pursuing PhD degree programs. Some are engaged in the private seed sector. One student from Niger, Magagi Abdou, started a seed company called *La Sabelienne de Semences* (Halal) that is growing and producing seeds of millet, sorghum, maize, cowpea, groundnut, sesame and okra. Another student from Sierra Leone, Ernest Kamara, who works for the Sierra Leone Agriculture Research Institute (SLARI), has been mandated by the government to help domestic seed companies produce quality seed.

That the KNUST MSc graduates in plant breeding have to-date published over 20 papers in referred journals highlights the importance and relevance of their research. Moreover, some of the internally generated funds from grants and other donor-generated funds have gone into renovating infrastructure, such as laboratories, staff offices and work spaces for students.

Makerere University, Uganda

In 2008, Makerere University initiated a regional MSc in plant breeding and seed systems. This was done in conjunction with the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and coincided with the first phase of program sponsorships from AGRA for training in plant breeding, along with student sponsorships from the Strengthening Capacity for

Agricultural Research in Africa (SCARDA). The training incorporates partnerships with NARS and CGIAR centers based in Uganda. Results from students' theses are fully utilized in the national research programs because they are embedded in breeding programs, and in some cases the students have the option to take some of their developed lines to their home countries.

Grants received from AGRA have enabled Makerere University to train MSc students from Kenya, Mozambique, Rwanda and South Sudan, as well as Uganda (Table 2.4). At its present strength, 30 students can be successfully trained in one cohort, with additional cohorts starting every other year. These AGRA grants were supplemented by other funders such as SCARDA, ASARECA and RUFORUM.

All Makerere graduates are either working in the agriculture sectors of their countries or pursuing further studies. Two students from Rwanda and two from South Sudan are leading national breeding programs of specific crops. The students have also published more than 20 articles in refereed journals. More than 15 of the students have gone on to PhD programs.



Training seed company managers on how to use and maintain affordable processing machinery and providing links to suppliers made it easier for emerging seed companies to graduate from hand-sorting and other manual operations and scale up the supply of clean seed.

University of Ouagadougou, Burkina Faso: MSc program in plant breeding for the Sahelian region

The low number of plant breeders in the Sahel countries, including Burkina Faso, Mali and Niger, is highlighted in Table 2.1. As long as the human resources available in the important discipline of plant breeding remains overstretched, the quality and scope of work will remain compromised. According to Professor Jean Didier Zongo of the University of Ouagadougou, there should be at least one PhD and three MSc-level plant breeders per country per crop at all times.

In 2009, PASS, through EACI, awarded a grant to the University of Ouagadougou to train eight plant breeders at the MSc level from Burkina Faso, Mali and Niger. To develop a curriculum that addressed the needs of the Sahelian sub-region, the University of Ouagadougou consulted widely with key partners from the region, including NARS and various other universities. When the program commenced, AGRA supported 8 students in cohort one, which had a total of 19 students. A second cohort of 12 students was not funded by AGRA.



The third cohort had 15 students. International research centers and several sub-regional and regional universities were actively involved in teaching, thesis research supervision, and internships.

A unique feature of this program was a 45-day internship with smallholder farmers, seed companies and the national research institutes in the students' respective countries – INERA in Burkina Faso, IER in Mali, and INRAN in Niger – at the end of the first year. This approach allowed students to experience the realities of

working in their chosen profession, solving day-to-day problems, as they pursued their education. This approach was intended to lead to more participatory action research and hence greater uptake of the varieties resulting from the students' research work. Although some course work was undertaken during the second year, the main activity was proposal development, planning for research and the actual research (which was conducted in the student's home country).

Post-graduate Student Training Results, 2007-2017

Figures 2.1 to 2.5 show the total numbers of students enrolled and graduated with time, the number of students funded per country, the gender proportions of the students (Table

2.6 also shows gender data), and the total number of varieties released by the students, highlighting the scale of the sub-program.

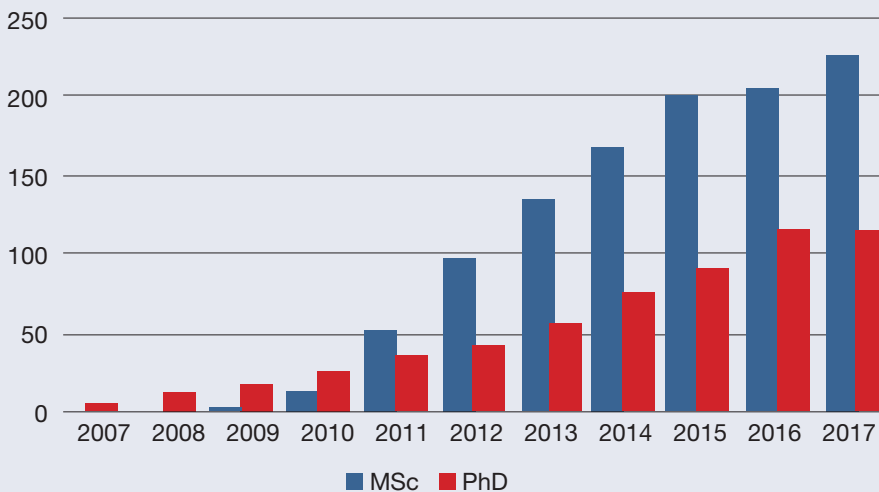


Figure 2.1: Graduated MSc and PhD students, as of March 2017

The initial PhD student graduations are students inherited from Rockefeller funding at ACCI.

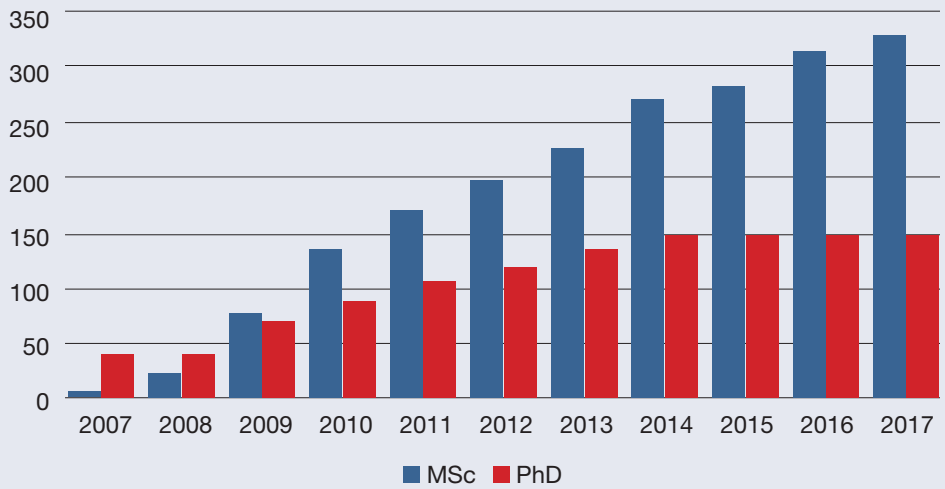


Figure 2.2: Total enrolled students funded by AGRA over time

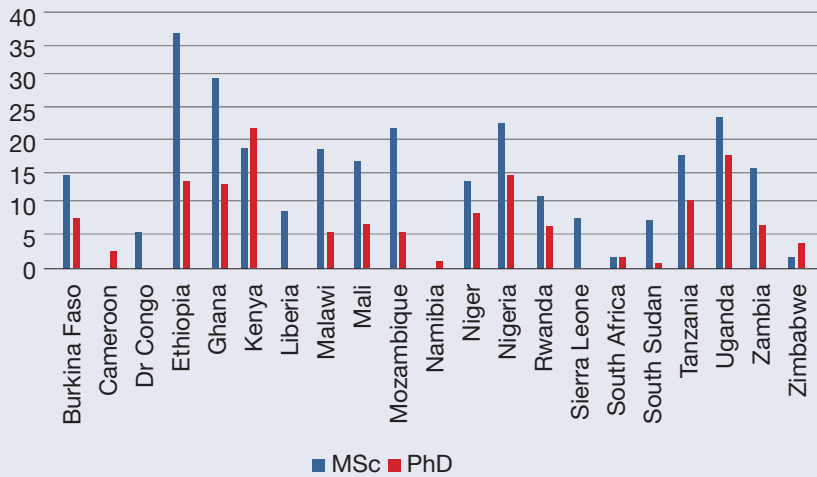


Figure 2.3: MSc and PhD students enrolled, students per country

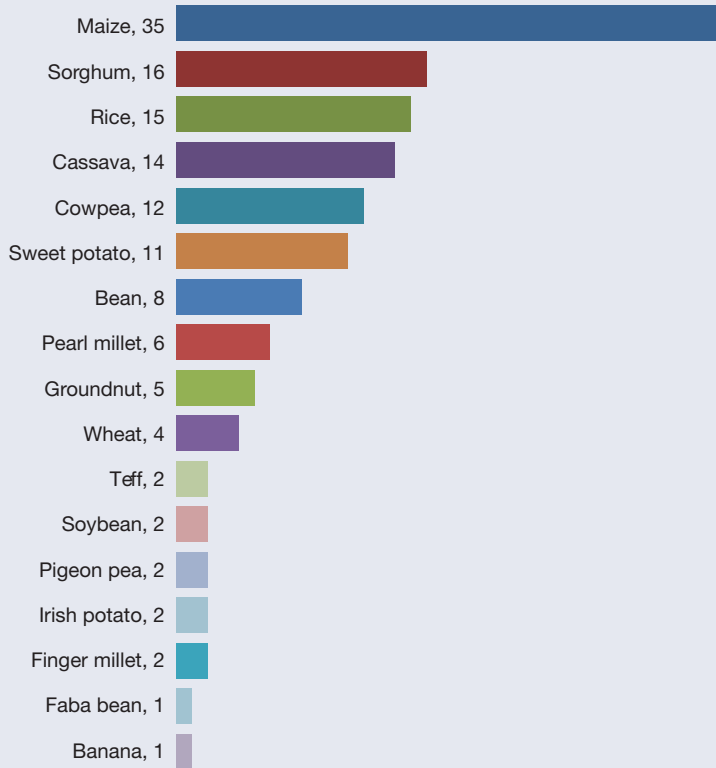


Figure 2.4: Crops that the PhD students worked on for thesis research (students by crops)

Table 2.5: Gender changes in the PhD plant breeding training with PASS support

Time	Females
2002-2006	16
2007 and beyond	30

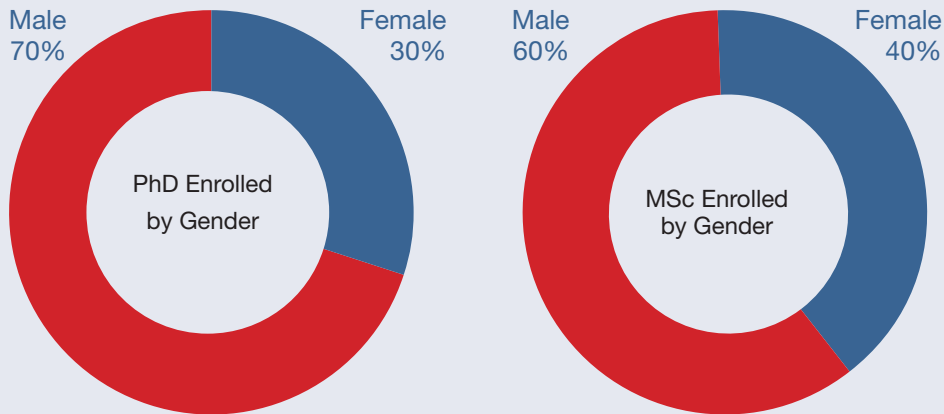


Figure 2.5: PhD and MSc students, by gender

Short-term Training Courses

EACI also supported short-term training courses on relevant crop improvement and seed production and processing to scientists, technicians and other key stakeholders to improve seed systems in Africa.

Seed Enterprise Management Institute University of Nairobi

The Seed Enterprise Management Institute (SEMI) was established in 2010 through funding from PASS to build management capacity within PASS-funded seed companies. This is a collaborative project between the University of Nairobi's College of Agriculture and Veterinary Sciences (CAVS), AGRA, the International Maize and Wheat Improvement Centre (CIMMYT), Iowa State University (ISU), Kenya Plant Health Inspectorate

Services (KEPHIS), the Kenya Agricultural and Livestock Research Institute (KALRO), Kenya Seed Company, several leading agricultural consultants with deep knowledge of the seed industry, and several private, independent, Kenyan seed companies.

With input from these stakeholders, SEMIs developed a series of intensive, 1 to 2-week module courses focusing on the key issues of seed production, seed drying, processing and storage, seed business management, seed marketing, quality assurance and process management. A modern seed processing facility capable of processing a diverse range of crops and a seed laboratory were constructed through this support. A total of 960 seed company personnel from over 100 seed companies in 18 countries were trained through SEMIs by March 2017.

Ecole Nationale Supérieure d'Agriculture (University of Thies)

A West African SEMIs was started in 2015 at the School of Agriculture (ENSA) of the University of Thies to train Francophone seed enterprise personnel using courses like those taught at the University of Nairobi. ENSA admitted participants from five countries – Senegal, Burkina Faso, DR Congo, Mali and Niger – and had trained 84 participants by March 2017.

Training of Agricultural Technicians

Plant breeders rely heavily on support from agricultural technicians who, in most national agricultural research centers, are the day-to-day managers of trials, including responsibility

for data collection. Some of these technicians have not received the required training for their roles, leading to incorrect data collection and analysis and ultimately wasting resources and time. The training of technicians was intended to significantly improve the quality of research and data collection, leading to faster delivery of reliable results. PASS awarded a grant to Uganda's National Crops Resources Research Institute (NaCRRI) and the International Institute of Tropical Agriculture (IITA) at Ibadan, Nigeria, to train technicians from all over sub-Saharan Africa. One hundred and fifty technicians from 17 countries in sub-Saharan Africa working on a wide range of crops were trained.



Midekssa and Pamela practice how to cross sweet potato

Key Impacts of the Training Programs

Through the EACI initiative, the capacity of national agricultural research systems to breed varieties that can be adopted by farmers has significantly improved. Over 490 scientists have been trained with funding from PASS, and in some countries PASS has funded the first-ever plant breeders for specific priority crops that had previously not been included in the breeding agenda. Examples are the first maize breeder for Mali and the first sweet potato breeder for Burkina Faso. A total of 136 varieties of a wide range of crops have been released by former students, and 72% of these varieties have been commercialized. The trained students have changed the work ethics of their local research stations through their persistent engagement with farmers and agro-industries, thus ensuring relevance of research outputs.

All universities that have managed training grants have improved capacity to conduct quality post-graduate training of scientists in African universities. The strengthened collaboration between NARS and universities ensures that the students have hands-on experience not only in breeding but also in breeding management practices and has made universities more relevant to the agriculture sector. NARS programs from Uganda, Kenya, Tanzania and Ghana request for post-graduate students to conduct thesis research with their scientists.

MSc graduates from the program from Liberia, Rwanda, Sierra Leone and South Sudan have gone on to manage national breeding programs of priority crops in their countries.

Networking

Most of the universities have hosted students from two to three countries, thereby fostering networking among students and the ability to share germplasm, experiences, and joint learning. The PhD programs, which include students from more than five countries, will increase this networking by encouraging the creation of an alumni system of AGRA-funded students.

Sustainability of the Training Programs

Some of the students participating in PASS-funded training programs have been able to secure their own funding from diverse sources, including government organizations. This has made the training programs more sustainable. Makerere University, WACCI, KNUST, Sokoine University, and Eduardo Mondlane University have all attracted students funded by governments and other donors. Some of these universities, such as ACCI and the University of KwaZulu-Natal, have significantly increased staff numbers, who in turn contribute to raising funds for student scholarships.

Challenges and Lessons Learned

Even with the successes realized, several challenges remain, ranging from insufficient funding to ensuring on-going effective management of the training programs. Inadequate staff at the universities (most universities had two or less plant breeders as academic staff prior to receiving support from PASS) necessitated having the students work with NARS or CGIAR centers to increase

supervision, as well as benefit from the better infrastructure found in some of the centers. This apparent shortcoming, however, has contributed to much closer liaisons between the universities and the research centers and exposing the students to real working environments. Even when sufficiently trained academic staff are available, it is therefore proposed that joint supervision become an established feature of the PASS programs.

EACI has faced real challenges in attracting women plant breeders. This is in part the result of fewer women studying crop science at the undergraduate level, but the main problem is that even women who do qualify often do not apply for post-graduate training. One reason is that most women headed for post-graduate studies are doing so during their child-bearing years and have young families and are often reluctant to move to another country. To overcome this challenge, PASS has supported the universities to facilitate quarters for families with small children and to provide material support that includes medical coverage, including maternity and child cover.

Attracting funds from donors remains a challenge as institutional funding of projects for infrastructure and equipment are not readily available.

Recommendations and Implications

The actual output from the program so far amounts to less than three plant breeders per priority crop per country. This does not take into account the various agro-ecologies per country. The need remains huge for plant scientists who can provide smallholder farmers with critical technologies for development, such as good quality seed of improved varieties. Governments and the private sector must therefore increase their investment in post-graduate training and short-term training of personnel to ensure an even flow of technologies to improve productivity of smallholder farmers. Finally, universities must plow some of their donor funding and student fees into improving their infrastructure to improve the quality of training.

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3 Crop Improvement for Africa

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Ensuring adequate food supply in Africa is one of the greatest challenges facing the modern world. African agriculture struggles against difficult constraints, such as lack of improved seed for farmers, a lack of support for research and extension, outdated government policies, and poor soils. While Asia realized its Green Revolution during the 1960s and 70s, securing a similar outcome remains a work-in-progress for Africa. Asia's success was partially due to governmental support to agriculture through provision of inputs to farmers and the enactment of new policies, but the greatest driver of the Asian Green Revolution was without question the provision of improved seed to farmers that resulted from breakthroughs in plant breeding leading to more productive wheat and rice varieties. Unfortunately, for several reasons the Asian experience cannot simply be replicated in Africa, including the far greater inherent diversity of Africa's agricultural landscape, its erratic rainfall and lack of irrigated land, its poor soils, and its highly segmented political landscape.

Fund for the Improvement and Adoption of African Crops

The Fund for the Improvement and Adoption of African Crops (FIAAC) was a sub-program of PASS designed to provide support to crop breeding teams to develop and release improved crop varieties. Simultaneously, it created awareness among smallholder farmers and

linked breeding teams to seed delivery systems to ensure that farmers could gain access to seed of new, higher-yielding varieties. Since FIAAC was initiated in 2007, over 600 new crop varieties have been officially registered by breeders funded by PASS.

Between 2007 and 2016, FIAAC developed and administered 162 grants to national breeding programs in 18 countries for important food security crops including chickpea, pigeon pea, rice, maize, sorghum, millet, cowpea, groundnut, cassava, sweet potato, soybean, faba bean, common bean, bread wheat, durum wheat, millet, tef and highland banana. FIAAC worked to ensure that breeding teams have the resources and capability to develop and release new crop varieties, which were subsequently promoted through demonstrations, field days, and distribution of small seed packs.

Agro-ecology-based breeding initiatives are located in appropriate zones in program countries. Breeders conduct their activities on research stations and out-stations and conduct on-farm tests across the agro-ecological zones, consulting with local farmers continuously throughout the testing and selection process. The breeding programs primarily focus on improving yield potential, reduced time to maturity, drought tolerance, and resistance to biotic stresses. These programs strive to continually improve the ability of crops to withstand various environmental conditions, including those associated with global climate change.

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Agro-ecological plant breeding maximizes production by selecting for adaptation in target environments, using local environmental forces to select plants (Ceccarelli and Grando 2007, DeVries and Toenniessen, 2001). By selecting breeding germplasm grown under local conditions, individual cultivars can be optimized for small areas that fit prevailing environmental and weather patterns.

Improving African Crops and Their Adoption

Focusing on African food crops

The African continent embodies a remarkably diverse range of food crops; this diversity is exhibited even within countries. Of course, not all food crops are of equal importance in each country. PASS supported crop breeding programs focused on crops of vital importance to the food security of each country within its program area, including rice, maize, tef, sorghum, wheat, millet, cowpea, groundnut, soybean, faba bean, common pigeonpea, chickpea, cassava, sweet potato, and banana. African farmers frequently plant different varieties of the same crop – such as early-, medium- and late-maturity – for various reasons. A survey conducted in eastern Uganda showed that farmers planted an average of seven different varieties of cowpea on their farms (Orawu 2007). They plant different varieties to fit their diverse needs in terms of use at the household level, or for food security or cultural needs. For example, cowpea is used both as food and fodder. Farmers therefore select early-maturing varieties in order to have food early in the season, and late-maturing varieties to preserve for later use. In the case of roots and tubers, varieties can be stored

underground. In West Africa, farmers plant according to seasonal variations. Women farmers prefer varieties that cook quickly, are tasty and high-yielding. Because such diverse needs cannot be satisfied by exotic varieties, PASS has tailored its breeding strategy to incorporate farmer preferences.

Using local germplasm

Local crop germplasm can sometimes confer special traits for adaptation to various environments, diseases, and pests, in addition to high-quality food value. Ecology-based breeding focuses on capturing local adaptation requirements plus farmers' diverse needs, while at the same time introducing traits such as higher yield potential, disease resistance, and early maturity. Moreover, the use of local germplasm ensures that local genetic diversity is not completely lost as farmers modernize their farming practices. A breeder's vision must span the requirements of farmers and consumers alike by selecting for traits that both groups of users prefer.

Agro-ecological zones

Africa's agro-ecologies range from below sea level [in Mozambique for example, rice is grown below sea level (at -15 masl)] to the highlands of Ethiopia (>2,400 masl), where unique crops like tef and faba bean are grown. The high-altitude areas of Rwanda are suitable for climbing beans, while the mid-altitude areas of Kenya and Ethiopia are well suited to maize. Moreover, African agriculture is primarily rainfed; apart from irrigated rice and horticultural crops, the use of irrigation is rare. While major agro-ecologies are classified as lowland, mid-altitude and highland, each of these include sub-ecologies that are described in terms of their

elevation, latitude, rainfall amounts and patterns, maximum and minimum temperatures, soil types and associated water holding capacity, and prevailing crop and livestock patterns.

Many experiences and lessons learned can be highlighted from ten years of crop breeding by PASS, including those described in the case studies cited below.

Case Studies

Rice in Mali

Fousseyni Cissé is a senior rice breeder at the *Institut d'Economie Rurale* (IER) of Mali. He was an active participant in the Nerica network led by Dr. Monty Jones in the 1990s.⁴ The training he received enabled him to experiment with the interspecific breeding method developed by Jones at his home station in Mali, a landlocked Sahelian country in West Africa that experiences drought frequently. Rice is a staple food in this country of 14 million people. Prior to Fousseyni's intervention, several *Oryza sativa* varieties had been developed for Mali's various ecologies, but they were all susceptible to the major constraints of drought and diseases, and yields were poor.

With PASS support, Cissé is developing interspecific rice varieties for drought tolerance under floating (deep water) and rainfed lowland conditions in Mali. He experimented

with interspecific crosses to develop new and improved rice varieties by combining the high-yielding capacity of *O. sativa* with the resistance of *O. glaberrima* to various stresses, especially drought. The interspecific breeding approach employed by the Africa Rice Center combines conventional and anther culture techniques to overcome the sterility problem frequently encountered when combining the two cultivated rice species, *O. sativa* and *O. glaberrima*. Cissé used only conventional hybridization to overcome the sterility barrier in F₁ generations through successive backcrosses or multi-parental crosses.

The new developed lines combining the superior traits from both parents have been evaluated, with the participation of farmers, under four rice ecologies in Mali, i.e., upland, lowland, deep water, and irrigated conditions.



⁴ Nerica is an abbreviation for 'New Rice for Africa'.

Cissé evaluates new lowland rice varieties at Banguineda, 2007

Promising lines selected by farmers and extension services in the different agro-ecosystems have been evaluated in on-farm trials through participatory varietal selection to identify promising lines for each agro-ecosystem.

In 2010 and 2011, this breeding project released the first 20 local, interspecific hybrids adapted to the various rice agro-ecologies of Mali: DKA-1, DKA-5 and DKA-11 for irrigated rice; DKA-10, DKA-14 and DKA-21 for lowland, non-irrigated rice; and DPA-P2, DKA-P3 and DKA-P16 for rainfed rice. Cissé then worked with farmers/seed multipliers and seed companies to ensure widespread access to seed of the new varieties.

Farmers were thus provided with new adapted rice varieties that combine higher yield potential (over 30% more production compared to local varieties), good grain quality, and drought tolerance. Cissé's project is helping local seed companies by providing technical assistance and foundation seed to ensure farmers adopt new improved rice varieties. Along the way, he has also trained several BSc students while completing his own Master's degree. He is now the head of lowland rice breeding for the Malian government.

Dramane Diabate has adopted DKA-P16, an interspecific hybrid rice

Dramane Diabaté is a farmer from the village of Blendio in the rural commune of Niéna in the Sikasso region in Mali. He was one



of the farmers integrated into participatory variety selection. He has since adopted DKA-P16, one of the interspecific rice varieties developed by Cissé. He has become self-sufficient in rice. With the income he has earned by selling surplus rice grain, he bought a pair of oxen and a plow, and is able to meet his daily expenses.

Groundnut in Uganda

“Groundnut is highly nutritious and a valued crop in Uganda,” says David Kalule Okello. He knows what he’s talking about. In Uganda, groundnut is ground into a paste to make a sauce that is eaten with bananas, locally known as *matoke*, a staple food in Uganda. Groundnuts are also processed into peanut butter or roasted and consumed as a popular snack. The farmer-preferred variety, Acholi White, has a pale color that farmers prefer for making peanut butter because of its taste and ease of shelling. But Acholi White is low-yielding and susceptible to rosette and leaf spot diseases. Another landrace, Igola 1,

is high-yielding with a high oil content and is resistant to rosette disease, but it has a bitter taste. An introduced variety, Serenut 2, has good flavor and is resistant to rosette, but is difficult to shell and process. One can appreciate the difficulty of getting the right product.

This is where PASS and Okello came in. In 2007, Okello received a PASS grant to develop a marketable, high-yielding groundnut variety resistant to both rosette disease and leaf spot that would be accepted by farmers in eastern Uganda. The program focused on improving the local Acholi White variety. Okello involved

farmers in variety development, and used farmers' as well as exotic germplasm as sources of disease resistance.

He initiated crosses between landraces and combined these with exotic sources of rosette and leaf spot resistance. The crosses read like tongue twisters: Acholi White x Igola; Igola x Acholi White; Gwerinut x Serinut 2; and Serinut 2 x Igola. Okello has since developed and released nine varieties that are being commercialized by seed companies throughout Uganda (Table 3.1). Groundnut is serious business in Uganda and groundnut farmers could never thank Okello enough.

Table 3.1. PASS-supported groundnut varieties released in Uganda

Variety	Maturity	Yield (kg/ha)	Year released	Remarks
Serenut 5R	100–110	2500–3000	2010	Virginia, tan-seeded
Serenut 6T	90–100	2500–3000	2010	Spanish, tan-seeded
Bugondo (SGV 99018 - Serenut 7T)	100–110	2500–3700	2011	Virginia, tan-seeded
Achieng (SGV 99019 - Serenut 8R)	100–110	2500–3700	2011	Virginia, red-seeded
Sweetnut (SGV 99044 - Serenut 9T)	100–110	2500–3700	2011	Virginia, tan-seeded
Rosenut (SGV 99024 - Serenut 10R)	100–110	2500–3700	2011	Virginia, red-seeded
Giant (SGV 99031 - Serenut 11T)	100–110	2500–3700	2011	Virginia, tan-seeded
Nasarri Red (SGV 99048 - Serenut 12R)	100–110	2500–3700	2011	Virginia, red-seeded
Ekalam (SGV 99052- Serenut 13T)	100–110	2500–3700	2011	Virginia, tan-seeded
Nakabango 0(SGV 99064 - Serenut 14R)	100–110	2500–3700	2011	Virginia, red-seeded

Striga resistance in the Sahel

Cowpea is a staple food in the Sahel. In the Sahelian and North Sudanian zones, the two highest cowpea-producing areas of Burkina Faso, farmers have ranked infestation by *Striga gesnerioides*, a particularly nasty parasitic weed, along with drought and low yield, as the most important constraints to cowpea production. Yield loss due to *Striga* can reach 90% with moderately resistant cultivars and 100% with susceptible cultivars. But food is only widely acceptable when it is pleasing to the eye and palate, and in Burkina Faso farmers prefer the large, white-colored grain for consumption and for sale.

For this reason, Dr. Jean Baptiste de la Salle Tignegre, a senior research scientist and cowpea breeder at INERA, started a participatory cowpea breeding project with



Farmers and researchers conducting organoleptic tests at Koupela (Dr. de la Salle is on the right taking notes)

support from PASS. A former graduate of the African Centre for Crop Improvement (ACCI), de la Salle demonstrated an aptitude for scientific research as well as an ability to work as part of a team.

The project aimed at breeding *Striga*-resistant cowpea varieties adapted to Burkina Faso farming systems and ecological zones. Four short- to medium-maturing varieties with large, white and smooth-textured grain, as well as resistance to *Striga*, were developed (with farmer participation) and released.

A special session with farmers was also organized to change the scientific names to local names, a move applauded by farmers. The new names were Komcalle (which means “hunger stopper”), Nafi, Tiligre and Gourgou.

The new grain variety is 22-48% larger compared to the most popular improved variety still widely grown by farmers. Nafi matures at 67 days, yields 2 MT/ha, has tolerance for drought, and resists the aphid-borne mosaic virus and *Striga*.

Farmers said that the cowpea variety with larger grain is the characteristic most required for market. A lady from Bik-Baskoure village in Koupela district, central eastern Burkina Faso (140 km from Ouagadougou) says that for the same quantity of the two varieties, the owner of large grain will sell all her stock quickly, go home and carry out other tasks. The small grain owner will sell only after the large grain owner has sold all her stock.

Farmer Participation

The success of the PASS breeding program relies heavily on participatory plant breeding, which involves local farmers in the breeding process to ensure that selections suit their needs (Walker 2008). Involving farmers in all stages of the breeding process is critical to encouraging variety adoption. PASS-supported crop breeding

programs employ a cost-effective approach to select varieties under local environmental conditions. Thus, programs not only address plant traits and maximize yields and stability in a specific environment, but also consider farmers' preferences.

Participatory variety selection of beans in Rwanda...



Participatory variety selection begins with a participatory rural appraisal in which farmers identify constraints to production and their preferences for certain varieties, considering gender preferences, food security, and economic and cultural needs.

Experience has shown that effective selection of bean varieties in Rwanda must involve separate sessions with men and women, with different selection criteria offered for each gender. Women want bean varieties

that mature early and cook in a short time because they need to prepare food for their families. Men choose varieties based on the monetary value, such as higher-yielding varieties. Men and women meet separately because of cultural norms.

The most successful approach has been the use of strings of various colors. Men are invited to the selection field (usually on-farm or at the research station) and tag their preferred variety with green string. Women are separately invited to the same field to tag their preferred variety with red string. This allows the researcher to rank the variety for preferences on vote categories and also rank the most preferred variety by both men and women.

A follow-up meeting provides these farmers the opportunity to explain why they chose the varieties they did. Farmers' opinions and researchers' data are compared to identify the most appropriate varieties. This process led to the release of 28 bean varieties in Rwanda between 2009 and 2013.

... and in Malawi

Farmers participate in a similar process of selecting bean varieties in Malawi. Farmers are invited to participate in variety selection during the whole growth cycle so that they can make a holistic and informed decision on their preferred varieties. Women are responsible for what their families eat, so

like their sisters in Rwanda they choose varieties that are early-maturing, have excellent pod setting ability, have large grain size, an attractive color, and can be used as a vegetable. In this photo, women were invited before the crop was harvested to select their preferred variety (inset) while the crop was still green.



Participatory variety selection of beans in Malawi

Linking Breeding Programs to Seed Producers

Another innovative approach is to link breeders to the commercial seed supply chain. Typically, varieties are bred by public institutions such as NARS, and the private sector seed companies commercialize them. PASS strengthens the link between the breeders and seed companies by bringing them together, conducting joint demonstrations, producing breeder and foundation seed, and sharing information. By strengthening this link, PASS ensures sustainability. This process is described in detail in Chapter 4.



Dr. Geoffrey Kananji, bean breeder, Malawi, explains to CEOs of seed companies the breeder seed production process of bean varieties developed through AGRA support in Malawi

Public-Private Partnerships

Seed companies are important in the seed production chain to multiply and disseminate seed. After Dr. Diallo (right) released the first sorghum hybrid in Mali at the end of 2008, he worked with Faso Kaba, a local private seed company, to commercialize the variety. Mme. Coulibaly Maimouna, the CEO of Faso Kaba (left), admires this high-yielding Sewa sorghum hybrid in a farmer's field.



Creating Awareness of Crop Breeding

PASS used a multi-faceted approach to create awareness and excitement about the benefits of using improved varieties. FIACC creates awareness through demonstrations, field days, farmer participation in varietal selection, distributing small test packs, agricultural shows, and by spreading the word through brochures, radio and television, and short video clips. Where appropriate, these media were translated into local languages. A unique model that has proved effective is the use of village-based advisors and massive demonstrations, as illustrated by the FIPS model (see Box).



Achievements

Over the course of 10 years, PASS strengthened the capacity of local breeders to produce locally adapted, high-yielding crop varieties. PASS supported a critical mass of plant breeders to actively develop higher-yielding crops for farmers in their localities.

Between 2007 and 2016, PASS support spurred rapid development and increased numbers of variety releases each year. As a result, farmers in PASS program countries now have a wider choice of crop varieties to meet their varied needs. As expected, however, not all countries are progressing at the same rate in terms of crop variety development. Assessment criteria have therefore been developed to help countries build robust breeding programs. PASS has even classified levels of breeding programs to identify areas of special intervention for plant breeders.



Technical staff of national agricultural research institutes like IIAM (left) in Mozambique, and NARO (right) in Uganda, were eager to learn basic breeding skills, and played a critical role in the official release of over 600 improved crop varieties.

Farm Inputs Promotion Services (FIPS Africa) Model

The problem of getting yield-enhancing technologies to farmers at scale as quickly and cost-effectively as possible can be achieved by supporting rural youths to establish networks of Village-Based Agricultural Advisors (VBAs). Cost-effective and rapid dissemination requires VBAs to follow five key approaches. First, instead of working with best farmers or groups, the young VBA takes a village approach whereby a farmer from every household in the village should be enabled and encouraged to experiment with the new technology. This eliminates farmer jealousy and lack of self-confidence since every farmer will see for themselves how the technology performs on their own land. This allows a VBA to reach 200 households in a village instead of 20 households in a group, increasing the speed of uptake and reducing cost per household.

Second, the tried and tested small pack approach – developed by FIPS-Africa under previous grants from the Rockefeller Foundation and AGRA – is implemented. This approach understands that farmers want to experiment with new technologies, but have traditionally been unable to do so because of large pack sizes of inputs. Smallholder farmers are highly risk averse, and even if

they have money for new inputs, they will not risk planting their entire half-acre plot to a technology that they have not before seen applied to their own land.

By carrying out demonstrations on small pieces of land and disseminating large numbers of small promotional packs of improved varieties/fertilizer types, FIPS-Africa allows large numbers of small farmers to rapidly experiment on their own land in a way that is risk-free. For example, FIPS-Africa can repackage 1 ton of early maturing bean seed from national research centers into 25 gram packs that are then disseminated to 40,000 smallholder farmers. If farmers like the product, they may harvest two handfuls and save it to replant in the following season.

Third, since the VBAs earn an income from the farmers through their activities, they are motivated to reach as many farmers as possible within a day. This encourages a VBA to reach more households. The cost to FIPS-Africa is also reduced since the farmer is cost-sharing or paying. Additionally, because VBAs will be able to continue providing service and inputs after the initial project, this provides an essential exit strategy to ensure that the African Green Revolution will be achieved in a sustainable way (a key goal for AGRA).

Table 3.2: Some crop breeding interventions and the results

Crop	Country	Intervention	Results
Rice	Mali	Interspecific crosses made by combining the high-yielding capacity of <i>O. sativa</i> species with <i>O. glaberrima</i> resistance to various stresses with emphasis on drought tolerance	22 short-duration modern rice varieties In some locations, these rice varieties have made double cropping in some agro-ecologies possible on land that was previously single cropped Farmers producing more food

Crop	Country	Intervention	Results
Rice	Nigeria	Development and dissemination of high-yielding, drought-tolerant rice varieties for food security and improved livelihoods of Nigerian farmers	3 higher-yielding, stress-tolerant varieties that include farmer preferences for taste, texture, milling, and other properties Community-based and private sector-based initiatives are multiplying and distributing seed
Sorghum	Mali	Local Guinea race sorghum crossed with Caudatum race to increase the productivity of local Guinea sorghums while retaining required adaptive and quality characteristics (photoperiod sensitivity, yield stability, good grain quality) from local Guinea race	7 inter-racial (Guinea x Caudatum-race) hybrids developed locally Yields increased by between 40% and 60% over local Guinea race
Cowpea	Burkina Faso	Farmer-preferred characteristics bred into inferior local cowpea varieties	4 <i>Striga</i> -resistant varieties preferred by farmers: large-sized, white color, smooth-textured grain
Cassava	Ghana	High-yielding and disease-resistant (to cassava mosaic) genes introgressed into farmer-preferred landraces	6 high-yielding, cassava mosaic-resistant varieties released in less than 5 years.
Millet	Mali and Burkina Faso	Male-sterile populations used to develop downy mildew-resistant, top-cross hybrids adapted to the Sahelian zone	5 hybrid varieties resistant to downy mildew and adapted to the Sahelian zone One seed company is producing seed for commercialization
Groundnut	Uganda	Local germplasm introgressed with exotic germplasm to breed for groundnut rosette and leaf spot disease	8 varieties released: easy to shell and process by farmers
Finger millet	Kenya	Local varieties crossed with exotic lines to introgress blast resistance	4 varieties released; early-maturing, brown seed types preferred by farmers; higher yield
Sweet potato	Mozambique	Varieties crossed to improve local germplasm for drought, high dry matter content, virus resistance and high beta-carotene content	15 varieties released with drought and virus resistance and high beta-carotene content that are now widely grown by farmers

Hybrid sorghum puts smiles on farmers' faces

Says Mr. Bourema Sacko, Marako village, Ouélessébougou district, Mali:

Sorghum hybrid Sewa yielded 20 kg more compared to the local variety Sakoika when I planted an area of 100 square meters. This is equivalent to a gain of 2,000 kg/ha. This is surprising! This hybrid variety also tastes better than my local variety. This hybrid is really welcome because just by cultivating a little land area, I am able to feed my family and also sell some for higher income to take care of my financial obligations. Cultivating a small area means that I have reduced labor costs. Another advantage of this hybrid variety is that the fodder is greatly liked by livestock. I feed my animals the stover.

Says Mr. Coulibaly Bourama, Balyani village, Kita district, Mali:

I got 800 kg more from every hectare when I planted the Sewa hybrid. This hybrid variety has helped me solve my family problems. In the next season, I will plant this hybrid in a large area, so I can produce enough grain to feed my family and market the surplus to increase income.

Says Bassirou Samaké, Dialakoroba village, Ouélessébougou district, Mali:

I got more than 1,000 kg/ha yield difference between Sewa hybrid and my two local varieties Sakoika and Toroba. I am not only a farmer but also a trader. I am planning to grow 3 hectares of Sewa hybrid this coming season to feed my family and sell the surplus to invest in my shop and pay school fees for my children.



Reaching farmers with improved crop varieties

Lack of knowledge is probably the main reason farmers are not using new improved varieties. They simply don't know about the varieties or are unaware of their benefits. Variety promotions and demonstrations are critically important if small-scale farmers are to take up the new varieties being developed by plant breeders. Field days and demonstration plots are educational tools to showcase improved varieties and best management practices that can be used to maximize crop productivity.

Field demonstrations are an excellent approach for breeders to introduce their varieties because farmers can easily see and understand differences in performance. A field day, whether on the farm or on research stations, is an organized agricultural event where farmers are invited to view different crop varieties and enhanced agricultural practices.

Local agricultural shows are good opportunities for breeders to showcase improved varieties. One of the most important events for Kenyan farmers is the Agricultural Show of Kenya, an annual event held in each county. It is important for breeders to establish demonstration plots during these events to ensure that farmers and seed companies are exposed to new varieties.



Highland banana is a leading staple food of Uganda. The national banana breeding team, led by Dr. Wilberforce Tushemerweirwe, was the first to develop improved, disease-resistant varieties.



Information and knowledge sharing

Information is shared through breeder networks, meetings, exchange visits, agricultural shows, field trips, travel workshops, mentoring, conferences, training programs, farmer magazines, publications, and papers to peer-reviewed journals.

Breeders' meetings – Breeders' meetings supported by PASS evolved over the course of the initiative. Initially, the meetings were designed as a forum for breeders to exchange information on breeding specific crops, discuss variety release and commercialization issues, and develop action plans. Networks of rice, maize, and cassava breeders each held meetings in 2007. The feedback received from these meetings induced PASS to hold a single meeting of all grantees in 2008. But because of the large number of participants and the high costs of holding separate meetings, PASS decided to call a meeting of a smaller group of breeders leading high-impact programs, and to enhance the meeting by inviting local seed entrepreneurs.

One of the major outcomes of the 2012 meeting was the creation of the concept of the *Modern and Visionary Breeder*, which led to the development of “*The 20 Critical Rules for a Modern Plant Breeder*”. The 2014 meeting adopted the theme *Modernizing Plant Breeding in Africa* to advance plant breeding to the next level.

The 20 Critical Rules for a Modern Plant Breeder

Rule 1: Understand the customers and the environments.

- Establish product profiles based on these needs.
- Set priorities of the breeding program depending on the product profiles and environment.

Rule 2: Assemble relevant germplasm.

- Not all germplasm is useful for successful crop improvement today and therefore a breeder should collect and maintain diverse lines and genotypes with the quality traits desired by farmers.
- The lines could be elite or farmers' landraces that have potential as breeding material.

Rule 3: Be a practical and hands-on breeder/manager.

- Avoid the approach of an armchair scientist.
- Do not avoid going to the field and getting your hands dirty.
- Take a leading role and do not solely depend on technicians. Always lead by example.

Rule 4: Establish a crossing block.

- Regularly generate useful genetic variability by making smart crosses according to your breeding objective and goals.

Rule 5: Regularly conduct yield trials.

- Evaluate sufficient numbers of genotypes to get the desired results depending on your crop of focus. Replicate plots over a range of locations on-station and on-farm.
- Locations should be representative of the area where the new cultivar will be grown.
- Select the best type of experimental design to achieve objectives

Rule 6: Regularly conduct a critical number of demonstrations and on-farm trials.

- Demonstrate the special attributes of new varieties to large numbers of farmers, seed dealers, and other end-users by having large numbers of demonstrations close to them.
- Include checks of local, previously-tested and released varieties.
- Enable sufficient time for farmers to participate in the evaluation.

Rule 7: Work as a team with scientists of other disciplines.

- Recognize the importance of other scientists, such as pathologists, entomologists, and agronomists, and work with them without getting distracted to come out with an all-around product.

Rule 8: Make use of off-season nurseries.

- Rapid progress can be made by making use of off-season nurseries, irrigating during the dry season, and shortening the period from breeding to the release of new varieties.

Rule 9: Breed parents that synchronize well during flowering (for hybrid crops).

- Only release varieties with a maximum of ± 3 days difference in flowering interval between parental lines.

Rule 10: Know and follow procedures for variety release in your country.

- Master all interrelated series of activities from identifying promising lines for further testing to releasing a new variety and making breeder seed available for further multiplication.
- Understand the standards for release of varieties (yield requirements and unique traits).
- Generate the requested, country-specific data required to secure formal release.
- Engage actively with the variety release committees to urge the release of a genotype

Rule 11: Prepare variety descriptors.

- Have ready both general and morphological descriptions of the varieties being released.
- Ensure that the varieties are in the national catalogue.
- Provide assistance to the seed certification inspection staff in identifying the varieties.

Rule 12: Maintain stocks of viable parental lines for all varieties and hybrids.

- Maintain high purity and quality of elite parental lines (nucleus seed) regularly used in the breeding program.
- Ensure good storage conditions and hygiene (temperature, humidity, pest-free) in the storage of parental lines.
- Observe proper isolation distance from sources of pollen or seed that could cause a reduction in genetic purity.

Rule 13: Maintain adequate stocks of breeder seed (for self-pollinated crops).

- Note that breeder seed has the highest level of genetic purity of any class of seed.
- Maintain adequate (at least 50 kg) stocks of pure seed of released varieties and hybrids.
- Store in facilities that maintain high germination. Temperature and humidity control are important when seed is to be stored for more than 1 year.

Rule 14: Know and maintain contacts with seed companies.

- Collaborate and link with private seed companies for production and commercialization of new varieties.
- Work closely with seed companies and share materials for testing with them, particularly those nearing release.
- Teach seed producers and dealers about new skills in production and management practices and develop new concepts of “good seed”.

- Ensure that adequate quantities of pure seed are available at the appropriate time.
- Get feedback on changing farmers' perceptions of desirable plant types and seed traits.
- Have the demonstrations of new varieties in areas where seed companies operate.

Rule 15: Contact seed companies at least 1 year before a variety is released.

- Involve seed companies in variety evaluation
- Plan seed production and demos together, preferably on the seed company farm.
- Know your variety well and be ready to provide feedback to private seed producers with urgency.

Rule 16: Seed increase plots.

- Have and maintain seed increase plots as routine and one season in advance to ensure timely and sufficient quantities for demonstrations, small pack samples, and evaluation on yield trials.

Rule 17: Maintain a good data management system.

- Analyze and maintain good quality data for key traits of experimental results on yield and disease in hot spots, and on-farm data in representative locations.
- Use the best statistical techniques to enable the most rational choices between treatments.

Rule 18: Continue to be willing to learn.

- Get new ideas.
- Enquire and visit other breeders to impart new knowledge.
- Communicate regularly with other breeders, seed companies, variety release committees, etc.

Rule 19: Increase the likelihood that you will make a difference.

- Keep the work on track, and sing out when things go wrong.
- Provide information whether or not what you did made a difference.
- Make adjustments so that you are more likely to make a difference.

Rule 20: Get that first release done! Then work to improve it.

- Promptly release your first variety even if not perfect, as long as it meets the target objective.
- Take advantage of the pre-release of varieties.
- Take this opportunity to increase seed of pre-released varieties and initiate links with seed companies.

Sustainability

Nothing is more frustrating to a scientist with a PhD from a university in the US or Europe, full of knowledge and excitement about returning home to work, only to find that things have been at a standstill. The first shock: You report to your duty station and you are assigned the same office you occupied (if you are lucky to find it vacant). It still has no computer or Internet. You are not assigned a vehicle to visit farmers and you do not have operating funds. The laboratory infrastructure has aged considerably. Yet this is the same institution that sent you for further studies so that on your return you would be able to improve agriculture and to impart this knowledge to other scientists.

Unfortunately, this is the norm rather than the exception in most sub-Saharan African NARS. PASS set out to change all these. Since 2007, PASS has invested in building the research infrastructure in NARS by providing operational funding, refurbishing infrastructure (cold storage facilities, irrigation equipment, vehicles, tractors, computers, small field equipment) in over 100 crop breeding programs. The cost of each breeding program is USD 50,000 per year, generally extending over a period of 6 years during which PASS officers provide technical and moral support to the teams of breeders. These PASS grants ensured that normal breeding operations could be conducted in a timely, efficient manner. The varieties released continue to reach farmers through a public-private model that focuses on continuous and sustainable supply of improved seed. In some counties, such as Kenya and Uganda, this model has advanced to the level where the private sector is presently paying royalties to support the breeding programs. The model is currently being piloted in several other PASS countries, and is well advanced in Ghana.

In Mali, sprinkler irrigation was installed at Sotuba Agricultural Research Station (SARS). This irrigation facility is supplying water to a 10-hectare research field at Sotuba during the dry season and provides supplementary irrigation during drought spells in the rainy season. Also, the irrigation system is helping to produce breeder and foundation seed of various crops to satisfy the needs of local seed companies, farmer associations, and farmers. Breeder and foundation seed is produced under irrigation in the off-season when almost all the usual diseases and insects are absent, thus yielding high-quality seed.

Similarly, the CSIR-Crop Research Institute in Ghana sourced financial assistance from PASS to expand irrigation facilities on the research fields, with the main aim of ensuring continued irrigation of field trials year-round. Thus, sprinkler and drip irrigation systems were installed on the research fields at Fumesua to expand the availability of supplementary irrigation from 6 hectares to 60.



PASS invested heavily in the breeding of improved varieties of pulse crops important to African farmers, including the work led by Rose Wangari of Kenya (left) to develop cowpea varieties resistant to *Alectra*, a parasitic weed.

Lessons Learned and Recommendations

Several lessons learned over the past 10 years deserve to be highlighted, along with some recommended actions.

- The use of local germplasm in breeding programs ensures that the local crop diversity is captured, thus enabling farmers to preserve this diversity.
- Varieties released are not always commercialized and the rate at which farmers adopt them is slow because of a lack of awareness. To overcome this barrier, PASS deployed several commercialization officers to ensure breeders work closely with seed companies, and to conduct more awareness activities.
- Knowledge of farmers' production constraints and their preferences has helped breeders plan for the sustainable use of the available resources. It is therefore important to develop varied uses for the new varieties.



Farmer participation in the breeding and selection of new crop varieties dramatically increased the ability of breeders to meet local needs and preferences. Here, Rose Mongi of Tanzania (second from right) and Jane Ininda of PASS (left) receive feedback from farmers on a series of new bean varieties.

- Bringing together breeders ensured that information and breeding materials are continuously exchanged. Weak breeding programs can be strengthened through mentoring and by providing appropriate genetic material. The breeder network can be enhanced by inviting private seed companies to breeders' meetings. This can result in increased commercialization.
- Breeding programs should incorporate new breeding tools – molecular breeding, double haploids, and new methods of capturing data – to accelerate the genetic gain in the breeding cycle and release more improved varieties.
- African governments generally provide little support to research. However, PASS officers learned that when policy makers are presented with evidence of impact, it is easier to convince them to amend policies and increase support for research. In 2012, Tanzania made a major policy change that allows seed companies to access and multiply breeder seed for commercialization. Such changes can occur only when governments are exposed to ongoing plant breeding activities.
- PASS crop breeding grants were for six years, after which it was expected that governments would recognize their value, and continue to provide support. In this context, governments should implement the Maputo and Malabo Declarations that call for increased allocation of funds to agriculture and agricultural research.

Emerging Initiatives

PASS was expanded to post-conflict countries – the Democratic Republic of Congo, Liberia, Sierra Leone, South Sudan – where farmers lack improved seed and organized seed systems are non-existent. In such countries, most farmers are unaware of improved seed and continue to use landraces, recycled seed, or source seed from their neighbors, resulting in low yields. Developing seed supply systems in these countries, where breeders lack improved germplasm, requires a targeted and comprehensive approach. PASS, with support from USAID, the Howard G. Buffett Foundation, and the Embassy of the Kingdom of Netherlands, initiated programs for sustainable seed delivery systems. Despite continued unrest, operations in South Sudan are more advanced than in the other three post-conflict countries and can be cited as a case for similar interventions.

South Sudan

South Sudan is the newest country in Africa and, at the time of this writing, has only recently begun to emerge from a decades-long civil war. As in other countries of Africa, agriculture is the most important sector. Over 90% of the population is poor and vulnerable, and depends directly or indirectly on agriculture or agriculture-related activities.

The civil war resulted in high illiteracy levels and minimal investment in agricultural development. Producing food to ensure food security for the 8.5 million South Sudanese is a major challenge. Much work has been done on crop improvement in sub-Saharan Africa but this knowledge has not been effectively used in South Sudan because of armed conflict and political instability. Since independence was achieved in 2011, sustained

peace and stability have proven elusive, and agricultural activities are only slowly beginning to stand on their feet, as are other sectors. The government of South Sudan has come up with a Comprehensive Agricultural Master Plan (CAMP) that emphasizes agriculture as a key pillar of the economy.

South Sudan is a net importer of staple foods – sorghum, maize, rice – and seed. Conditions on the ground in some parts of the country, however, have improved over time, especially in the Greater Equatorial states where PASS is working.

In 2011, PASS established an office in Juba with financial assistance from USAID and the Howard G. Buffet Foundation. In 2013, the Dutch government signed an agreement with AGRA to support development of the seed sector. The objectives of this project are to enhance capacity of South Sudanese scientists through high-level training in plant breeding and seed systems, support breeding programs in the ministry of agriculture, and the establishment of operational seed enterprises.



Breeding for small but locally-important “niche” agro-ecologies like this lowland, non-irrigated, rice-growing zone in Sierra Leone, allows a broader range of farmers to use modern, high-yielding varieties. In this ecology, tolerance to iron toxicity is key to adaptation.

Six scientists (two female) from the directorate of research completed their master's degrees in plant breeding and seed systems at Makerere University in Uganda in February 2015. One student finished the first year of PhD training in plant breeding at the University of KwaZulu-Natal, and a second started his PhD in plant breeding at the same university in January 2015. PASS has also been providing support to technicians from seed companies to attend short-term training courses at the AGRA-supported Seed Enterprise Management Institute at the University of Nairobi.

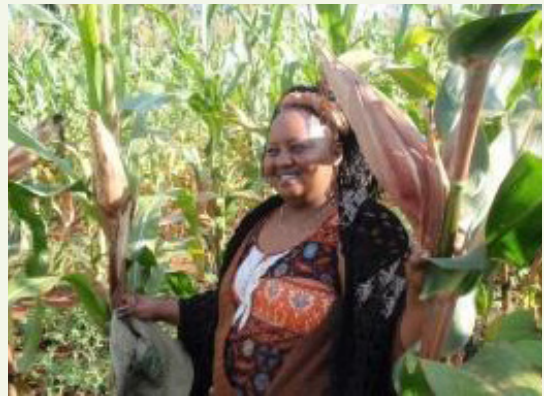
Since 2012, PASS has awarded research grants to five breeding programs (maize, rice, sorghum, cassava, groundnut). The University of Juba has also received a grant to breed cowpea. These breeding programs are using an ecology-based breeding approach. Because they are still nascent, the programs started by fast-tracking releases from introduced germplasm, but they are also bringing in and testing improved material from NARS programs in Kenya (Kenya Agricultural Research Institute – KARI, now the Kenya Agricultural and Livestock Research Organization – KALRO) and Uganda (National Agricultural Research Organization – NARO) for local adaptation.

Private seed companies are important for multiplying and scaling up seed production. PASS supports seed companies to scale up the production of seed of improved varieties and to make the seed available to farmers. Before this intervention, there were no local seed companies, and farmers depended on free distribution of seed and seed imported from neighboring countries. The biggest challenge was that the imported seed did not meet the standards of quality (some seed was adulterated and of poor quality) and lacked the adaptability to local

environments. PASS therefore awarded grants to ten locally owned private seed enterprises: Century Seed Co, Greenbelt Seed Co, Afrogenics Seed Co, and South Farmers Co Ltd. Today, farmers have access to certified seed of maize, sorghum, rice, groundnut and sesame. Moreover, these seed companies now have access to improved varieties from PASS breeding programs for scaling up.

Maize breeding in South Sudan – Maize is the second most important cereal crop (after sorghum) in South Sudan. Although the country has a large diversity of maize germplasm, the local cultivars and landraces perform poorly and the average yield is below 1 MT/ha, regardless of the farming practices applied. A maize improvement program was initiated in the country in the early 1980s, and a few improved open-pollinated varieties were introduced to farmers, mostly from Kenya and IITA-Nigeria. However, with time these maize cultivars degenerated.

Improved maize cultivars, especially high-yielding, early-maturing, disease- and pest-resistant varieties, must be introduced for use by smallholder farmers, the majority of whom are women.



Dr. Jane Ininda in a farm planted with hybrid maize

PASS, working through the Directorate of Research of the Ministry of Agriculture, provided a 3-year grant (2012–2015) to improve maize using the ecology-based breeding approach. The objectives were to:

- Collect and characterize at least 500 accessions of local maize germplasm across the high potential greenbelt agro-ecological zone of South Sudan;
- Collate baseline information on farmer trait preferences, production constraints, and create awareness on the benefits and use of improved cultivars; and
- Evaluate at least 200 improved maize cultivars from regional programs and release at least 8 varieties to seed companies.

In partnership with KARI and NARO, four high-yielding and disease-resistant mid-altitude hybrids and two open-pollinated maize varieties were released in 2012. About 700 maize accessions of local and introduced germplasm have been collected and assembled at the Palotaka Basic Seed Center for maintenance and population base development.

Democratic Republic of Congo

PASS initiated interventions in variety development and seed supply in Eastern DRC, focusing in North and South Kivu provinces since 2014. Farmers in Eastern DRC mostly grow landrace varieties of maize, beans, cassava, and rice. The greatest need was to enable farmers to rapidly access quality seed of improved varieties. PASS recognized the need to support plant breeders based in INERA Mulungu to rapidly evaluate hybrid maize varieties introduced from Uganda, Kenya and CIMMYT. Additional varieties of beans

– both climbing and bush types – were introduced from Rwanda, while a disease-resistant cassava variety was introduced from Tanzania. Using a farmer participatory selection process, these varieties were reevaluated against the local checks. As a result, 14 varieties were released in February 2017. The varieties were approved by the national regulatory authority SENASEM, and listed in the national variety release catalogue. Of the varieties released, one is the hybrid maize “UH5053” originally developed through the PASS-supported program in NARO-Uganda. For the first time in Eastern DRC, farmers have accessed locally produced hybrid seed. The cassava variety “Kizimbani” was selected by farmers because of its high yield potential and good taste, thanks to its resistance to the devastating cassava brown streak disease. The variety also has additional resistance to cassava mosaic disease.

Kenya

Before 2000, only two maize hybrids – H511 and H512 – were marketed widely in the mid-altitude areas of Kenya. Released 30 years previously, these varieties had become susceptible to the notorious maize streak disease. Smallholder farmers in the mid-altitude zones suffered serious losses due to diseases such as maize streak virus, Turicum leaf blight, and gray leaf spot. Desperate to increase their yields, farmers were growing late-maturing hybrids bred for the highland areas that were unadapted to mid-altitude areas. The result was often disaster.

The first initiative to support breeding for mid-altitude areas in Kenya was The Rockefeller Foundation-supported program, *Ecosystem-based breeding for disease-resistant maize varieties for the mid-altitude areas of Kenya*. The aim was to develop disease-resistant maize hybrids with farmer-preferred traits. Smallholder farmers are

very particular regarding certain attributes like semi-flint grain types and early maturity. As a result of this effort, 63 hybrids suited for mid-altitude areas were released between 2004 and early 2017. These new maize hybrids have contributed immensely to the development of small private sector seed enterprises in Kenya, and improved food security in these highly-populated zones. Once KARI released the varieties, several small- and medium-sized local seed companies became interested in selling them (Table 3.3). Farmers now access disease-resistant varieties and are happy that change in on-farm productivity is now a reality. Concurrently, this intervention has resulted in more than 100 elite inbred lines being developed and catalogued. The lines have been shared with other breeders in DR Congo, South Sudan, Ghana, Uganda, and Tanzania, among others. It was during this period that a full cycle NARS breeding program in Kenya developed into one of the strongest and most robust showcase breeding programs in sub-Saharan Africa, courtesy of the commitment and diligence shown by The Rockefeller Foundation.

Selected achievements include:

- 37 maize hybrids varieties released, of which 25 hybrids have been commercialized. The varieties have been licensed on exclusive or non-exclusive rights to 9 independent, small private seed companies in Kenya and Uganda.
- More than 18 MT of breeder seed was produced.
- 21,000 MT of certified maize seed was produced and sold to farmers, most attributed to hybrid seed.
- More than 1 million farmers are aware of new varieties through promotional activities by breeders, seed companies, and FIPS-Africa (Table 3.1). The seed is sold through a network of agro-dealers established by the companies, freelance agro-dealers, or through CNFA-certified agro-dealers.
- Every year 4,000 MT of seed is produced and sold to 84,000 farmers and planted on 160,000 hectares (AGRA traceability study, 2014).

Table 3.3: Sample of New maize hybrids being marketed in Kenya

Variety name	Type	Licensing agreement	Seed company
KH500-22A	Hybrid	Exclusive	Olerai
KH500-42A	Hybrid	Exclusive	Olerai
YARA 1	Hybrid	Exclusive	Victoria
MU03-137	Hybrid	Exclusive	Olerai
KH500-33A	Hybrid	Non-exclusive	Freshco
KH500-21A	Hybrid	Non-exclusive	Freshco
KH500-21A	Hybrid	Non-exclusive	Dryland
KH500-31A	Hybrid	Non-exclusive	Freshco
KH500-43A	Hybrid	Exclusive	EASEED
KH500-31A	Hybrid	Non-exclusive	EASEED
KH500-31A	Hybrid	Non-exclusive	Faida

What the farmers say

Joshua: *I liked the Yara 1 variety because it is early-maturing, has big cobs, sweet flour, uniformity of crop, a big kernel, and it's also good for consumption as cooked green maize. I also liked MU-019 because it has a good taste and big kernels. It's early-maturing, good for fodder, and has uniformity.*

Wangaruiya: *I liked the KH500-31A variety because of its good cobs, higher yields, and big stalk for fodder. It's good for green maize and it is medium-maturing.*

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4 Setting Up Seed Companies in Sub-Saharan Africa

George Bigirwa¹ and Issoufou Kapran²

Describing the power of seed to alter farmers' prospects for a productive, prosperous life can be a difficult task. Seed, after all, gets buried in the ground and, after germinating, disintegrates, leaving behind a crop which must be tended and harvested before the farmer can realize any benefit. But it is the seed that carries the DNA responsible for programming the crop's growth, including how much of the edible portion the crop creates. Hence, seed is often characterized as setting the upper limit on farmer productivity. Seed is also a living, biological technology which must be cared for in specific ways in order to function properly. In the never-ending endeavor of securing sufficient food, the measures a society puts in place to deliver seed to its farmers are some of the most delicate and demanding of all.

Most farmers in sub-Saharan Africa are smallholders whose access to seed of high-yielding, locally adapted varieties of their staple food crops remains very limited. Whereas this may not have posed a serious problem to feeding the continent's people during Africa's long period of low population growth, in the present-day context, where population is expected to double by 2050, it represents a critical threat to prospects for food security, stability, and progress. Over-reliance on traditional, low-

yielding crop varieties with limited response to improved crop management condemns Africa's farmers to a vicious cycle of food insecurity and poverty as they cannot produce enough to support their families. Low productivity in a continent where most countries are already net importers of food, and where population growth is much higher than food production growth, can only lead to alarming deficits. The food deficit in sub-Saharan Africa is projected to rise to 60 million MT and USD 14 billion by 2020 (Conway 2013).

Most governments in Africa started realizing the importance of seed in the early 1960s, as evidenced by the establishment of national seed companies. In many countries, these organizations were funded jointly by the national budget and international development bodies. Other countries had long-term seed projects generally housed and implemented by the ministries of agriculture, sometimes following tragic food crises brought about by calamities such as drought in the Sahel or war in Sierra Leone and Liberia. However, the track record of supplying farmers with the seed they need through government agencies is poor. With the possible exception of hybrid maize in southern Africa, sustained adoption of improved varieties by smallholder farmers has been limited (Rusike et al. 1997; Christou and Twyman 2004).

The two areas that suffered most in public seed enterprises were quality control and marketing.

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Quality control was housed either in the ministry or in the parastatal seed company itself, and thus lacked the checks and balances needed for rigorous maintenance in a product whose quality can only be assessed after it has already been purchased and used. The end result was poor quality seed regularly being allowed into the system, which discouraged many farmers from becoming active users of purchased seed. In the absence of a marketing infrastructure at village level, seed would typically be delivered to ministry offices at the district level with no means of informing farmers of its availability and no real incentive for increasing its usage. Often, seed was delivered to agricultural offices late in the season when farmers had already finished planting, resulting in carryover stocks that lost viability with time because of poor storage.

The International Monetary Fund and World Bank-sponsored structural adjustment wave that led national governments in sub-Saharan Africa to privatize and deregulate their economies represented a major breakthrough in creating more demand-driven seed supply systems, as private individuals were now able to establish their own seed enterprises and enter the market. The increase in competition for market share

in seed did not spare many government seed companies. Currently, few still exist.

In the vacuum that resulted from the downturn in activity by public seed agencies a number of NGOs began to initiate local solutions, sometimes increasing access to seed of improved varieties, but mostly centered on recycling farmers' traditional varieties. Meanwhile, true private investment in seed enterprises languished as a classic case of market failure, made worse by the reluctance of deregulated banks to invest in agribusiness, including seed. Within private spheres it was often said that "the people who understand the importance of seed don't have money, and the people with money don't understand the value of seed." Moreover, true freedom to operate for private seed companies emerged slowly from within highly-regulated environments toward those which genuinely encourage private investment. Nevertheless, in most of sub-Saharan Africa official seed policies are on a trend towards full liberalization. This positive environment is an incentive for private investment in seeds as illustrated by the growing number of local seed companies in a number of African countries (Table 4.1).



Chacha Goryo, of Tanzania, here holding an ear of hybrid maize seed and standing in his 100-hectare production field was typical of the new breed of African seed entrepreneur: visionary, in-touch with farmers' desires for increased yields, and convinced of their ability and willingness to pay for better seed.

Table 4.1: A shift from public seed companies to private local, regional, and multinational seed companies, an example for 8 countries 2007–2014

Country	Number of seed companies	
	Before 2007	2014
Burkina Faso	1	9
Ghana	1	15
Mali	1	8
Niger	1	8
Nigeria	1	74
Uganda	5	23
Tanzania	11	47
Kenya	<25	109 ^a

^a Over two thirds are vegetable seed importing companies. It should also be noted that not all seed companies every year, others only do so when they strike a deal with some NGOs or local governments.

Given the vital role of high-quality seed in shifting from low to high-yielding agricultural systems, the alarming food situation in sub-Saharan Africa calls for a drastic transformation to make quality seed of improved and adapted crop varieties available to farmers. It is against this backdrop that PASS was established to address the challenges within Africa’s seed supply system.

The central challenge facing PASS at its outset, however, was an acute lack of dependable seed multipliers and marketers to get the seed of improved varieties out to agro-dealers and farmers. The combination of high regulation, low access to capital, and a lack of available improved crop varieties in many countries meant that few entrepreneurs were emerging to take up the business of supplying seed.

Even so, PASS bet boldly on Africa’s private sector. In contrast to nearly every seed initiative that had come before, PASS focused squarely on local African entrepreneurs who identified

improved seed as a product on which they believed they could establish viable businesses.

This approach, however, was not without its risks or challenges. Whereas running a shop selling seed and other inputs to farmers may be considered a mostly straightforward undertaking, the production, processing, packaging, and distribution of certified packaged seed to large numbers of agro-dealers within a context of low farmer purchasing power and low farmer awareness involves several multiples of increased risk, investment, and uncertainty. Predictably, the number of individuals with the idea, competence, and means to establish commercial seed operations was very limited. A few brave individuals did exist, however, and PASS set as one of its central missions to accelerate their learning, growth, and access to new products and farmers, thereby reducing the risk of failure.

Between 2007 and early 2017, PASS intervened in a large way to increase the number of private seed companies operating in sub-Saharan

Table 4.2. The different categories of seed entrepreneurs supported by PASS

Country	Private Seed Companies	Public Companies	NARS	Farmer Associations/ Cooperatives/NGOs
Burkina Faso	6	0	0	0
DRC	4	0	0	0
Ethiopia	7	5	0	0
Ghana	11	0	0	0
Kenya	6	1	3	2
Liberia	2	0	0	1
Malawi	6	0	1	1
Mali	7	0	0	1
Mozambique	8	0	1	0
Niger	5	0	0	1
Nigeria	6	0	1	2
Rwanda	5	0	1	1
Sierra Leone	2	0	0	1
South Sudan	10	0	0	1
Tanzania	15	0	1	0
Uganda	9	0	2	2
Zambia	3	1	0	1
Total	112	7	10	14

^a NARS = National agricultural research system. These were mainly supported to disseminate vegetatively propagated crops like cassava and sweet potatoes.

Africa (Table 4.2). The centerpiece of PASS's intervention was a continual search process to identify interested groups and individuals to establish and manage seed companies. This was combined with a standardized package of support that included:

- A one-time, USD 150,000 grant to support the production and marketing of seed at affordable prices in small packages

among communities of smallholder farmers in need of this product;

- Enrollment of seed company managers in a series of training modules operated by the Seed Enterprise Management Institute at the University of Nairobi;
- Site visits combined with free advice on methods of production, processing, marketing, and overall firm management



Komsaya Hybrid production by Agroproductions, Burkina Faso

from experienced former seed executives from advanced seed markets, including the USA and India;

- Knowledge regarding the locations of agro-dealers trained and supported by PASS; and
- Information regarding the release of new crop varieties by public breeding teams supported by government, PASS, and other donor agencies.

PASS also organized frequent gatherings at a national level where seed company owners, crop breeders, agro-dealers, and government policy makers could interact and learn from each other's experiences.

A number of elements made this approach to dealing with seed scarcity at the village level relevant to poor, smallholder farmers. First, it was reasoned that opening new markets for seed where farmers lacked knowledge of its value was a task best suited to small firms with lower operating expenses, which might be able to operate profitably at relatively low volumes

of sales. Second, the opportunity represented by reducing seed package size appeared to be significant, as it meant a lower outlay of scarce cash by farmers, and the small amount of land that would be involved in testing the new varieties would limit the level of perceived risk by farmers to a manageable level. Third, PASS was investing heavily in the establishment of agro-dealers in farming areas where previously few or none had existed, thus removing a physical barrier to the presence of improved seed in the market, at the right time and at the right places. In the early stages, PASS also supported agro-dealers to plant demonstration plots of seed they had in stock, so that farmers could see for themselves the increased productivity of the seed. Fourth, PASS insisted that the companies it chose to support produce and market seed of a wide range of crops important to smallholder farmers, not only maize and other lucrative products. And finally, to avoid setting up new, private sector-based monopolies and ensure healthy competition among several operators, PASS purposely provided support packages to

multiple emerging private seed companies in each country.

Initially, three categories of seed producers were supported in almost equal number, including private, public, and farmer associations. However, it was quickly observed that groups from the latter two categories tended to stop producing seed when PASS funding came to an end. Public sector seed supply has historically been hampered by the lack of a business culture and mindset among government employees, the assurance of receiving a salary regardless of performance, and the bureaucratic operating procedures common to many public agencies. Farmer associations and cooperatives also suffer from a dearth of business skills, especially in marketing. In addition, the management structures of such groups are often not adapted to developing an autonomous and professional stance driven by the opportunity of expanding market share. Nor are they open to reinvesting in the business to build higher levels of performance and efficiency in the future. Private entrepreneurs, on the other hand, tended to have a passion for the seed business because many of them initially were farmers themselves.

The PASS Model for Seed Enterprise Development

The underlying assumption guiding PASS was that in each country there would exist a pool of potential private seed entrepreneurs or organizations looking for opportunities to better organize and supply high-quality seeds of food crops to smallholder farmers.

From 2007 to early 2017, PASS personnel used various approaches to identify pools of potential grantees. In the beginning, in-country visits and informal discussions with local insiders allowed PASS to discover existing seed entrepreneurs who had a passion for the businesses they had already established or were eager to start. This process was later changed to placing advertisements in national newspapers calling for concept notes, followed by a pre-selection exercise.

Each time PASS announced its interest in speaking to seed entrepreneurs it received several hundred applications, thus facilitating a transparent and effective search for grantees. In some cases, additional candidates were identified during due diligence visits. Once vetted, the most promising



Local seed companies like Hadia Seeds in Ethiopia, owned and operated by Hadia Gondji (right), produce improved varieties of crops of national importance, including teff, noug, and fava bean.

entrepreneurs were invited to submit proposals for a one-time startup grant. Winning a PASS startup grant also opened other opportunities for technical and business development support (BDS).

Seed Grants

Most grant beneficiaries were true start-up seed enterprises that generally had been in existence for less than two years. These enterprises were given a one-off grant spanning two years to assist them address three main aspects of their business:

- Increasing seed production levels;
- Enhancing farmer awareness; and
- Establishing mechanisms for seed dissemination through a network of agro-dealers.

Increasing seed production levels

Grantees were given support to increase seed production levels of selected staple crops, including maize, rice, sorghum, millet, wheat, beans, cowpea, groundnut, and soybean. As indicated in Figure 4.3, more than 50% of the seed produced was of maize, which reflects not only the importance of the crop as both food and feed, but also the greater availability of improved maize varieties across the continent.

There were significant country-to-country variations with regard to the mix of crop species emphasized by seed companies, with the example of upland rice taking pre-eminence in Burkina Faso and millet dominating seed production and sales in Niger. Varieties were sourced from public institutions that supplied breeder and/or foundation seed. Grantees produced seed on their own farms or on contracted land, and did so according to quality control measures enforced by government agencies. Based on early high demand for seed, companies went a step further to contract

and train additional growers to ensure the supply of high-quality seed (see photo). PASS encouraged those who could to invest in irrigation in order to ensure stable, high-quality seed production.

I was a merchant in Niamey, the capital city of Niger, with no interest in farming. Working as a seed contract grower for Alheri Seed Company has definitely convinced me that seed farming is profitable, as I made CFA 30 million (USD 60,000) from seeds I sold to the company.

Amadou Sabo (Maigarin Bozaraoua), Dogondoutchi, Niger, 2014

Enhancing farmer awareness

As is the case for any new product, demand creation plays a vital role in popularizing its use. Hence, another key task undertaken by seed companies was increasing farmer awareness regarding the importance of using quality seed of improved crop varieties and informing farmers where they could source the seeds.

From the perspective of a seed company, creating farmer awareness is an excellent marketing tool for increasing the demand for seed. Given that most farmers were unaware of the different varieties available, a portion of each grant was used for farmer education and creation of awareness. This was achieved by setting up demonstration plots in strategic places, such as roadsides, markets, places of worship, schools, and sources of water. New varieties were planted side by side with both commercial checks and local varieties for comparison. Plots were divided into two sub-plots – with and without fertilizer – so that farmers could also directly observe the impact of combining the new seed with fertilizer.

Another strategy for awareness creation was holding field days where farmers were invited to view the new varieties under different management practices. Field days were highly successful as farmers had an opportunity to ask questions of experts and also share experiences with other farmers.

Promotion and advertising were also critical to informing farmers about the new seed. One of the most successful forms of promotion was radio. Agricultural radio programs are regularly aired on local stations throughout Africa. Once seed companies were in business, it suddenly made sense to inform farmers about the attributes of new varieties and where to get the seed. Some radio stations allowed farmers to call in with questions or comments. Sometimes farmers were even invited to radio studios to talk to fellow farmers and share experiences. To motivate and encourage more listeners, talk show programs occasionally announced quizzes where winners were rewarded with packs of improved seed.

Large agricultural shows and forums were also organized at district and national levels, and various agricultural technologies were put on display. Seed companies often took advantage of these shows to engage with the public through exhibitions and establishing small demonstrations, and good amounts of seed were often sold at such events. In Tanzania, this is an annual event which ends on 8 August, popularly known as *nane nane* (eight-eight in Kiswahili), and is a statutory public holiday.

Establishing mechanisms for seed dissemination through a network of agro-dealers

While seed companies might manage one or several sales outlets at or near their main warehouse, the vast majority of farms in any given country are located far from commercial centers. Directly supplying them with seed presents logistical complications no single company can manage. Just like manufacturers of soap and toothpaste, seed companies need



Private farmer-multipliers and vendors of stakes for supporting cassava plants like these farmers in Zanzibar can rapidly disseminate new varieties.

locally-owned and managed sales outlets to reach customers. Thus, once seed supply was secured and seed had been packaged, building relationships with local private seed sellers was another key activity undertaken by the companies. In instances where agro-dealers had never existed, seed companies arranged for their training, with a focus on product knowledge and handling, record keeping, and customer care.

Prior to the creation of seed companies focused on sales to smallholder farmers, most of the customers wanting improved seed were large-scale commercial farmers who bought seed in large lots. When smallholder farmers became important customers, an additional element of effective distribution became appropriate packaging. For a long time the traditional package size was 25 kg for maize (enough to plant one hectare) or even bigger. However, this size was unsuitable for smallholder farmers who wanted to plant a smaller area, or farmers who simply didn't have enough money to buy 25 kg at one time. To make seed affordable to a wider group of farmers, seed companies were encouraged to provide smaller packets of 1, 2, 5, and 10 kg. Other companies have gone the extra mile to package seed in even smaller amounts – 200 and 500 gram packets – and to distribute some as free samples.

Today successful seed companies use a range of innovative ways to avail seed to farmers, including mobile vans equipped with loudspeakers, or motorcycles that circulate during village market days, particularly in areas where agro-dealers are still not present. One initiative by the FAGRI seed company in Burkina Faso was to build movable seed kiosks and gradually pass them on to trained pilot farmers who became de facto local distributors for their villages and towns (see photo).



A seed kiosk by FAGRI Seed Company to expand the distribution network

Access to loan facilities

Africa's commercial banks are usually less than keen to lend to agricultural enterprises, including seed companies, because of perceived high risks. Whenever they do lend, they charge high interest rates and require large amounts of collateral, which most start-up companies supported by PASS do not have. Moreover, when loans are available from commercial banks they frequently are not tailored to the needs of seed companies, which tend to have longer business cycles than other types of enterprises. For example, it may take a seed company up to two years between the time breeder or foundation seed is procured and the time certified seeds are sold and the proceeds recorded in company accounts. Cash flow needs are often extremely high and follow seasonal patterns, such as when a company needs to pay their out-growers at harvest time.

PASS has attempted to address these financing needs by creating specific investment funds for seed companies that want to further expand their working capital or investment capital for seed processing machinery, irrigation equipment, or land for seed production.

To accomplish this, PASS worked with several partners to establish two investments funds that could handle both debt and equity investments. The first was the African Seed Investment Fund (ASIF), managed by Pearl Capital, based in Kampala, Uganda. As of 2014, 13 seed enterprises had benefited from the USD 12 million fund. The amounts received by participating seed companies ranged between USD 350,000 and USD 2,000,000. The second fund was the West Africa Agricultural Investment Fund (WAAIF), managed by Injaro Investments Limited (IIL), based in Accra, Ghana. WAAIF was started by AGRA in 2009

as a USD 3 million fund but later attracted other investors, reaching total commitments of USD 49 million by 2014 under the new name of Injaro Agricultural Capital Holdings Limited. By 2017, the fund portfolio included a total of USD 9 million committed in debt and equity, including commitments of USD 5 million made to six seed companies.

Thanks to these and other interventions, the total capacity in seed production among seed companies supported by PASS increased from less than 3,000 MT in 2007 to more than 127,000 MT in 2016 (Figure 4.1). However, not all countries experienced the same level of seed sector growth. Ethiopia, Uganda and Nigeria emerged as top seed producers (Figure 4.2). Likewise, not all crops figured equally in seed sales, with maize, rice, and wheat taking the lion's share (Figure 4.3).

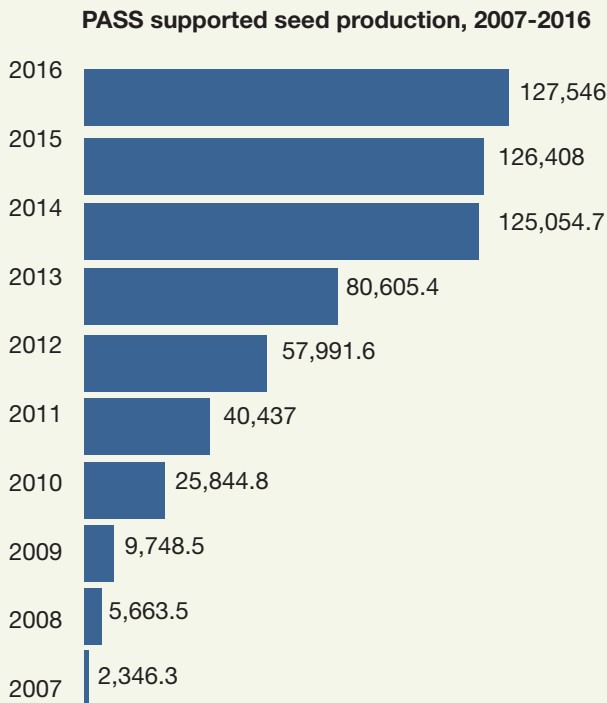


Figure 4.1: Seed production by PASS-supported seed companies, 2007–2016

Certified Seed Production by Country, 2016

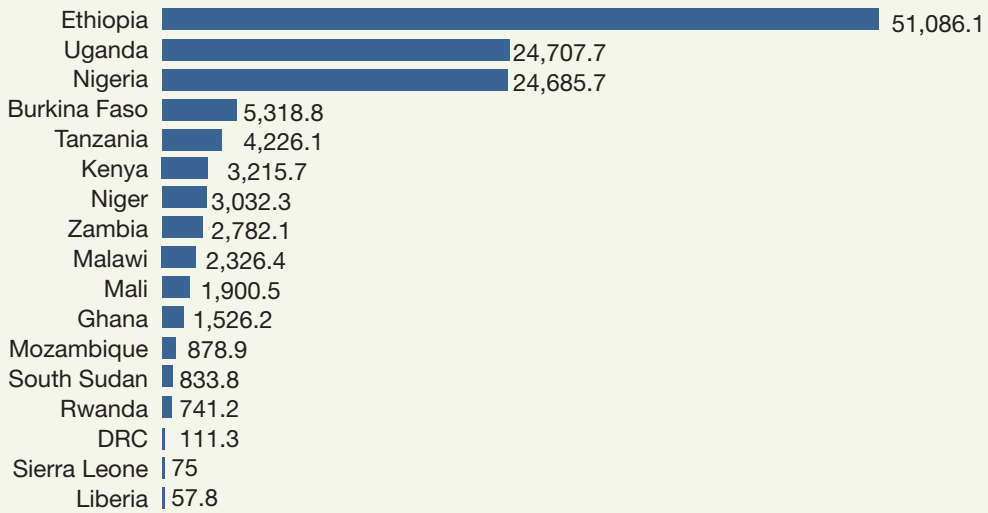


Figure 4.2: Seed produced by PASS grantees in each country, 2016

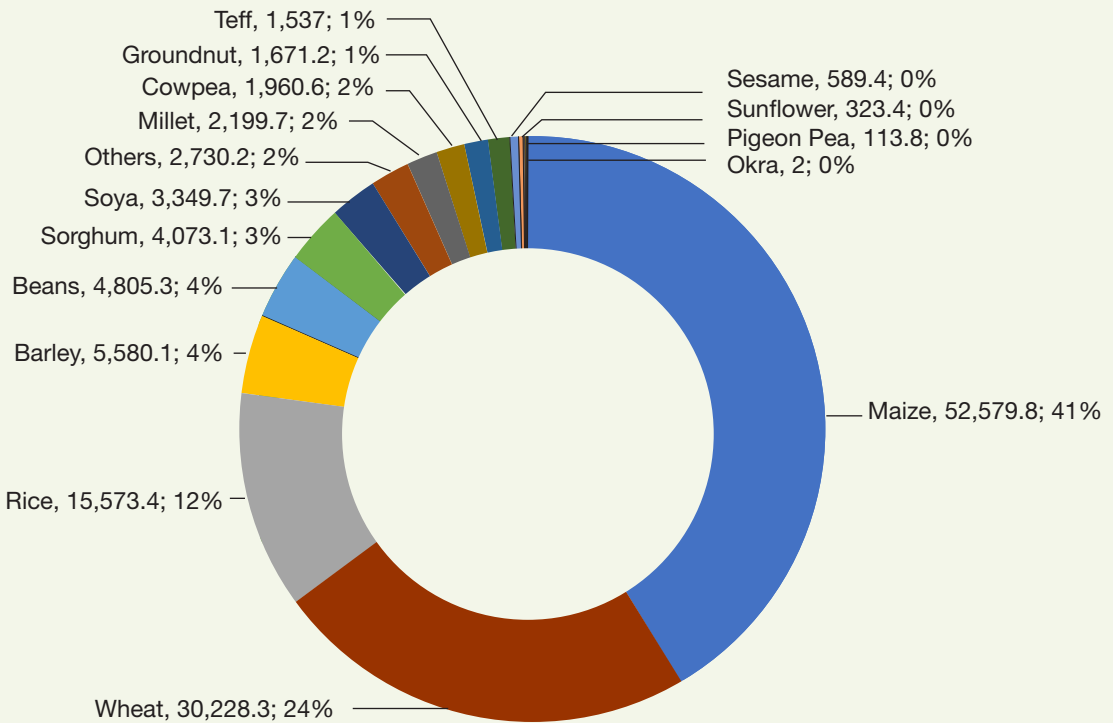


Figure 4.3: Seed production (MT) by crop in percentage of total, 2016

Developing the human capacity to manage seed enterprises

Running a seed business is a very specialized venture that requires technical know-how and unique business skills. Given that most of the grantees were start-up seed companies, and because the seed industry in Africa is still young, it was imperative to establish a seed training institute on the continent. Prior to the inception of PASS, trainees were generally sent abroad. The Seed Enterprise Management Institute (SEMI) was therefore established in Kenya (housed at the University of Nairobi) to bridge this gap.

At SEMI, short-term specialized courses are offered in partnership with the Seed Science Center of Iowa State University in the USA, the International Maize and Wheat Improvement Center (CIMMYT), both the College of Agriculture and Veterinary Sciences and the School of Business at the University of Nairobi, the Kenya Agricultural and Livestock Research Organization (KALRO), the Kenya Plant Health Inspectorate Services (KEPHIS), and experienced private sector seed specialists.

SEMI offers five courses annually:

- Seed Production
- Seed Processing
- Seed Business Management
- Seed Marketing
- Seed Quality Assurance

To date, SEMI has trained over 960 students from 22 countries, as shown in Figure 4.4. While only a few students have been trained from some countries such as Cameroon, others, such as Tanzania, with 99 students trained, are beginning to build a cadre of knowledgeable professionals. Seed company staff showed great appreciation for this practical learning, as well as the opportunity to network and interact with peers from across the continent. The University of Nairobi is now beginning to receive applications from self-sponsored students whenever donor-funded spots are not available.

In 2016 PASS opened a new training center at the University of Thiès (ENSA) in Senegal to offer training modules like those of SEMI, but focusing on the needs of Francophone seed companies in West Africa (Burkina Faso, Mali, Niger and Senegal).

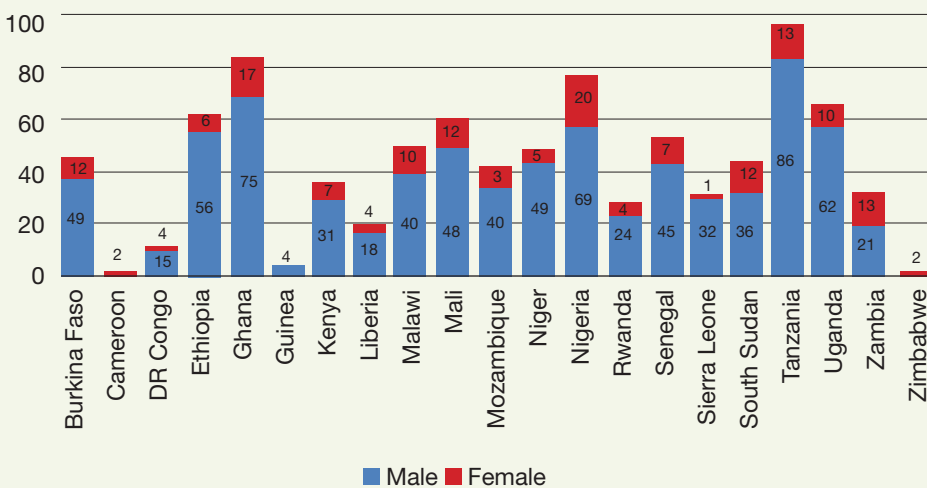


Figure 4.4: SEMI participants by country of origin and gender (2010 to March 2017)

Business development services

To further provide support to seed companies, PASS assembled a team of retired seed experts from multi-national seed companies and private companies who were willing to share their experiences by mentoring seed company grantees. These consultants regularly visited the companies, worked with the staff, looked at the infrastructure and operations, identified areas of strength or problems, worked out solutions, and provided general business development services (BDS). The three core areas for BDS support are:

- Seed production and processing (offered by former Cargill/Monsanto executives);
- Business management and marketing (offered by a former CEO of Channel Bio Corp in the USA, as well as a senior manager from Syngenta in India); and
- Financial management (offered by financial analysts who have worked in various banks and accounting firms in Africa).

One key achievement of this arrangement was that BDS consultants were able to share unique ingredients for entrepreneurial growth and farmer value in the seed sector with African small- and medium-sized enterprises (SMEs). In so doing, the consultants developed tailored tools for improving management. Among these tools were:

- A manual on production research used to enhance technical production capacity, to select and maintain inbred lines, and to produce economic seed yields for hybrids (Westphal and Kapran 2009)

- The African Seed Company Toolbox: 52 Tools Every Seed Company Manager Should Know How to Use (O'Connor, 2009), a handy guide that covers good seed industry business practices for such areas as product development, customer satisfaction, company growth, seed quality, and profitability, as well as providing templates for seed company financial tools such as cash flow statements and balance sheets. Since becoming available online to seed companies, The African Seed Company Toolbox has been downloaded over 2,000 times and is now available in both French and English. In addition, close to 700 hard copies were given out at no cost to seed company staff and academic institutions.

Another important contribution by consultants was in identifying low-cost, versatile seed processing equipment that suppliers agreed to modify to suit the specific requirements and conditions of seed companies in sub-Saharan Africa.

In 2009, the PASS seed processing consultant and the seed systems managers traveled to Burkina Faso, Ghana, Mali, Niger and Nigeria to assess the availability of seed cleaning equipment for seed companies. They found that most of the equipment (all of which belonged to the governments) was in disrepair. Cleaning sieves were in such a condition that packaged seed coming from these obsolete seed processing plants contained up to 30% damaged material, which would of course prevent farmers from realizing value from that seed. Thus, farmers were actually paying very high prices for only about 70% of the seed they were receiving.



Saleem Esmail, founder and CEO of Western Seed Company, Ltd., of Kenya, was among the first seed entrepreneurs in Africa to take the supply of hybrid maize seed to scale among smallholder farmers.

The equipment could handle cleaning and grading of all types of crop seeds at high volumes. For areas without electricity, a generator could be used. It occupied little space and could be calibrated to pack seed in different volumetric or automated sizes, with options for treating seed as well. This enabled the companies to improve their efficiency, handle large volumes of seed, and release it to the market in branded packages in time for planting season. Between 2011 and 2014, the equipment was purchased and installed by 33 seed companies in 11 countries, increasing the annual seed processing capacity to 8,000 MT per location, with no major breakdowns reported.

The importance of BDS for the successful delivery of high quality seeds has not escaped the attention of the African Development Bank, which recently partnered with PASS to expand this kind of support to 54 seed companies across sub-Saharan Africa.

Attachment of seed specialists

PASS recognized that with the extreme seasonality of the seed business, combined with the difficulty of training large numbers of private company staff in many locations on the intricacies of hybrid seed production, it would be beneficial for technical staff at seed companies to have access to longer-term coaching and training. The solution was to second breeders and seed production experts to seed companies, thereby enabling technical staff at the companies to learn. Seed specialists were therefore attached to new seed companies for up to six months, working with the technical staff on a daily basis, imparting knowledge and at the same time helping to put systems in place for quality control, management of out-growers, hybrid seed production, parent seed planning and forecasting, production roadmaps, and automated record keeping.

Our exposure to AGRA consultants and AGRA-sponsored local and international trainings gave us a leading edge in the Nigerian seed industry.

Ibrahim Abdulahi, Managing Director of Maslaha Seeds, upon the company's achievement of producing 12,000 tons of assorted seeds, 2013



Hundreds of practical, hands-on learning opportunities like these between experienced seed professionals and managers of emerging private seed companies were key to achieving the ambitious seed production targets set by PASS.

These practices, whereby seed companies go a step farther from the production recommendations offered by public breeders and leading to higher volumes of quality seeds, are considered production research (O'Connor, 2009). This is especially the case for new hybrids, for which it is important to precede commercial seed production with an understanding of how the inbred lines used to produce the hybrid respond to new agro-ecologies and local management practices (MacRobert 2009). Given that many companies were venturing into a new territory of maize hybrid seed production, they needed technical guidance. This called for the development of a production research guide, which later became an important tool for hired secondees to extend the required practical skills to seed company staff, particularly in Nigeria, Ghana, and Mali (Westphal and Kapran 2009), and recently in Burkina Faso, Niger and Senegal. Through these attachments, the knowledge of hybrid seed production has increasingly shifted from the exclusive domain of breeders to the managers of PASS-supported start-ups.



AGRA supported Maslaha Seeds Limited, one of the most successful seed companies in Nigeria, move the certified seed closer to farmers in rural villages by providing training in seed production planning, seed handling, and management of the overall process.



Motivated professional seed entrepreneurs like Maimouna Coulibaly (right), here describing a new product to AGRA's president, Agnes Kalibata, represented a break from the past, when seed supply was the exclusive domain of public agencies.

I am ready to hire a breeder for my company to speed up the process of marketing the new hybrids, but where are the breeders for hire?

Lawan Gwadabe, Managing Director of Seed Project Company, Kano, Nigeria, 2009

Periodic exchange visits were organized through which companies visited each other to share experiences and learn new approaches to solving business problems. This was primarily done within countries and regions, although some companies were facilitated to travel to India to learn about the Indian seed system.

Exchange visits

Seed companies in Africa remain at different stages of development. Those in East and Southern Africa are generally more developed than their counterparts in West Africa. However, even within a given country there are variations. Through networking and meetings convened by the PASS seed team, companies were encouraged to share experiences and not view each other as competitors, since the seed needs in any given country are huge and regularly remain unmet.

Technical guidance by SEPA program staff

The PASS team in charge of seed production played the role of incubator managers and facilitators. The team visited seed companies on-site on a regular basis in order to backstop, provide guidance, and discuss future plans for serving smallholders. The technical guidance covered topics such as choice of varieties, seed production research, selection and management of out-growers, farmer education, seed processing, storage, and marketing.

Since the majority of the seed companies did not have their own research and development programs, they depended exclusively on public research to license released varieties. Unfortunately, the relationship between the public and private sectors in Africa is often prickly. The two groups were in dire need of a *rapprochement*. This was accomplished by getting the two camps to focus on the message that they needed each other and should be partners. To this end, several in-country meetings were held in almost all AGRA countries, bringing public and private stakeholders together under one roof to make them understand the need to work together. In Ghana, this led to a memorandum of understanding between public maize breeders and private seed companies in 2011 and paved the way for better collaboration. That collaboration has given birth to the production of foundation seed by private seed companies under public sector supervision, supported by PASS.

Finally, the close interactions between seed companies and the seed team allowed PASS to pinpoint such structural issues as the lack of access to foundation seed, policy and regulatory barriers, and inappropriate competition from government – all encumbrances that limit the capacity of private companies to deliver high-quality seed, reliably and on time, to smallholder farmers. PASS encourages seed companies to be national advocates, and also brings such issues to the attention of AGRA's policy specialists for advocacy with national authorities in charge of seed policy and regulatory agencies.



Detasseling maize. Seed company Nafaso trained and employed outgrowers to produce hybrid seed for the first time in Burkina Faso

Case Study 1: Toward food security and improved incomes in Uganda



AGRA-supported seed companies depend largely on contract growers. Julius Onen is an outgrower for Pearl Seed Company in Uganda.

While Uganda's economy is entirely dependent on agriculture, the majority of farmers still use seeds of unimproved varieties, with only an estimated 20% of farmers growing seeds from the formal sector (Hilfswerk and Lwakuba 2012). Like many African countries, Uganda underwent deregulation of the seed sector in 1999, with the bowing out of the government seed parastatal, the Uganda Seed Project, after having achieved its highest ever production of 2,500 MT that year (Joughin, 2014). Today, the Uganda government's main contribution to the seed sub-sector is limited to a regulatory role, as well as research to develop new varieties and the production of breeder and (occasionally) foundation seed.

Pearl Seed Company Limited (PSCL), owned by five Ugandans, is a local private seed company that began operating in 2010. It is headquartered in Kampala but

maintains production stations in central, western and northern Uganda, using out-grower schemes since it does not have its own farms. The main crops grown by the company are maize (68% OPVs and 32% hybrids), rice, sorghum, beans, and soybeans (Figure 4.5). All varieties are

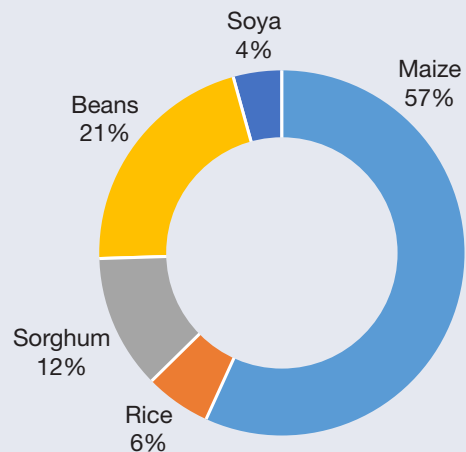


Figure 4.5: Crops and tonnage produced by PSCL in 2015

Year	Amount of seed produced (MT)	Remarks
2010	446	Sold all
2011	860	Sold all
2012	1,013	13 MT as carryover
2013	4,687	80 MT as carryover
2014	5,622	21 MT as carryover
2015	6,889.60	Sold all

sourced from the National Agricultural Research Organization (NARO), which sells breeder and foundation seed to private seed companies.

Seed processing is performed in Kampala, but this is an expensive operation because seed must be transported over a distance of up to 350 km. Initially, seed was manually processed, occasionally using locally fabricated machines, but this changed in 2011 when a modern processing facility was procured from China, which has greatly eased the work and enabled the company to put seed on the market on time. Four packet sizes (1, 2, 5, and 10 kg) are used, the latter being for large orders from governmental and non-governmental organizations. Eighty-five percent of the sales are through a network of agro-dealers.

Achievements

The company has grown by leaps and bounds. There has been a steady rise in the amount of seed produced with no or very little carryover stock. This is attributed to good planning, management, and focus on quality. PSCL recently acquired a

3-acre piece of land near Kampala where it is constructing offices, warehouses, a laboratory, and a seed processing facility.

Challenges

One of the main challenges facing PSCL is working capital. Interest rates from financial institutions are high, ranging from 20-33%. In some years, drought has led to crop losses, resulting in failure to attain the projected volumes. Lack of irrigation facilities for out-growers and unpredictable weather are additional challenges. Low awareness of the value of improved seed by farmers means that the company has to invest in farmer education.

Future Plans

PSCL plans to reduce their crop portfolio and focus on hybrid maize, beans and sorghum. They also plan to acquire a farm and do some processing on site instead of transporting raw seed to Kampala. PSCL plans to recruit a full-time breeder to reduce dependency on NARO, since at times the company is unable to get desired quantities of foundation seed.

Case Study 2: Maslaha Seeds – tapping expertise and partnerships to become a top seed company

Nigerian smallholder farmers constitute the majority of the estimated 160 million population of the country, but they are also the hungriest and poorest citizens. Nigerian farmers harvest on average less than two MT of grain per hectare. This is because farmers have not had access to the improved varieties developed by the many national and international research institutes present in the country. Low seed production levels, long distances between rural villages, poor understanding of the advantages of improved seed, and the high cost of large seed packages have all combined to trap Nigerian smallholder farmers in a vicious circle of poverty and food insecurity.

Maslaha Seeds was incorporated in 2007 as a private company with a large portfolio of crops, including maize, rice, millet, sorghum, cowpea, and soybean. The founder, Alhaji Saidu Moh'd Dansadau, a onetime Nigerian Senator, was himself a farmer and trader of farm products for over 30 years. This made him well acquainted with the problems of agriculture in Nigeria. Although a relatively well-off farmer, Alhaji Dansadau had suffered from poor inputs just like smallholder farmers. He knew what it meant to buy expensive seed but to realize poor yields because the purchased seed did not deliver the promised high germination, high vigor, and resistance to major diseases. He decided to start his own seed company to combat this reality.

A key step taken by Maslaha Seeds in the early years was to hire a Managing Director, Alhaji Ibrahim Abdulahi, a business graduate with experience in Nigerian government privatization. The company established its mission as “*The development of new and improved varieties of crops and efficient systems for timely supply of quality seeds to farmers*”, and Ibrahim prepared a 5-year plan to realize it.

Maslaha Seeds started with important investments in farms, staffing, and infrastructure in 2007. While pursuing sector-wide partnerships, Alhaji Ibrahim met with PASS team in 2008 and detailed the huge ambitions of Maslaha Seeds to expand their seed business by building seed centers in at least four Nigerian states. PASS decided to support Maslaha as they strove to meet demand for high-quality seeds of improved varieties.

The company's production of hybrid seeds was improved through several field teaching practices conducted by PASS experts, which allowed Maslaha staff to install a system for identifying the best hybrids for the market through identification of uniform and vigorous plants leading to higher harvests in the seed fields. Internal quality control procedures were streamlined to enable the company to reach the standards of quality required by the Nigerian regulatory agency, the National Agricultural Seeds Council. The seed processing facilities and procedures

were examined by technical experts working with the Maslaha staff. This resulted in a significantly lower amount of seed impacted by breakage, malformation, and dirt, which in turn led to higher quality seed for Maslaha's customers. BDS consultants helped Maslaha evaluate management strategies for sustainable company growth, taking into account organizational structure and decision making, governance, product costs, financial performance, production planning, human resource requirements, and long-term advantages of direct seed sales to rural farmers as opposed to wholesale sales to institutions and government entities.

Maslaha Seeds then obtained PASS support for a pilot project to organize a more effective dissemination strategy by increasing smallholder farmer awareness of improved varieties and facilitating the affordability and timely delivery of high-quality seeds. Through the support, Maslaha Seeds was able to:

- Establish 400 demonstration fields in 200 villages to showcase improved seeds and agronomic practices;
- Produce 5 radio programs on seeds and best agronomic practices reaching 250,000 farmers;
- Develop 20,000 fliers and leaflets on planting and farm management distributed to farmers;
- Make 3,000 MT of certified seed available in small packs of 1, 2, and 5 kg, sold with a 15% price discount;

- Hire and renovate 200 seed shops for 600 registered and trained village seed dealers; and
- Locally deliver 3,000 MT of certified seed in good time planting.

With this strong foundation in place, Maslaha could take full advantage of the newly-announced Growth Enhancement Scheme (GES) of the Nigerian government. According to the Managing Director of Maslaha Seeds, "When the GES came, we were excited because it represented an expansion of our experience with the PASS pilot project. So we were ready."

Ultimately, Maslaha Seeds was a key player in the implementation of GES. The new policy created a platform for private sector companies to obtain better financing terms from commercial banks and to deliver seeds and other inputs directly to farmers. The goal was to boost farmer interest in the use of high-quality seeds of improved varieties. In 2012, a total of 5 million farmers were reported to have benefitted from GES – and in 2013, 10 million farmers.

Production by Maslaha Seeds grew substantially over the years, rising from 550 MT in 2006 to 12,665 MT in 2013 before experiencing significant declines due to carryover stocks linked to the suspension of the GES (Figure 4.6). In 2013, Maslaha Seeds became the first PASS-supported company to reach 10,000 MT of annual seed production.

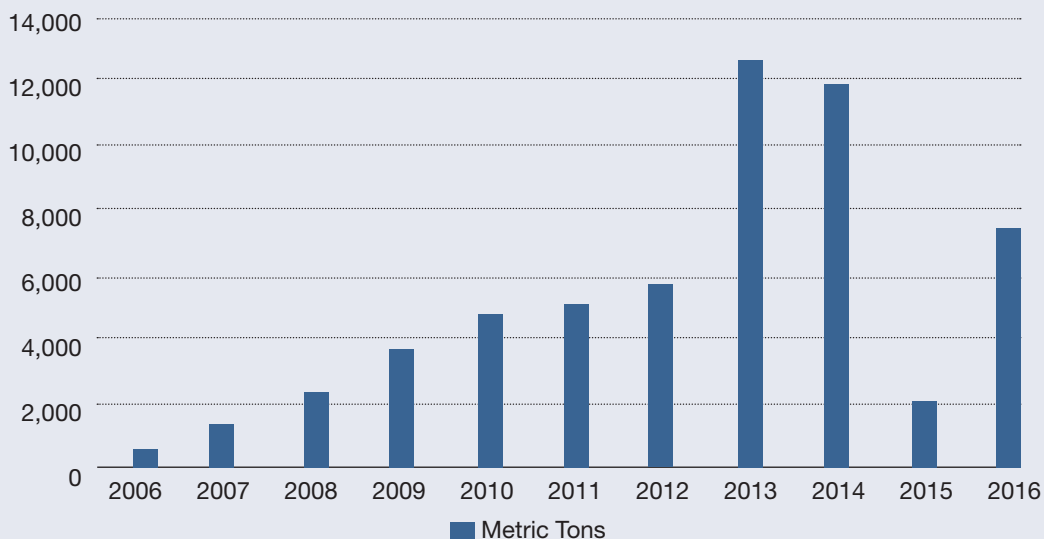


Figure 4.6: Seed production by Maslaha Seeds Company, 2006-2016

Important changes have continued as management has put in place a breeding team working with hybrid seed technologies, an extended out-grower system to increase seed output, new irrigation facilities to ensure seed quality in the dry season, and seed processing facilities. In doing this, Maslaha has increased career path options for their staff.

Alhaji Dansadau was a visionary in seizing the opportunity to start Maslaha Seeds so that smallholder farmers in Nigeria would

no longer suffer from the same input quality challenges that plagued him as a farmer. However, there is still much to be done. There are challenges in financing the continued growth of Maslaha Seeds and ensuring that additional professional skills are brought on board. In light of the fact that Nigeria's annual requirement for quality seed of improved varieties is estimated in excess of 500,000 MT, Maslaha's continued growth is important to Nigeria, to Africa, and perhaps beyond.

Meru Agro Seed Company, Tanzania

Meru Agro Seed Company is based in Arusha, Tanzania, and was registered in 2005. Prior to applying for a USD 223,900 3-year grant from AGRA in 2010, it had produced 12.7 MT of seed in 2007, 23.4 MT in 2008, and 70.1 MT in 2009. Following PASS support, Meru Agro produced 348 MT in 2010, 513 MT in 2012; 870 MT in 2013 and 1,145 MT in 2014. 2015 production dropped slightly to 722 MT due to drought, but rose to 1,261 MT in 2016.

Even after the grant period, it invested funds from a sister company to further strengthen the seed business. The success of this company is mostly due to the dedication and focus of the team. Like Ethiopia, the government of Tanzania did not allow private seed companies to produce foundation seed of public varieties, although this is now changing following revision of the policy. For a long time, this responsibility was entrusted only to

the government's Agricultural Seed Agency (ASA) which lacked capacity to satisfy the demand of close to 50 seed companies.

Foundation seed quality is another issue of concern. To avoid these parental seed problems, Meru Agro decided to contact CIMMYT for hybrid maize varieties, have them tested and then put into the national variety release process – a function overseen by government. Through this arrangement, the company has been able to release four of CIMMYT's hybrid maize varieties under its own name. Two have been in commercial production since 2012. This development contributed greatly to the anticipated volume jump from 870 MT in 2013 to 1,145 MT in 2014. In order to process this tonnage, the company has purchased a modern seed processing facility with automated packaging components. In addition, two new marketing managers and two new production officers have been recruited.

“When I look back on the journey we have walked as a company, words fail me. I started as an employee of another seed company, then decided to go my own way in 2005 as an agro-dealer, selling seed of other companies in one small rented room. Then with the coming of AGRA, I had the guts to venture into a full-fledged seed company and go from 12.7 MT to eventually over 1,000 MT, and grow from a one-man company to close to 30 staff, and from one room to an office of several rooms, warehouses, and branches. To me this is a miracle!”

Chacha Goryo, CEO, Meru Agro

Nafaso, Burkina Faso

Until 2006, Abdoulaye Sawadogo was a farmer producing maize grain and bananas before he ventured into seed production. He was identified in 2008 by PASS as a passionate seed producer in the difficult environment of Bobo Dioulasso, Burkina Faso. He had lost his last harvest to floods and was still waiting for payment for seeds he delivered to a parastatal a few years back. His operation was completely out of funds, yet he convinced his associates to keep going and a company (Nafaso) was registered.

PASS support allowed Nafaso to formally link up with breeders for the most advanced technologies, to train and organize farmers into a network of contract growers, to learn from experienced private seed company managers, and to increase the company's business contacts. Today, Nafaso is a pioneer in the commercial production of hybrid maize in Burkina Faso, as the company has brought to the forefront the farmer-acclaimed *Bondofa* maize hybrid. *Bondofa* was recently joined by *Komsaya* hybrid, both developed by the national research institute, INERA (*Institut National de l'Environnement et de la Recherche Agricole*). Nafaso is also INERA's partner in the production of foundation seeds of many other crops including rice, cowpea, groundnut, onion seed, and Irish potato.

Nafaso moved from the status of family business to a limited liability company, increasing employment from 23 (3 permanent and 20 casuals) to several hundred (14 permanent, 200 farm laborers, 15 seed processing employees, and 166 trained contract growers). The company received a loan from Injaro Agricultural Capital in 2012. Company assets now include a number of warehouses with individual capacity of up to 1,000 MT and a full set of seed processing equipment. Seed production jumped from 100 MT in 2007 to 1,318 MT in 2011, to 2,505 MT in 2012, and to 5,000 MT in 2015. The portfolio of seeds has been greatly diversified, and seed packaging from 50 kg bags to branded packs starting at 1 kg. Nafaso has become a rural household name through numerous on-farm demonstrations, as well as TV and radio programs. Smallholder farmers have access to the seeds through various channels, including Nafaso shops, agro-dealers, and farmer organizations.

Mr. Sawadogo and Nafaso were the winners of the 2012 AGRF prize for outstanding private sector company. In 2013, Mr. Sawadogo was among the West African private sector company representatives that met with US President Obama during his visit to Senegal.

Surprising the Skeptics

When PASS first unveiled its model of giving grants to seed companies, many were skeptical. They believed the companies would close shop as soon as the funding expired. The PASS view has always been that if it can identify good, committed private entrepreneurs who are also willing to invest their own resources, give them the necessary skills, and link them to public institutions with good varieties, they will remain in business. Years after their grants have ended, a clear majority of the companies are not only still in business but are expanding. Their growth can be measured in terms of the increased seed tonnage produced and sold, new professional staff recruited, quality systems put in place like automated accounts, new land and facilities acquired, and expansion into such infrastructure as irrigation, machinery and warehouses. Some of the companies have become bankable, leveraging resources from financial institutions to further invest in the seed business.

However, this is not to say that all grantees made it. Failures were mostly seen among farmer cooperatives/associations and NGOs. They lacked a clear business orientation and often wanted to share the profits with every member after each sales period, leaving little or nothing to plow back into the business. Several private companies also failed, with the main cause of failure being internal strife, in addition to poor decision-making.

Sustainability

PASS took the view that local seed businesses are best placed to determine which varieties are most suited to their particular agro-ecologies and thus bring the most value to their customers, a business practice that seed companies in the

developed world refer to as seed positioning. Using farmer needs and expressed demand as the foundation for building the supply chain encourages start-ups to continuously search for new breeding technologies for their customers. A side benefit to this approach is that since start-ups have low overheads compared to multinational seed companies, they can thrive on local niche markets for long periods until they develop stronger product portfolios and business skills.

Prioritizing Private Companies as Grantees

The seed business is hard – harder than most businesses. Seasonality provides a huge set of challenges, among them the fact that a company must always wait until at least the following season to market the seed crop it has just harvested. In the meantime, the seed crop must be protected from heat, moisture, insects, rodents, theft, and a variety of other threats.

Seed is a living technology, and it is fragile. The added challenges of weather risk, low levels of trained staff, and immature distribution networks make it easy to see that a seed business requires extremely strong planning and execution. Private entrepreneurs, with their desire to manage risk to turn a profit and grow their businesses, are the best possible actors in this field. However, the profit motive often appears to be only part of their vision, as many of the successful companies place equal weight on serving the farmers in their community. Clearly, however, profit motivation explains the willingness to put up with long-term risk taking, years of financial instability, planning, execution, and evaluation of new seeds.

Accessing finance

During the process of grantee identification, many start-ups complained about the difficulty of accessing credit at a reasonable rate from commercial banks. PASS has seen a significant number of companies make optimal use of their grants and emerge as viable young companies. There are now numerous examples of former grantees that have credibility with the same banks that did not want to support them a few years earlier. While it is easy to point to these successes, the stark reality is that the seed business requires high levels of working capital due to the seasonality of the cash flow and the high production cost of seed. The amount of finance flowing into the seed sector is still inadequate for Africa's needs, although countries such as Nigeria are successfully addressing these gaps.

Advocacy for an enabling policy environment

The mission of seed companies in the crop value chain is to first deliver their products and services to their local markets, and only after that to aim for national or international markets. In any mid-to-large African country, there should be at least 10-20 well-organized seed companies vying for market share. The presence of well-functioning seed companies producing and selling varieties of a wide range of crops would bring huge benefits to their countries. Food security, nutrition, farmers' disposable income, the environment, and national foreign exchange accounts, to name just a few major areas, would all benefit.

Thus, the most important recommendation for further development of Africa's seed sector is the creation of enabling policy environments for private sector operators. National governments must have policies that effectively encourage private sector participation and competition in the seed industry. Fully liberalizing foundation seed markets, removing barriers to investment, promoting adequate financing for the sector, removing government competition with the private sector, and ensuring that research and regulatory bodies are well-funded and well-run, can go a long way towards putting sub-Saharan Africa on the path to food security and more evenly distributed prosperity.

Today there are encouraging examples of reduced taxation on seed enterprises and tax breaks on importation of equipment for seed companies in some African countries. Governments should go farther to guarantee better access to credit, strengthen support to public breeding programs, facilitate access to land and irrigation for private companies and limit government interventions in seed to research, policy and regulatory functions. With a strong enabling environment, the seed sector in Africa truly has the power to transform the continent.

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5 Getting Improved Seeds to Smallholder Farmers through Agro-dealer Networks

Kebinde Makinde¹ and Fred Mubhuku²

The agro-dealer model is the single most important rural market revolution in Africa in decades. Agro-dealers expand the use of improved technologies by selling seeds and fertilizers in small, affordable packs. This also reduces the risk of experimentation with new technologies. National governments and donors need to rapidly scale up agro-dealers across rural Africa, as agreed by African heads of state at the 2006 Africa Fertilizer Summit in Abuja.

Akinwumi Adesina, 2010

Farmers need high-quality seed and planting materials to increase productivity, profitability, and incomes. Enhancing access by farmers to quality seed in a timely and affordable manner has become an important focus of development theorists, planners, and practitioners (Lynam and Twomlow 2014; Louwaars 2007).

Despite the vast array of technological innovations that have been developed for smallholder African farmers, adoption levels have been poor. Why should that be? The short answer is that technology on its own cannot bring about sustained growth. You can put good things on the shelf, but the trick is to get them into the right hands. Technology generation must go hand-in-hand with efficient and effective distribution systems that enhance access to the technologies by farmers. Clearly, the solution is to not just put good things on the shelf, but to bring the shelf itself to the farmers.

A major objective of the Program for Africa's Seeds Systems (PASS) is to ensure smallholder farmers across the continent have access to yield-enhancing technologies at the right time and at prices they can afford. Agro-dealer development is one of the pillars in the PASS value chain investments to trigger an African Green Revolution. In other words, a critical part of the business of PASS was setting up agro-dealers in rural Africa where they can make a difference.

Agro-dealers are small-to medium-sized enterprises dealing in agricultural inputs, such as seeds, fertilizers, tools and implements, agrochemicals, animal feeds, and veterinary products. The men and women who work as agro-dealers are "frontline" extension agents, providing smallholder farmers much-needed information on new farming technologies and agronomic practices. In some cases, agro-dealers also provide outlets for farmers to sell their surplus output and earn some income.

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The major goal of agro-dealer development is to develop a sustainable network of entrepreneurs who deliberately locate their businesses in rural areas to create a market infrastructure to reach smallholder farmers with high-quality inputs, technical information, financing, and access to cash markets – the tools they need to develop the prosperous livelihoods they deserve.

Agro-dealer Development: A Market-Driven Strategy

Smallholder farmers face enormous challenges in accessing good quality seed. For this reason, resource-poor farmers normally prefer using their own seeds, missing out on the benefits of high-yielding crop varieties that would increase their incomes. This, coupled with limited extension

Shining in a male-dominated field

A few years ago, Monica Awuku was one of many small entrepreneurs in Ghana who struggled for funds to set up and run small businesses. She worked hard to establish an agro-chemical business, but she did not have sufficient capital.

But by 2014, this mother of three had become the leading female agro-dealer in the Volta Region of eastern Ghana.

Her breakthrough came in 2012 when PASS gave her technical and financial assistance through its guarantee fund system. Though she was already a member of an input dealers' association, her relationship with PASS gave her the opportunity to acquire new skills through specialized training programs.

Before 2012, Monica had one shop, the Green Acres Agro-Shop in Ho, the regional capital of Volta. With financial assistance from PASS, she added two more. Her business is well-stocked and expanding rapidly. She has earned enough profit to build her own house and a residential block for rent. She also bought a vehicle for her business.

Taking note of Monica's business acumen, PASS trained her to mentor other businesspeople. Inspired, in 2010 Monica began to pursue a BSc degree in agribusiness. She received her degree in 2013.



Monica has employed five people to meet the growing demands of her business, and has also started off two women in the agro-dealer business. Monica is now eyeing another enterprise – moving into a distributorship.

services, effectively restricts Africa's farmers to using poor farming practices, leading to low crop yields.

Sometimes quality seeds may be available but farmers are unaware of their existence. Other barriers that farmers encounter include high prices, adulteration, and lack of access to credit. Thriving agro-dealer networks that respond to market needs can help overcome some of these challenges. Between 2007 and early 2017, PASS invested over USD 38 million to develop agro-dealers in 15 African countries (Figure 5.1).

Agro-dealer development is at the center of a market-led approach that PASS adopted to stimulate input use across Africa (Figure 5.2). Core elements in the strategy include agro-dealer mapping, training and certification, technology transfer, association building, financing and resource mobilization, advocacy, and communication.

Blended in different combinations, these strategic elements guided the work of service providers with whom PASS partnered to develop the business acumen of the agro-dealers we wanted to support.

Laying the foundation

Through a combination of open bidding and headhunting, PASS identified credible institutions working in agricultural development that could help to kick-start agro-dealer development.

In the early years of PASS's operation, international non-governmental organizations (NGOs) were selected because few local organizations had the required expertise in agri-business and input market development. Early partners included Citizens Network for Africa (CNFA), the International Fertilizer Development Center (IFDC) and CARE International.

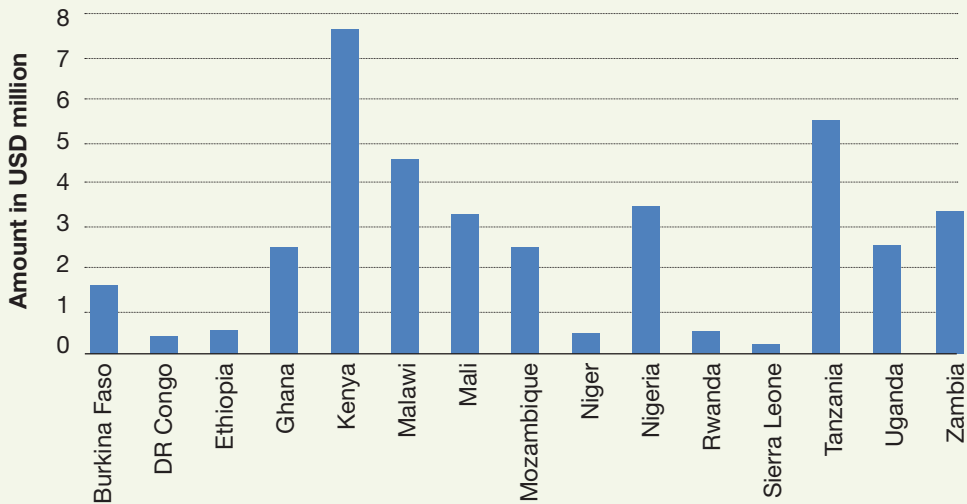


Figure 5.1. PASS investments in agro-dealer development in sub-Saharan Africa, 2007–2016

ADP focuses on functional capacities, while improving financial access awareness, and technology uptake

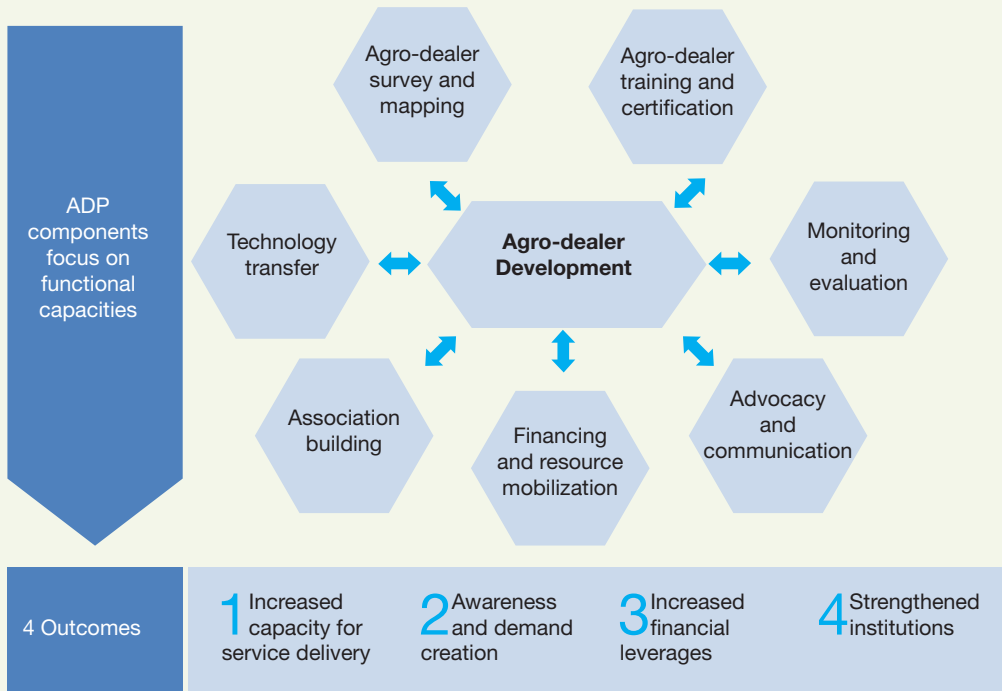


Figure 5.2: Strategic elements of agro-dealer development at PASS

From the start of the agro-dealer development sub-program in 2007, the development of local organizations was a key focal activity. This was a milestone in building local capacity for agricultural development. The role of local non-state value chain players working with PASS has progressively increased over the years. Table 5.1 shows the total investment and diversity of implementing partners across the 15 countries in the agro-dealer program. By the end of the PASS initiative, of the 18 service providers that had partnered with PASS, three were international NGOs, 11 were local NGOs, two were financial institutions, and one was a government institution.

The pioneers

With the first implementing partners on board, the next step was to establish the status of the agri-input market in each country. Using standard survey methods, the service providers mapped existing wholesale and retail businesses dealing in farm inputs.

The results revealed a situation that begged for intervention. Very few agro-dealers were operating, and these focused mainly on towns and big trading centers. Most were dealing in livestock drugs and feeds, agrochemicals, tools, and horticultural seeds. Very few stocked fertilizers or seeds of important staple crops like maize. In many countries, cooperatives and government agencies dominated the market.

Table 5.1: List of service providers for agro-dealer development engaged by PASS

	Country	Total investment (USD)	International NGOs	Local NGOs
1	Burkina Faso	1,753,413	IFDC	AGRODIA
2	Ghana	2,500,000	IFDC	GAABIC
3	Nigeria	3,500,000	IFDC	
4	Mozambique	2,125,950	IFDC	AGRIMERC
5	Kenya	7,316,661	CNFA	AGMARK
6	Malawi	4,422,851	CNFA	RUMARK
7	Mali	3,157,570	CNFA	MALIMARK
8	Tanzania	5,556,661	CNFA	BRITEN
9	Zambia	3,380,896	CARE	NAT
10	Uganda	2,592,123	-	UNADA & AT Uganda
11	Niger	462,112	-	CEB
12	Ethiopia	517,536	-	RCDC
13	Rwanda	513,600	IFDC	AGRIFOP
14	Sierra Leone	250,000	-	EDS
15	DR of Congo	399,744	-	AGMARK

IFDC = International Fertilizer Development Corporation; AGRODIA = *Association des Grossistes et Détaillants d'Intrants Agricoles du Burkina*; GAABIC = Ghana Agricultural Associations Business and Information Centre; AGRIMERC = *Organizacao para o Desenvolvimento Sustentavel da Agricultura e Mercados Rurais*; CNFA = Cultivating New Frontiers in Agriculture; AGMARK = Agricultural Market Development Trust; RUMARK = Rural Market Development Trust; MALIMARK = Mali Agricultural Market Trust; BRITEN = Building Rural Incomes through Enterprise; NAT = Nutri-Aid Trust; UNADA = Uganda National Agro-input Dealers Association; AT Uganda = Agriculture Trust Uganda; CEB = *Contribution A L'Education de Base*; RCDC = Rochdale Cooperative Development Consult; AGRIFOP = Agribusiness Focused Partnership Organisation. EDS= Enterprise Development Services, Sierra Leone

In view of the shortage of agro-dealers, PASS began collecting information on potential dealers during the initial survey. The list included general traders, retired civil servants, extension workers, produce traders and processors, and enterprising farmers. The names on the lists – our potential investors – were the first cadre of entrepreneurs to benefit from PASS support. More recently, a new crop of young, educated people with diplomas and degrees have joined the business, most likely attracted by increasing demand for improved seeds and other quality inputs that farmers need.

Training and certification of agro-dealers

Setting up agro-dealer businesses does not guarantee that they will be able to respond effectively to market demands. Most rural agro-dealers lack the technical and business skills to meet the needs of smallholder farmers. Yet agro-dealers are not only expected to sell inputs, but to also provide extension advice to farmers.

Unlike trading in ordinary fast-moving consumer goods, dealing in improved seeds, fertilizer, and crop protection products requires at least basic technical knowledge about the products. Agro-

dealers need to know how to handle and store inputs properly to maintain quality, to protect users and handlers from potential harmful effects, to advise farmers on the most suitable products, and how to properly use them for maximum benefits.

Well-trained agro-dealers with the right information and skills can improve farmer demand for yield-enhancing technologies, especially in remote locations without a vibrant public extension system (IFAD 2004). Farmers know a good thing when they see it.

To enhance the knowledge and skills of agro-dealers, PASS supported various service providers to design a training intervention with three key modules:

- *Business management training* includes topics on basics of marketing, record keeping, business planning, credit management, inventory management, customer care and sales forecasting.
- *Technical training* covers basic knowledge about seeds and fertilizers, including the different types of products and their field performance.
- *Safety-in-use training* includes aspects of proper handling, storage, and use of improved seeds, fertilizers, and crop protection products.


In some countries, these modules have been translated into local languages to make them accessible to a wider audience. In most cases, external trainers from input supply companies, financial institutions, and government regulatory agencies are invited to give practical examples. To reinforce key messages, trainers visit and mentor individual agro-dealers. Additionally, groups of dealers are brought together in “business clinics” to share experiences.

On completion of the three modules, agro-dealers are certified by regulatory institutions. Certification by these institutions buoys government confidence and reinforces input dealers’ self-assurance. Farmers, input suppliers, and financial institutions also have confidence in certified traders.


From 2007 to early 2017, the program trained 20,038 agro-dealers in technical knowledge, and 20,017 in business management (Figure 5.3). A total of 19,174 agro-dealers had been certified by early 2017 (Figure 5.4).

The training and skills acquired by agro-dealers benefit them in many other ways. The traders become more competent and are recognized by stakeholders – farmers, community leaders, development workers – as credible sources of improved inputs and technical knowledge, as well as reliable off-takers of farmers’ produce.

The business skills acquired are transferable. Once trained, an entrepreneur can use the skills in other ventures, including commodity trading and seed production. For example, Dryland Seed Company in Kenya started as an agro-dealership and evolved into a full-fledged seed enterprise.



As of March 2017, PASS supported agro-dealers had established 7,679 demonstration plots and organized 4,264 field days across the 15 countries in which it works.



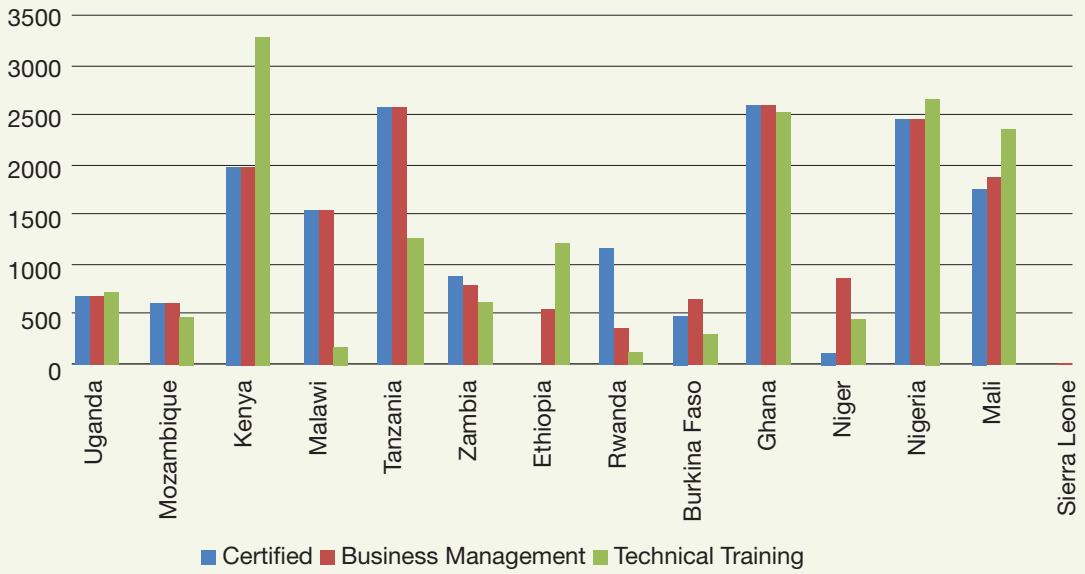


Figure 5.3. Number of agro-dealers trained through PASS funding, 2007 to March 2017

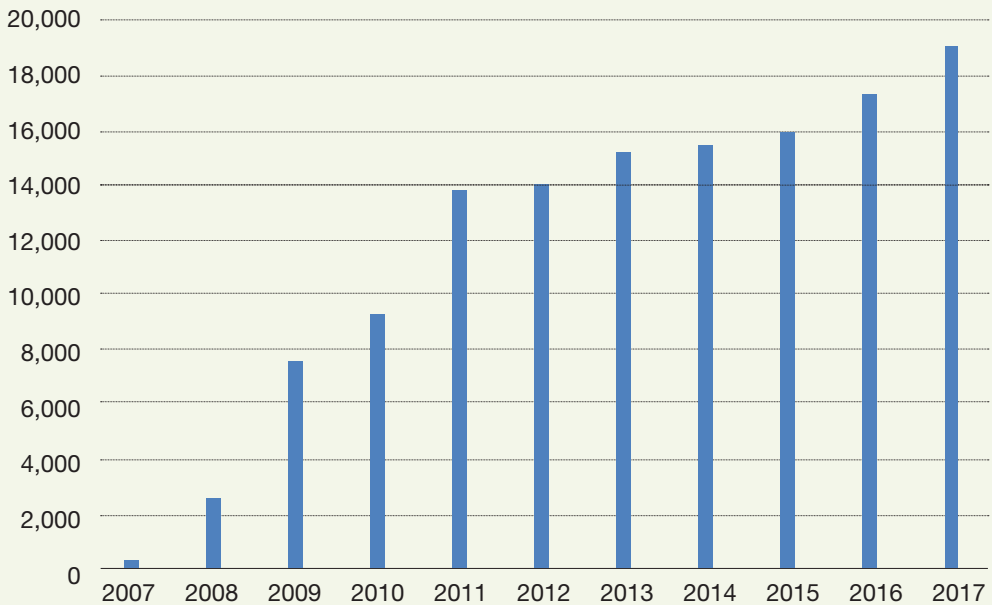


Figure 5.4. Total number of trained and certified agro-dealers, 2007 to March 2017

Business training triggers successful seed enterprise

Nelia Banda, 51, started her business after attending a PASS-organized business management course in 2010. With her own savings, she constructed a shop from home-made bricks, registered a business, and obtained a seed seller's license.

She set up her small agro-shop in Nyanje village, 87 km from Petauke town in Zambia's Eastern Province. The first year she made only USD 50, but by 2013, the business was generating annual profits of USD 4,000.

Nelia says she has benefitted immensely from promotions done by her agro-dealer association, such as demonstrations, field days, and seed fairs. Today, six leading seed companies supply the shop with seed on consignment.

In 2011, Nelia sold over 6 tons of maize seed. Sales almost doubled to 11.0 tons in 2012, and stood at 17 tons in 2013.

Nelia has built a warehouse and a six-room family house. She is also able to pay for two sons at the university. Such impressive stories MUST be told with pictures.

Facilitating access to credit

Although well-trained agro-dealers have tools that help them to focus on farmers' needs, they often lack capital to stock the full range of products farmers require. Like other enterprises, agro-dealers need timely credit to expand and strengthen their businesses. However, these entrepreneurs face an uphill task negotiating for credit because lending institutions traditionally perceive anything to do with agriculture as a high-risk investment.

PASS uses various approaches to position traders to become more attractive to lenders. Our business management training equips them with entrepreneurial skills, a plus in credit appraisal by banks. PASS also supports traders to develop bankable business plans.

In the early years of PASS (2007–2011), the program had a credit guarantee fund for supporting agro-dealer enterprises to obtain credit.

Service providers received funds from this facility and used them in different ways to capitalize traders.

First, service providers guaranteed traders taking loans from banks. After the traders repaid their loans, the money was released to benefit others in the network. This guarantee was extended to input suppliers who provided inputs to agro-dealers on consignment.

Second, the fund financed agro-dealers to set up business partnerships with input suppliers such as seed companies and fertilizer businesses.

Third, we provided support to agro-dealers in form of matching grants to open new outlets, refurbish or relocate shops, or diversify to post-harvest activities such as milling and output marketing. In Zambia, for instance, a total of USD 500,000 was disbursed in the form of risk-sharing matching grants between 2007 and 2011.



PASS facilitates “a handshake with financial institutions” by introducing traders to lenders and helping both to understand each other.

The matching investment grants were crucial in helping to set up agro-dealer shops in remote, underserved areas. The grants also supported agro-dealers to diversify their businesses to include sale of outputs to stabilize revenues.

The fund is now predominantly implemented by financial institutions after AGRA consolidated its credit support activities into a finance scheme that negotiated and rolled out a broader credit support program.

Demand creation activities

Demand creation activities are important for agro-dealers for two inter-related reasons. First, they are a standard promotional tool used to boost their businesses. Second, they help to inform farmers about improved inputs and lead to increased demand for these inputs.

Input supply companies, public extension services, and NGOs are key partners in creating demand for agricultural products and services. They work together to establish demonstration plots to show the performance of selected crop

varieties and practices such as use of fertilizers, appropriate plant spacing, and timely planting. Field days are held to create awareness about farming practices and agricultural inputs. The events also encourage networking among farmers, agro-dealers, extension agents, local opinion leaders, and other community members.

Such field days can be conducted several times during the course of a growing season to show good practices in various aspects such as planting, weeding, and harvesting.

A combination of demos and field days is now being used extensively to promote commercialization of new varieties released by PASS-supported breeders. Agro-dealers are also encouraged to take part in other public awareness events, such as agricultural shows, trade exhibitions, and seed fairs, to improve farmers’ familiarity with seeds.

By March 2017, PASS supported agro-dealers had established 7, 679 demonstration plots and organized 4,264 field days across the 15 countries in which it works.

The net result of these activities has been an improvement in volumes of seeds and fertilizers sold by agro-dealers, which almost quadrupled from 386,000 MT in 2007 to 1,525,689 MT in 2017.

With increased awareness of input demand, agro-dealers became interested in establishing new outlets to harness new business opportunities. They provided options for farmers by stocking a wider choice of varieties.

Given their training on product attributes and knowledge of local conditions, agro-dealers could provide the right information in response to farmers’ inquiries about varieties such as time of

planting, maturity dates, type of fertilizers, time of application, and other agronomic practices.

Opportunities to learn together on demonstration plots during field days and seed fairs as well as on radio and television programs

further exposed farmers to the potential benefits of improved seeds. Some agro-dealers provided seeds on credit to farmers, just as they also obtained credit from major input suppliers.

From struggling grocery to thriving agro-input hub

Christine Daka typifies how agro-dealers respond to new opportunities. Ms. Daka runs a successful agro-dealer business in Kaumbwe village, 45 km from Petauke town in eastern Zambia. The 46-year-old single mother was running a struggling grocery business until a local PASS service provider identified her as a potential agro-dealer in 2010.

“I attended training in business management, after which I made a decision to include fertilizer and seeds in the shop,” says Christine.

Christine registered her business, One Sister Agro Dealers, and started trading. But the business remained small until 2012 when she met input suppliers through a series of meetings organized by the project. She was introduced to suppliers, who started giving her inputs on credit. For instance, SeedCo provided a container of seeds on consignment in 2013 and four containers in 2014.

In the 2013/14 season, Christine sold 40.8 tons of seed and 48 tons of fertilizer, earning a profit of ZMW 35,000 (over USD 5,000), up from about ZMW 5,000 (USD 780) just two years earlier.

From her profits, Christine built a larger shop with more storage space. She also bought a truck to distribute inputs as she gears up to operate as a hub agro-dealer. And she has opened two other outlets. Christine currently enjoys good business relations with all major seed and fertilizer companies in Zambia.



Left, the old “One Sister” shop; Right, the new shop

Stronger together: supporting development of associations

Agri-input value chain stakeholders, like the entire agriculture sector, face challenges that require strong institutions to advocate for an enabling business environment. Credible agro-dealer associations, from grassroots to national levels, can provide a voice for articulating common aspirations. PASS recognizes the importance of collective action and supports efforts to build and strengthen dealer associations at different levels.

Through PASS support, dealers formed and registered formal associations, complete with elected committees, constitutions and funded secretariats. The support was extended to training in organization development, including strategic planning, to ensure effective management and sustainability of the groups.

In countries where national associations existed, PASS focused on strengthening the institutions. As a result, national associations such as the Uganda National Agro-Input Dealers Association (UNADA) and the Ghana Agri-Input Dealers Association (GAIDA) are key players in national policy forums. In other countries where national associations did not exist, such as Nigeria and Mali, PASS facilitated the emergence of associations.

Agro-dealer strengthening also involved organizing the agro-dealers into professional business associations able to provide training, financial linkages, and demand creation. Such value-adding activities boost membership and financial health of the associations. For instance, membership in agro-dealer associations in Nigeria increased six-fold, from 400 in 2008 to 2,700 in 2011. In Uganda, membership almost tripled, rising from 870 in 2007 to 2,500 over the same period.

One direct outcome of support to associations was improvement in organizational, managerial, and financial sustainability. With increased membership and dues accruing from services provided, many associations are financially empowered. Some of these associations use funds accumulated from service fees to sustain activities initiated by the project, such as training.

Empowered associations provided a pool of service providers in follow-up programs implemented at much lower costs. In Uganda and Ghana, for example, the national agro-dealer associations are implementing the agro-dealer development activities themselves.

Agro-dealer associations have also instituted mechanisms to self-regulate the activities of its members through peer pressure and better rules. For instance, UNADA now has a code of conduct to ensure integrity of operations by its members.

Associations play a role in demand creation by facilitating discussions about input markets on national radio and television stations. District agro-dealer associations in Zambia organize demos, field days, and seed fairs within their regions, thus promoting their members' businesses.

The existence of functioning agro-dealer associations has helped convince the national governments in Burkina Faso, Mali, and Nigeria of their value, and to implement targeted subsidy schemes through agro-dealers. In Uganda, UNADA led the development of a national seed policy that was debated in Parliament in 2014.

Mapping Agro-dealers to Improve Market Coverage

PASS conducted surveys and mapped the location of agro-dealers (see Figure 5.5 as an example of such mapping, in this case for those that received PASS training in Ghana). The program used the information collected to create geo-referenced databases, which proved effective in networking and building business partnerships with farmer-based organizations and other value chain actors.

In this way, it became easier for farmers and organizations that support them to locate agro-dealers. The information is also used by PASS to improve the agro-dealer networks by focusing efforts on areas where few agro-dealers are located. A good example of an intervention informed by results of the mapping is *Deepening Agro-dealer Impact in Coastal Kenya (DAICK)*, an initiative supported by PASS.

The databases have also become valuable tools for implementing new policy reforms to improve

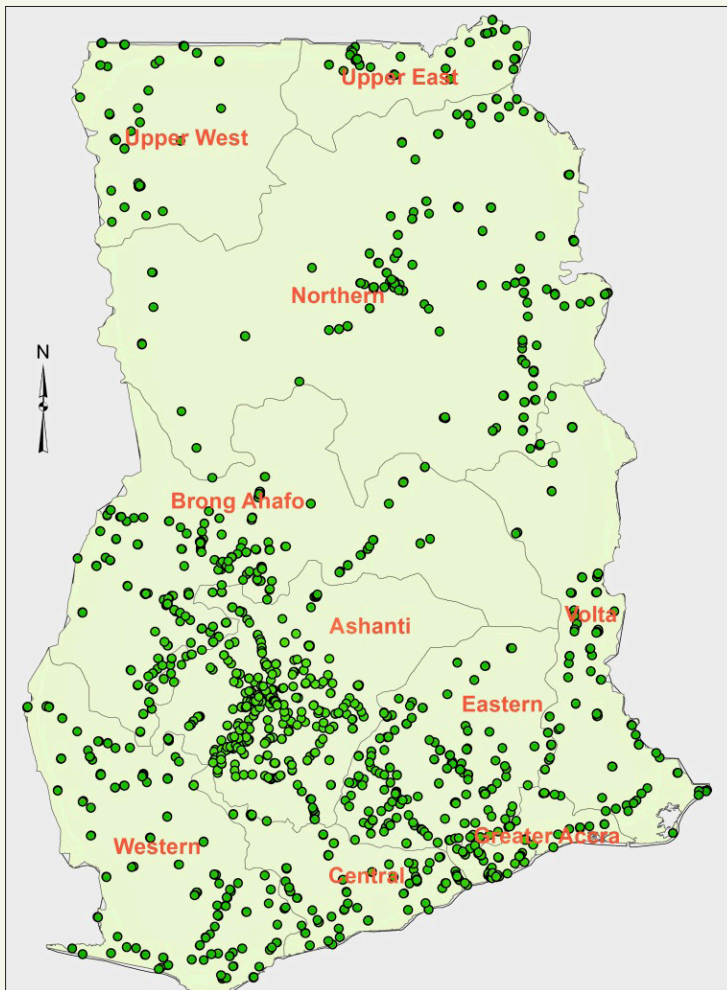


Figure 5.5: Location of agro-dealers in Ghana that received training from PASS

access to seeds and fertilizers for smallholder farmers. Because of the strength of their network, agro-dealers became an acceptable conduit for governments to implement input voucher schemes with minimal disruption of the input markets. With accurate databases, other innovations such as dissemination of market information, mobile phone text-based messaging, and credit facilitation have been introduced to offer business support to agro-dealers, as the GADD case study shows.

Using data from the survey, PASS worked with partners to develop SMS platforms that link actors within the seed production and distribution chains. Dealers use this technology to get up-to-date information from each other, local associations, and other information service providers. Traders use their phones to organize delivery times with suppliers, ask for and share advice with colleagues, and receive regular automatic SMS messages containing market.

PASS also provided information on the investment opportunities in the agro-dealer sub-sector through geographic information system (GIS) mapping, created business linkages with seed and other input suppliers, and facilitated an increase in the number of retail outlets, especially in rural areas.

Expanding the Network Brings Services Closer to Farmers

A key finding at the start of PASS in 2007 was that farmers walked long distances to buy farm inputs because agro-dealers were few and served vast catchments. Expansion of agro-dealer networks has reduced these distances (Figure 5.6).

Evidence from Ghana illustrates this achievement. In 2007, farmers in the country walked an average of 30 km to access inputs.

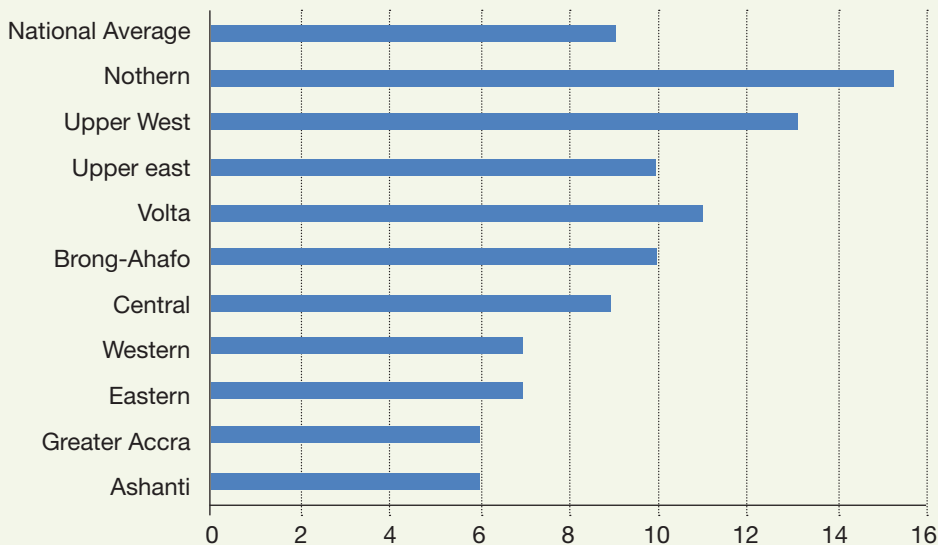


Figure 5.6: Average distance traveled by farmers to agro-dealers in Ghana, by regions, 2011

Linking seed producers to agro-dealers

Ghana Agro-Dealer Development (GADD) linked seed producers to agro-dealers through mFarms, a mobile phone platform. This service sent short text messages to numerous agro-dealers to announce the availability of seeds.

More than 700 agro-dealers from Eastern, Greater Accra, and different parts of Volta region of Ghana received the texts and wound up doing business with the seed company. In response to the new demand fuelled by the promotion, the company opened four distribution points in the Northern Volta,

Southern Volta, and Eastern regions to serve agro-dealers.

The SMS service has not only shortened search and discovery time for market information, but has opened avenues for farmers to access high-quality improved seeds from agro-dealers without having to travel far from their farms.

mFarms also hosts the agro-dealer directory created with PASS after a private firm, Image-AD, took up the listing and made it available on the platform.



PASS invested heavily in the training and establishment of thousands of village-level agro-dealers like this one in Western Kenya, removing the key physical barrier of access to improved seed for smallholder farmers, in many cases allowing them to purchase higher-yielding, certified seed for the first time.



Linking seed companies to agro-dealers in remote villages gave farmers in Mali their first opportunity to purchase certified seed of staple food crops. Once farmers saw the advantages of improved varieties, they began to ask for more choices.

By 2014, the distance had been cut to 9 km, according to research by the International Food Policy Research Institute (IFPRI) and International Fertilizer Development Corporation (IFDC). A 60-year-old woman who needs a 50-kg bag of fertilizer may not be able to manage a 30-km trip on her old bicycle. But when the distance is cut to only 9 km, she has a shot at it.

Easy access to dealers has boosted input sales by traders in Ghana. Sales of seed increased by 40% over 3 years, while fertilizer use doubled over the period.

Enabling subsidy schemes

The participation of agro-dealers in input voucher schemes provided a good opportunity

for governments to better appreciate the challenges and prospects of scaling up input market development.

As a result, the governments of Kenya, Malawi, and Tanzania changed from direct involvement in inputs distribution to using smart subsidy schemes through trained agro-dealers. This enhanced access to subsidized inputs by farmers. In Burkina Faso, farmers were impressed with the quality products supplied under the subsidy scheme by agro-dealers directly linked to the supply chains.

Engagement with agribusinesses helped policy makers to better understand payoffs in instituting a farmer focused distribution system that minimizes disruption of the agri-input marketing system.



Along with new seed, fertilizer, and other supplies, private local agro-dealers have become important sources of new information for smallholder farmers across Africa.

Ensuring sustainability

Concerns over sustainability of the PASS agro-dealer development program led to the design and introduction of strategic elements to strengthen the capacity of agro-dealers to respond to market operations based on lessons from implementation.

Informed by lessons learned, stakeholder recommendations and external program reviews, PASS implemented six measures to sustain agro-dealer networks and services.

- 1) *Development of hub agro-dealers.* Training courses are run by successful traders who have been specifically trained and enlisted to mentor start-ups and assist them with input credit and other business support. This concept emerged when growing agro-dealers took up bulk input procurement and marketing. A case in point is Sunuku

Cutting down the distance

Sunuku Agrovvet is in Langhangarer, a village at the base of Lake Eyasu in Tanzania's Arusha Region. The business grew fast because of a large customer base. Previously farmers travelled 75 km on bad roads to get inputs from Karatu, the nearest town.

Though there are large agro-dealers in Karatu, Sunuku could get inputs from Karatu only at the retail price. This meant that the trader could not make much profit. To get inputs at wholesale, the dealer traveled 200 km to the regional capital, Arusha. Transport costs ate into his meagre profit.

To support businesses like Sunuku, PASS developed hub-agro-dealers in the distribution network to provide wholesale services to rural retailers. Sunuku now buy inputs from hub-agro-dealers in Karatu at wholesale prices.

The creation of hub-dealers has greatly improved efficiency in the supply chain – as well as profits for businesses and better access to affordable inputs for farmers.

Agrovot in Tanzania, as the Sunuku story in the box attests.

- 2) *Use of commercial trainers in capacity building.* Fee-charging service providers were co-opted to meet the challenges posed by the rapid growth of agro-dealerships. Initially, the project met the cost of training, but limited funds meant not all agro-dealers could benefit. Agro-dealer associations suggested that members contribute to the cost of training so that the benefit could spread to others, an indication that they valued the service.
- 3) *Strategic linkages and business partnerships with value chain actors.* PASS fostered linkages between agro-dealers and other players in the value chain such as farmer-based organizations, seed companies, and fertilizer businesses through memoranda of understanding, business roundtables, crop demonstrations, business reviews, and policy engagement. Private sector-driven tools such as the mobile phone-based market information platform, the *mFarm* in Ghana, and agro-dealer directories will help to sustain linkages.
- 4) *Innovative financing.* The credit guarantee scheme AGRA operates through PASS proved to commercial lenders that agro-dealers are bankable. The good repayment record of traders (over 80%), coupled with growing agro-dealer associations, encourage banks and microfinance institutions to give credit to agro-dealers.
- 5) *Increase local capacity.* One of the most remarkable achievements of the agro-dealer program was building the capacity of local service providers through collaboration with international NGOs. Some of the

service providers are now affiliates of the international organization, which positions them to provide services across the input value chain.

- 6) *Policy advocacy.* Strong agro-dealer associations will continue to play an important role to sustain gains made with support from PASS. The project helped to entrench policy changes to promote agro-dealer business by facilitating agreements and memoranda of understanding to promote better seed varieties, increasing public awareness of issues affecting the supply and use of inputs, and encouraging agro-dealer associations to participate in forums such as national seed exchange working groups.

Challenges and Lessons Learned

Limited experience with financial linkages and the bureaucratic and stringent requirements of financial institutions delayed the supply of credit to agro-dealers. As a result, the volume of credit and number of agro-dealers that benefited from banks were short of target. In some cases, agro-dealers were helped through financial support innovations that included the use of supplier credit, matching funds, and recourse to microfinance institutions.

Many agro-dealers found it difficult to access adequate volumes of improved seeds and fertilizers. This is due partly to the low volumes of high-quality seeds available and limited capacity by traders to work over extended geographic areas.

Unfair competition from fraudulent seed producers purveying low-quality seeds is another big challenge. However, PASS expect to see this

challenge dissipate as genuine seed companies increase the volume of seeds they produce and agro-dealers become a stronger voice against counterfeiters.

Mixed in with the good news is the bad news is that funding to support training for all interested parties is insufficient. In Nigeria, for instance, PASS invested USD 3.5 million to train 2,500 agro-dealers selected from a pool of about 12,000. It would take an additional USD 13.3 million to cover all those interested in receiving training.

While local training service providers are offering some of the training needed to professionalize agro-dealers, these service providers lack adequate expertise and resources. For instance, they cannot afford to translate and tailor modules into audio-visual formats that are easier to understand for semi-literate agro-dealers.

Finally, building business linkages between agro-dealers requires building trust among the different value chain actors. Without trust, the prevailing low access to technologies by smallholder farmers cannot be reversed.

PASS is using these and other emerging lessons to refine its agro-dealer development interventions and build stronger partnerships with other actors and stakeholders.

Conclusions

PASS facilitated training and certification of over 19,000 agro-dealers in 15 sub-Saharan African countries. Through this network, 403,638 MT of seed and 1,525,689 MT of fertilizers were sold to farmers between 2007 and March 2017. Trained agro-dealers also accessed over USD 51 million worth of credit from financial institutions. This demonstrates that PASS investments have not only enhanced the service orientation of agro-dealers to their clients, but it has also helped them to improve business relations with input suppliers.

Across Africa, agro-dealers have gained a reputation as critical value chain actors in agricultural development by governments, donor partners, regulatory agencies, and farmer-based organizations. Trained agro-dealers are providing much-needed farmer education, complementing the role of extension services, while their associations are taking on the role of training to ensure competencies are sustained. Indeed, developing agro-dealer networks provides an infrastructure that can effectively deploy innovative practices, such as use of soil fertility test-kits and urea deep placements, as well as appropriate farm equipment targeting smallholder farmers.

PASS's investments in agro-dealers have generated fundamental changes in policy by demonstrating that the local private sector is effective, and that, given the right environment, can increase access to inputs by farmers.

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6 From Shelves to Farms Through Public-Private Partnerships

Regina Richardson¹ and Sammy Okita²

Ever since he inherited his own piece of land, Wahabu Yahaya has been growing maize on his farm in Dimabi, Northern Ghana. He sows two hectares to maize, carrying on a family tradition of growing this important staple food crop.

But until recently, despite his best efforts Wahabu was unable to harvest any more maize than his parents had for decades – four or five 100-kg bags per acre (1.25 MT/ha) each season. This harvest was hardly enough to sustain his household of 15 members.

In 2013, Wahabu's fortunes changed dramatically for the better when Heritage Seed Company, with support from AGRA, introduced him to a high-yielding hybrid maize variety called *Mamaba* ("mother's child" in the local Twi language). Although *Mamaba* had been developed and cleared for commercial use in Ghana in 1996, it was not readily available to many farmers. Wahabu was happy with the harvest and wanted other farmers to benefit. Heritage Seeds was also impressed with Wahabu's farm, and contracted him as an out-grower to produce *Mamaba* seed, which in turn allowed many more farmers to benefit from the higher-yielding capabilities of hybrid maize.

Thousands of kilometers to the east in Kenya's Great Rift Valley, a farming couple, Elizabeth

and Joseph Gathuru, are planting five new improved orange fleshed sweet potato varieties (OFSP) – *Kenspot 1*, *Kenspot 2*, *Kenspot 3*, *Kenspot 4* and *Kenspot 5* – as commercial secondary vine multipliers. These two farmers have made a name for themselves, as well as some badly needed cash, multiplying varieties of early-maturing, vitamin A-enriched sweet potatoes developed through a grant from AGRA by Dr. Laura Karanja and Dr. Joyce Malinga, plant breeders working at Kenya's Agriculture and Livestock Research Organization (KALRO) Njoro centre. The new OFSP varieties are popular among farmers because, unlike traditional varieties, they grow well in high altitude areas with erratic rainfall. The introduction of the orange fleshed sweet potato products in school feeding programs, together with the value added by small-scale entrepreneurs within local households who make OFSP cakes, has increased the market demand for vines. The two farmers multiply and sell clean vines to other interested farmers at one shilling per vine. When they started in 2013 they were able to sell on average 30 bags of vines, earning up to 260,000 Kenya shillings, much needed income that they used to pay school fees, buy two dairy cows, and renovate their home.

We highlight these two farming families here because they demonstrate the power of commercializing new crop varieties. Reducing turn-around times between the official release of a new crop variety and its appearance in the

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market involves streamlining a series of steps that take the seed from variety release by the breeding station to licensing, production, certification, and marketing.

Every public plant breeder has a story to tell about the frustration of seeing their hard work get stuck in the wheels of bureaucracy, or sit on the shelves of research organizations. These two cases, plus countless others like them, provide evidence that it is possible to significantly reduce delays in getting high-quality seed to the farmers who need it.

The Turning Point

Within a year of AGRA's establishment in April 2007, national research breeding programs that had transitioned to PASS from being supported

by The Rockefeller Foundation released 24 new varieties, three quarters of which were commercialized. During subsequent years, the national breeding programs continued to release more varieties, a direct result of the catalytic effect of five years of training scientists and making targeted investments to re-energize and retool research institutes. By 2010, 163 varieties had been released. That year alone, 142 of the 163 varieties released were put on the market, an impressive 4 in every 5.

Then came the turning point. The number of new released varieties increased significantly in in both 2011 and 2012, outpacing efforts to commercialize them (Figure 6.1). In 2011, private companies were only able to put into commercial production half the seed varieties released by increasingly efficient breeding systems.

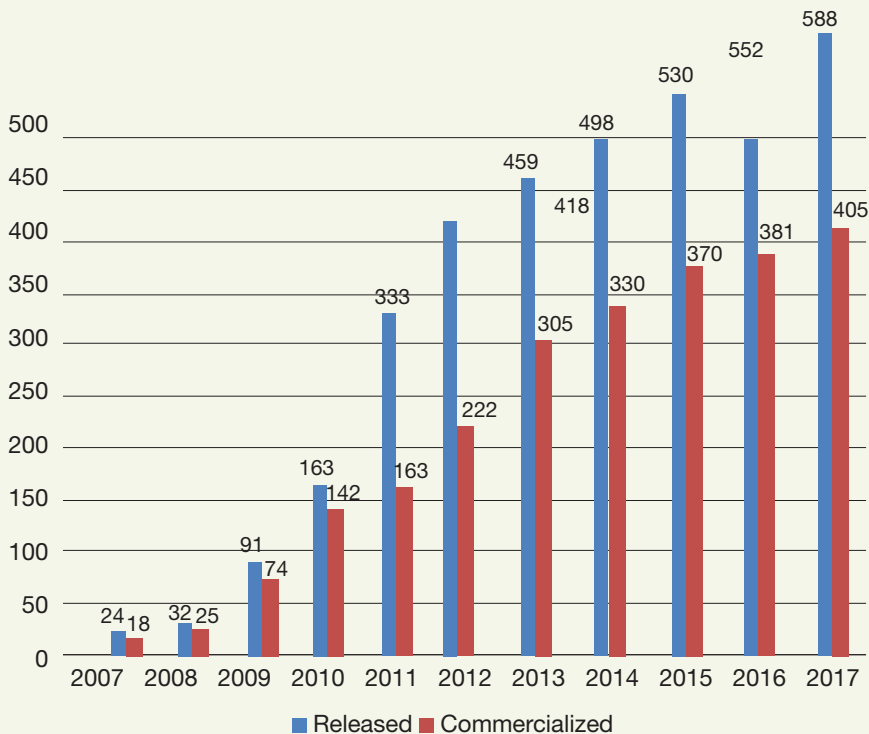


Figure 6.1: Status of varieties released versus varieties commercialized, cumulative totals from 2007 to March 2017



Profits earned from the sale of fast-moving products such as hybrid maize seed allow seed companies to add improved seed of other crops to their product lines. Here a sales assistant at Dryland Seed Company of Kenya shows small packs of seed of improved bean and cowpea varieties.

This falling proportion of new crop varieties reaching farmers at-scale forced the PASS team to pause and take stock. Clearly, something needed to be done. No one wanted desperately needed seed to be stuck in the pipeline. The team's diagnosis of the problem revealed three bottlenecks that had been hidden in plain sight.

The first was frosty relations between the public research organizations responsible for breeding and the private companies best placed to produce and market new varieties. Misgivings between these two groups are rooted in history. For decades throughout most of Africa, everything related to crop breeding and improved seed, including production and marketing, remained the exclusive domain of government agencies. When policies were liberalized and seed entrepreneurs began to emerge in the 1990s, their focus was largely

limited to marketing of standard, well-known varieties. Knowledge of the value of new crop varieties was scant, and difficult to obtain. Hence, lag times between the release and the commercialization of seed of the new varieties remained worryingly high.

Another bottleneck lay within the seed companies. Many signed licenses to produce the new varieties for commercial production but lacked the skilled people or resources for effective sales and promotion. Others simply did not have sufficient land to produce seed of the new varieties at scale.

A third crucial bottleneck that was encountered was the inability of public researchers and foundation seed agencies to produce sufficient quantities of breeder and foundation seed to meet the rapidly increasing demand by seed companies, which in turn were responding to increasing

farmer demand for certified seed. For example, in 2013 two start-up companies in Kenya were licensed to multiply and sell a newly released bean variety, but were unable to acquire the 30 kg of breeder seed they needed to get started.

PASS program officers met with government officials in each program country, making the case that, in addition to the foundation seed being supplied by government agencies, private seed companies should be allowed to produce foundation seed under the supervision of public breeders. In several countries, the strategy worked. Foundation seed supply became less of a problem in Malawi, Uganda, and Mali, for example. But in other countries, governments were adamant that foundation seed was the exclusive domain of public agencies, and its supply became a major constraint to further progress. The fact that PASS was funding both breeding programs and seed companies made the search for solutions to these three problems even more urgent.

Getting Seeds to Farmers: An Arduous Task

The PASS team agreed that thawing relations between the two camps through mediation would help, but it would not be a magic bullet. Ensuring effective and growing private-public partnerships would take a more comprehensive and sustained effort.

Thus, in 2013, based on recommendations from the PASS Phase I Mid-Term Review, a new unit was formed with the primary mandate of improving commercialization of newly released seed varieties across AGRA's target countries with a focus on strengthening partnerships between public plant breeders and their institutions and private seed companies. With a staff of four – three seconded from within the PASS program – the commercialization team was mandated to fast-track the journey of new varieties from research shelves into input markets and farmers' fields.



Farmers are often reluctant to try new varieties they have never seen in the field. Small (50 g or 100 g) packages of seed, marketed in places frequented by smallholder farmers, reduce the perceived risk of trying a new variety.

The team's first step was to improve working relations between public breeding organizations and private seed companies. Over several months, the PASS team organized round table discussions to discuss and resolve differences of views and plot a way forward. These meetings set the stage for developing an important cross-cutting function in AGRA's seed systems investments.

A promising start

By the end of its first year, the commercialization team had achieved significant success in bridging the gap between breeders and private seed companies. In Kenya, for instance, breeders began working closely with private seed companies on joint field trials to ensure faster selection and licensing of varieties for multiplication and marketing.

In Uganda, five newly released varieties of rice and two newly released maize varieties were taken up by seed companies immediately after their release in 2013. With PASS support, the companies negotiated and signed memoranda of understanding to bulk foundation seed and market the new rice varieties. The rice breeder, an alumnus of the PASS-funded training program at ACCI, gave each company 3 kg of breeder seed of each variety. He also provided technical advice to ensure the companies produced quality foundation and certified seed for the market.

In Ghana, to forestall a lack of breeder seed the maize breeder, Dr. Kwadwo Obeng-Antwi, worked closely with several seed companies, most notably Heritage Seeds, Innovations Village, and M&B Seeds to increase parental lines of newly released high-yielding maize hybrids during the main season of 2014. He also provided quantities of these lines and some hybrid seeds for trials to be done by the Savannah Agricultural Research

Institute (SARI), a counterpart research institute in the Northern Region of Ghana. With the close technical supervision of public maize breeders, hybrid seeds are currently being produced from these lines by the seed companies for commercialization.

Also in Ghana, a groundnut breeder at the Crops Research Institute at Fumesua took commercialization of his new groundnut varieties to a higher level. In addition to working with private seed companies, he gave breeder seed to specific farmers he had personally trained to produce foundation seed in selected locations across the country, including Diesi in the Upper West Region.

Successes, as well as some failures, were recorded in other critical areas along the PASS seed value chain. Foundation seed supply has improved, but remains a critical bottleneck to the growth of seed systems in a number of countries.

Approaches Used

Public-private partnerships and commercialization

In order to strengthen partnerships at national level, PASS began facilitating commercialization meetings to bring together all concerned parties to discuss better ways of enhancing the efficiency of production and dissemination of certified seeds. During these meetings, participants brainstormed and laid down strategies to address emerging threats in the value chain. In 2014, such meetings were organized in Ghana, Kenya, Mali, Mozambique, Niger, Nigeria, and Uganda.

Outputs from these meetings were incorporated into the activities of the commercialization team.

Some examples of learning include:

Parental line development – In both Ghana and Kenya, one major issue has been the inadequacy of the parental lines for newly released maize hybrids. To deal with this issue, an agreement was reached whereby seven seed companies in Ghana and eight in Kenya volunteered to work with public sector breeders to multiply parental lines.

Information sharing in Ghana and Uganda – The mistrust between breeders and seed companies in some countries was such that the companies were unwilling to share their production figures with breeders. Through the intervention of PASS commercialization officers, seed companies have now realized the importance of updating breeders on the performance of their varieties.

The importance of timely release of information – The commercialization unit improved access by seed companies to real-time information on new varieties released or in the pipeline. This is now done by providing them with regular updates. Seed companies are now able to share their production plans with breeders and to submit their requests for breeder seed in good time to aid planning, thus dramatically strengthening communication channels between breeders and seed companies.

Technical backstopping of seed companies by breeders – PASS supported breeders who were willing to organize training sessions for seed producers on a regular basis to equip them with the necessary technical know-how on breeder/foundation seed handling and multiplication. For example, the maize breeding teams of the Savannah Agricultural Research Institute (SARI) and Crops Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR-Ghana) organized a series of training sessions for seed producers.

Similar training sessions have been organized by the maize breeding team of the national research system of Burkina Faso, *Institut de l'Environnement et Recherches Agricoles* (INERA), in Bobo-Dioulasso. Most of the important seed companies in the country – Agro-Productions, Fagri, Nafaso, and EPC-SAC – were represented.

Such meetings were also convened at Sotuba, Mali, by the maize breeding team of the national research institute, *Institut d'Economie Rurale* (IER) for Comptoir 2000, Faso Kaba, and Soprosa seed companies. By encouraging breeders to provide on-site technical backstopping to private sector seed producers, they have become familiar with the operational sites of seed producers.



Farmer field days like this one in Mali give local farmers an opportunity to learn about new varieties and methods of cultivating them, ask questions, and communicate their needs and preferences.

Developing a portfolio of seed varieties – PASS encouraged and facilitated the exchange of germplasm among breeders and seed producers for cross agro-ecological testing. Descriptors for released varieties have been gathered from breeders and compiled into a simple directory. This is used to guide seed companies on varieties available for commercialization. The directory includes information on crop type, variety and origin, year of release, general characteristics, and other attributes as well as recommended farming practices.

Identifying best bets – With the intervention of PASS commercialization officers, breeders provided technical advice to seed producers on economically viable and socially acceptable varieties likely to generate high demand and best suited for specific agro-ecologies. Information was also provided about the unique characteristics that set certain varieties apart from those already being planted. These interventions helped seed companies prioritize varieties for immediate commercial seed production.

Developing seed production plans – Seed companies need accurate plans to effectively respond to market demands. The commercialization team used a special spreadsheet (seed calculator) developed by the International Maize and Wheat Improvement Center (CIMMYT) to aid in seed production planning and forecasting. The calculator ensures that breeder seed is available at the right time and in the right quantities for multiplication.

Breeder and foundation seed production and parental line increases – Continuous hybrid seed production requires a continuous supply of parental lines. In recent times, breeders have been overwhelmed with high demand for breeder seed and parental lines. PASS commercialization officers intervened to have breeders liaise with seed

companies to multiply parental lines in order to meet the ever-increasing requirements for hybrid seed production.

Increasing smallholder demand for certified seed – Seed businesses will only thrive if there is demand for their products. A sure way to create demand is to empower small-scale farmers to make the right variety choices. This is achieved through farmer awareness creation, such as farmer-participatory and on-farm demonstrations, farmer field days, in-store merchandising, strategic roadside demonstrations, and through such promotional activities as talk shows on local radio stations. These efforts are mostly conducted by seed companies. PASS commercialization officers tracked these efforts and encourage breeders and agro-dealers to participate in them.

Seeking farmer feedback – The participation of breeders in farmer awareness creation efforts has improved real-time feedback from farmers. Private seed enterprises and agro-dealers are encouraged to interact with farmers to understand how they perceive new varieties. Getting this feedback first-hand helps researchers respond more sensitively to real needs and challenges.

Licensing and royalties – Licensing agreements are initiated to formalize partnerships between the national agricultural research institutions and the private local seed companies. For example, lengthy licensing procedures in Kenya tend to delay access to new varieties by seed companies, but after consecutive meetings between PASS commercialization officers and the legal office at the research institute, seed companies are now able to acquire new varieties within three months of application. Follow-up on accumulated royalty payments by the commercialization officer has resulted in prompt payments leading to access to the new varieties. A previous experience with licensing of maize hybrids in Ghana did not turn

out as successfully. Some seed companies were unable to settle their end of the bargain due to issues relating to pricing, quality of parental lines, storage, and handling. Lessons learned in this experience are being applied to ensure successful licensing partnerships. This is key to sustaining research and maintenance of parental lines.

Strategic marketing and distribution channels

– The PASS commercialization team assisted seed companies in designing marketing strategies that include pricing, branding, seed promotion, advertising, and routes to market. By providing technical and marketing support to private enterprises, we enable them set up effective and certified seed distribution systems peculiar to their operations.

In Burkina Faso, mobile kiosks are placed in rural areas prior to crop planting and moved into other communities as necessary. Seed enterprises have also set-up sales outlets and other distribution channels in communities to widen their coverage area. A database of agro-dealers trained and developed with PASS support was shared with seed

companies. This enabled the companies to position their branded seeds appropriately and make the varieties readily accessible to the farmers. Branded promotional items, including demonstration signage and in-store merchandising (point-of-sale) materials, were developed to improve the competitive advantage of our seed company partners.

A considerable amount of advertising was also purchased on Ghanaian radio stations – by Heritage Seeds in Tamale, Antika Seeds in Wa, and by M&B and Mabert Seeds in Ho – to inform the public and promote the various company brands.

Naseco Seed Company in Uganda established 1,800 strategic road-side demonstration plots that resulted in sales of up to 2,000 tons for Longe 10H maize seeds.

In Kilifi County, Kenya, Olerai Seed Company developed a new market for its variety *Olerai 22* through road-side demonstrations. PASS has been happy to contribute to each of these efforts.



Government licensing of publicly-bred crop varieties for production and sale by private seed companies, like the Rwanda Improved Seed Company (RISCO) shown here, has increased the availability of quality seed and allowed many more farmers to benefit from higher-yielding varieties.

Critical Factors for Adoption of New Varieties

We observed that varieties and hybrids with a clear selling point that respond to a real need in the eyes of farmers are likely to be quickly commercialized and adopted. That selling point can be classified as one of three critical factors: 1) *a product attribute*, such as resistance to a specific disease or pest; 2) *market demand*, or an opportunity to generate cash; or 3) *promotional efforts* that advertise desirable traits that resonate with smallholder farmers.

Product attributes

Disease resistance – Varietal resistance to diseases, particularly new ones, is one clear driver for adoption of new varieties. An example comes from wheat in Ethiopia. In 2010, an epidemic of yellow rust, also known as stripe rust, hit several major wheat-producing areas of the country. Prolonged light rains combined with low temperatures led to devastating losses to the disease, to which all the popular wheat varieties were highly susceptible. In 2010, two newly released varieties – *Danda'a* and *Kakaba*, both CIMMYT lines – were identified by the Ethiopian Institute of Agricultural Research (EIAR) in a wheat breeding program supported by PASS. These varieties proved to be high-yielding and resistant to the disease and have been rapidly multiplied and deployed to replace susceptible varieties. Another variety released in 2011, *Shorima*, is also resistant to yellow rust and has already been picked up and multiplied by seed companies in large quantities to counter the disease threat.

Another example can be seen with cassava. An epidemic of cassava mosaic disease-Uganda variant (CMD Ug) struck East and Central Africa in the late 1990s and led to the rapid dissemination of

new resistant varieties. The subsequent epidemic of cassava brown streak disease (CBSD) that has been spreading through the same areas since 2010 is leading to the replacement of CMD-resistant types with varieties that resist both CMD and CBSD in Kenya, Mozambique, Tanzania, and Uganda. Such varieties as *Kizimbani* in Zanzibar, *Kiroba* in mainland Tanzania, and *NASE 14* and *NASE 19* in Uganda are being multiplied and sold to farmers because they can withstand the diseases. In future, only varieties that combine resistance to CMD and CBSD are likely to be taken up by farmers in these countries.

Maize lethal necrosis (MLN) disease first appeared in Kenya's Rift Valley in 2011 and rapidly spread to other areas in Kenya, as well as to Tanzania and Uganda. The disease is caused by the interaction of maize chlorotic mottle virus and the sugarcane mosaic virus (or related cereal viruses) and causes greater crop losses than either of the viruses alone. MLN can cause total crop losses and its appearance has stimulated an urgent response by CIMMYT and KALRO to identify promising inbred lines and hybrids with resistance. Olerai Seed Company's seed production farms are located in Narok, the main hotspot for the disease in Kenya. The country's Plant Health Inspectorate Service (KEPHIS) rejected two of Olerai's certified seed harvests for the susceptible variety *KH500-46A*, which obliged the company to shut down maize seed production in Narok.

Similar, though less dramatic, examples come from other crops where pests and diseases are important constraints to production. Root rot resistance in beans, rosette resistance in groundnuts, and *Striga* resistance in cowpea have all contributed to new varieties being chosen by seed companies for multiplication and successful sales to farmers who face these problems.

Climatic stress tolerance – Earliness and extreme earliness in maize as a means to escape drought have become desirable traits in the face of changing patterns of rainfall. Early-maturing and extra-early-maturing varieties and hybrids have been successfully commercialized and adopted by seed companies in the Sahelian zones of West Africa on the basis of these characteristics and farmers’ recognition of their advantages. Early-maturing cowpea varieties are sought by farmers in Burkina Faso, Ghana, and Mali. With the shortening annual rainfall periods, these varieties are increasingly desirable to farmers, and seed companies are therefore looking to commercialize them. PASS commercialization officers have identified several early-maturing cowpea varieties in Mali and arranged for testing them in Ghana.

Market potential

The existence of a definite market – Farmers will buy seed when they see a ready market, and seed companies are becoming quick to respond by multiplying suitable varieties. For example, sunflower and soybean varieties have been adopted in Uganda largely because oil-extracting companies have been buying sunflower grain at attractive prices. Similarly, brewing companies in Kenya, Tanzania, and Uganda have been contracting farmers to grow sorghum varieties suitable for brewing. Purchase of seed of various crops in response to demand from the market has become widespread throughout East Africa, Ghana, and Mali. In each of these cases, seed companies have been quick to respond and multiply seed.

Farmer preference for doing business with other farmers – Groundnut and cowpea varieties released in Ghana in 2012 and 2013, as well as cowpea varieties released in Burkina Faso in 2012, were not popular with seed companies despite

intense efforts by the PASS commercialization officer. This is because farmers tend to distribute seeds of these self-pollinated crops among themselves, resulting in less lucrative opportunities for seed companies. These varieties were mostly commercialized through direct partnerships with technically competent farmers who are closely linked with breeding programs.

Commercialization challenges for rainfed production systems – Commercialization of maize varieties in Kenya is becoming very challenging for local seed companies who depend on rain-fed seed production systems due to the increasingly erratic rainfall patterns experienced during recent years. Some large-scale farmers have irrigation facilities that enable them to produce seed as outgrowers for the seed companies. Commercialization officers therefore need to identify potential farmers who can produce hybrid maize seed under irrigation and to link them to appropriate seed companies.

Intense efforts and investments required to introduce new varieties – Seed companies that have established their market niche are sometimes wary of introducing new varieties into their product lines, especially when the new varieties do not offer significant advantages over their current varieties. This is because introduction of new varieties to farmers requires a considerable investment of funds, time and effort, all of which tends to weigh heavily on the seed companies.

Promotional efforts

Limited marketing capacity limits the number of varieties – Emerging seed companies with limited investments in promotional activities are usually wary of increasing the number of varieties in their portfolio. For fear of not being able to sell their seeds, these companies decide to access small quantities of varieties for testing and typically take only a fraction of newly

released varieties for commercial production. For example, seed companies in Ghana decided to test only soybean varieties that were new in 2012 instead of going into commercial seed production. The decision was made because the companies knew that farmers are fond of a popular variety, *Jenguma*, and considerable marketing will be required to introduce the new varieties. The commercialization officer thus needs to continuously develop pipelines for uptake of new varieties, including scouting for processing companies and projects interested in purchasing large volumes and linking them to seed companies. These projects then buy off seeds for farmers in their network who will then produce the grains.

Limited funding for promotion – Due to limited financial resources, emerging seed companies in Kenya are unable to develop products that can compete effectively with the relatively well-endowed regional and multinational seed companies. It has become imperative for the commercialization officer to hold market strategy meetings with the marketing teams of seed companies to enhance their distribution and promotion skills.



Supporting the commercialization of recently-developed drought-tolerant maize hybrids by local seed companies like this one in Kenya accelerates the introduction of new crop varieties among smallholder farmers.

Looking Ahead

The experiences of farmers like Wahabu and the Gathurus indicate that great successes are in the making. Their stories show how farmer-driven models for delivery of seed are possible, especially those of vegetatively propagated crops such as cassava, which seed companies find bulky and consider “slow-moving”. This option is also likely to increase the adoption of legumes such as cowpea and groundnut.

Successes achieved so far have been in collaboration with seed actors in the different countries. Much remains to be done to ensure that smallholder farmers benefit from the various support structures being put in place to make varieties easily accessible to farmers.

One critical area that needs to be improved is how best to promote high-quality products. The number of on-farm variety demonstrations should be increased dramatically to reach as many farmers as possible. This will culminate in higher adoption of well-adapted improved varieties released through the national research institutes.

PASS supported seed companies to conduct variety promotion activities, but these efforts need to be strengthened to reach a wider population of smallholder farmers.

Varietal promotion efforts have been undertaken in Africa with positive impact by organizations such as Farm Input Promotions Africa Ltd. (FIPS) and Sasakawa Africa Association (SAA).

Ghana's struggle to overcome hybrid seed shortage

Maize is a staple in many communities across Ghana. It is second in importance after cassava but it is the number one cereal crop. The availability of new, more productive varieties is most likely the initial driving force behind commercial seed system expansion in Ghana.

Sadly, however, maize yields have remained low – about 1.7 MT/ha, a far cry from the potential 6-8 MT/ha that could be obtained by cultivating high-quality cultivars. Equally dismaying is the slow release of new improved varieties suitable for different areas in the country. For instance, no new hybrids were released between 1997 and 2004.

AGRA's PASS program stepped in to support Ghana's seed sector. A partnership with the Crops Research Institute succeeded in getting four varieties released in 2010 and six in 2012, including five hybrids. However, the optimism created by the quick release of improved seed varieties was short-lived. A lack of parental seed for multiplication meant the varieties could not be immediately produced in large amounts for marketing to farmers.

To deal with the situation, the PASS team organized a meeting that brought together breeders, seed companies, government agencies, and other stakeholders. During

the meeting, seven seed companies agreed to increase parental lines in the 2014 season, under the supervision of AGRA-supported maize breeder Dr. Obeng-Antwi. Five of the seven seed companies took up the challenge: Heritage Seeds in Northern Region, ACSL in Brong Ahafo Region, Innovations Village in Central Region, and M&B and Mabert Seed Company, both located in Ho.

At the end of the 2014 major season, more than 1,300 kg of seed were available for three hybrids – *Aseda*, *Tintim*, and *Opeaburo*, to kick start commercial-scale hybrid seed production. Multiplication of additional parental lines under irrigation was undertaken at the same time.

Following this development, PASS partnered with and supported the Savannah Agricultural Research Institute (SARI) of Ghana to develop additional improved varieties in order to strengthen the maize genetic base in the country. Another four drought- and *Striga*-tolerant top-cross hybrids; *Kunjor-Wari*, *Kpari-Faako*, *Suhudoo*, and *Wari-kamana* were released by SARI in 2015. Additional support was provided to SARI to multiply parental lines of some of the key farmer-preferred hybrids, including *Tintim*, *Opeaburoo*, *Kunjor-Wari*, and *Kpari-Faako*.

Malian researchers break new ground

Yellow maize is widely consumed in Mali and thus has a high share of the domestic maize grain market. Much-awaited yellow flint maize hybrids were finally released by the Malian national research institute – *Institut d’Economie Rurale* (IER) in 2015. Seed companies had been requesting such varieties for several years, motivating AGRA to invest in the development of these and other such varieties to meet the needs of farmers.

The maize hybrids will accelerate seed business among local seed companies, consequently impacting the productivity and revenue levels of smallholders. Specific details of the released varieties are shown in the table below:

The new varieties, with an average yield of 5 MT/ha, have come at an opportune time when focus is on boosting farmer productivity and doubling the yields of maize farmers. There is huge demand for yellow maize by the poultry and livestock industries as well. White maize is mainly produced for the commercial grain, flour and export markets. The higher yielding hybrids will ensure optimum returns on investment for farmers.

Preceding these releases, IER (with support from AGRA) released two locally developed maize hybrids, *Tcheba* (white) and *Farako* (yellow).

This was the first official introduction of locally developed maize hybrids into the maize value chain in Mali. These hybrids, which were developed using locally improved germplasm (*Djorobana* and *Sotubaka*) exhibit yield potential of 7-8 MT/ha on farmers’ fields; this compares very favorably to the average maize yields of 2.65 MT/ha achieved in Mali. To boost adoption of the improved maize hybrids, PASS supported IER to officially launch the hybrids in Sikasso (the largest maize-producing region in Mali). A field day was organized to sensitize the general populace and create extensive farmer awareness about the new hybrid maize varieties. More than 500 smallholder farmers, seed producers, agricultural agents, and researchers benefitted directly from field visits to a 26 hectare *Tcheba* adoption field and 2 hectare *Farako* seed production field. They had the opportunity to compare these fields with others planted with imported hybrids, which were stunted in growth with very small ears and minimal grain filling, due to poor adaptation. Following the field visits, a workshop was organized in which farmers were educated about the importance of planting hybrid seed and how these and other such hybrids differ from GMOs. The event was aired by the national media house ORTM and on five local radio stations.

Crop	Variety	Variety Type	Maturity Period	Yield Potential (MT/ha)	Other Attributes
Maize	Soden	OPV	85-90 days	5 - 6	Flint, white grain, tolerant to drought and <i>Striga</i> .
Maize	Tiéblenkè	OPV	85-90 days	4 – 5	Flint, yellow grain, tolerant to drought and <i>Striga</i> .
Maize	Farako	Top-cross Hybrid	90-100 days	7 - 8	Dent, yellow grain, tolerant to drought and <i>Striga</i> .
Maize	Filani	Top-cross Hybrid	90-100 days	8 – 10	Flint, yellow grain, tolerant to drought and <i>Striga</i> .
Maize	Tech	Single-cross Hybrid	90-100 days	7 – 8	Flint, white grain, tolerant to drought and <i>Striga</i> .



Rice gains from new varieties

In Kenya, there is no dispute that maize is the king of cereals, consumed by the vast majority of the population. In some areas, food is synonymous with this staple. However, rice is putting on a good show as an increasingly urban population adopts a more varied diet. It therefore made sense for PASS to pay more attention to this crop.

In June 2013, an AGRA-supported scientist, Dr. John Kimani, developed four improved varieties of rainfed lowland rice at KALRO, all of which were released by the government. Two additional varieties, *Komboka* and *Saro 5*, were released in June that year and two more, *MwIR2* and *MwUR4*, were released in April 2014.

Seed companies have enthusiastically welcomed the new varieties and there is every indication that enough seed will be made

available for planting by farmers in areas suitable for the crop.

With guidance from one of AGRA's commercialization officers, East African Seed Company applied for licensing of *Komboka*, while FreshCo is seeking a go-ahead to commercialize *Saro 5*.

The commercialization officer gave out samples of the newest varieties to four companies that agreed to host on-farm trials in 2014. The firms – Gicheya Farm, Alphega Seed, Elgon Kenya, and Dry Land Seed Company – were expected to select their preferred varieties and apply to KALRO for licensing in 2015.

Rice is unlikely to overtake maize anytime soon, but it looks like the crop is poised to become Kenya's second favorite cereal.

New kids on the block boost Kenya's seed market

The seed industry in Kenya has grown tremendously since the early 1970s, when the only company in existence was the public firm, Kenya Seed Company. A competitive market is now well established with over 100 private firms operating in 2014 (according to the Kenya Plant Health Inspection Service), producing 65,000 MT of assorted crop seeds.

AGRA's PASS program has realized the importance of strengthening the seed sector by building the capacities of these local seed enterprises to act as vehicles of transfer of improved seeds to small-scale farmers.

Since 2005, many local seed companies have emerged, taking advantage of the liberalization of the seed market. New crop seed companies have now firmly established themselves as credible market players. They include Western

Seed Company, Dryland Seed Company, and Leldet Seed Company – all registered to start operations. PASS provided grants to Dryland and Leldet seed companies that enabled them to increase the production of hybrid maize seed fourfold – from 50 MT in 2006 to over 200 MT in 2014.

Another successful firm is Olerai Seed Company, which was licensed to exclusively produce two maize seed varieties developed with support from PASS – *KH500-46A* and *KH500-22A*. Both are mid-altitude varieties popular with farmers. A commercialization officer from PASS guided the company to increase its volume of *KH500-22A* from 50 MT to 200 MT in 2014. Post-production ensured good sales, driving up the company's revenue.

Gicheya Farm, one of the newest entrants, was licensed to produce hybrid maize varieties *KH500-51A* and *KH500-52A*. In addition, the PASS commercialization officer has worked closely with Gicheya farm on uptake of three new bean seed varieties: *KK8*, *Cal194*, and *Red 33*. These varieties are well suited for growing in rotation with maize. PASS has also supported the commercialization of bean varieties *KK15* and *KK8* by Elgon Kenya, Western Seed Co, Crop Africa, and Leldet Seed Company.



New bean seed variety KK8 at Bungoma Chemist, an agro-dealer in Bungoma, Kenya



How one seed company embarked on the path to success

In 2013, a PASS commercialization officer came to learn that a new seed company, Elgon Kenya, had been registered for operation. After several meetings with the company management team at their head office in Nairobi, the company sent an application to KALRO and obtained a non-exclusive license to produce seed of two new maize varieties, *KH125-01SG* and *KH125-03SG*. The license agreement was signed in December 2013 and the company began multiplying seed in 2014. What caught the officer's interest was that the firm hadn't receive sufficient quantities of breeder seed from the breeder to meet its seed production projections. He therefore negotiated with the maize breeder (based at

Katumani station) to produce breeder seed for the 2 varieties. Elgon Kenya received 10 kg of breeder seed for *KH125-03SG* in 2014 and began producing foundation seed. Wanting to see things for himself, in 2015 he traveled from Nairobi to the company's seed production farms in Marigat, a small town deep in Kenya's Great Rift Valley.

There he learned out that the company had increased the breeder seed and had begun multiplying needed foundation seed. Elgon Kenya was able to produce 10 MT of certified seed of the newly licensed maize variety *KH125-01SG*, which will hit the market in 2017, branded as *Malaika125*.

What they say

AGRA Seed Commercialization Officer
Regina Richardson:

On the essence of commercialization...

“Breeding a great variety is no guarantee for farmer uptake. The challenge is to find creative and effective ways to guide us through the complete process of variety development and farmer uptake.”

On the sustainability of African seed systems...

“One major way to make all the structures that PASS is putting in place in the various countries sustainable is by getting the majority of smallholder farmers on the continent to cultivate high-quality seeds of improved crop varieties. Seed commercialization is the component that brings to life the PASS vision of contributing to a Green Revolution in Africa.”

And on the challenges of creating partnerships...

“Some of the initiatives undertaken were pretty much new and met initially with reservation. It took a lot of convincing to get things started. The good thing though is that so far we are on the right path and are achieving positive results.”

AGRA Seed Commercialization Officer
Samuel Okita:

“Hugo Wood, the Director of Olerai Seed Company, has been an inspirational figure in my seed commercialization world in Kenya. Despite Kenya Plant Health Inspection Services rejecting harvested KH500-46A seed twice in one year due to the incidence of maize lethal necrosis virus, he has not given up. Instead, he has held his head high and is hopeful of overcoming this huge loss. This entrepreneur is a true seed champion in Africa worth emulating.”

Challenges Facing Seed Commercialization in Kenya and Uganda

In 2011, a new disease emerged in Kenya and Uganda, causing a major shift in maize seed production by seed companies. Maize lethal necrotic disease (MLN) is caused by a combination of two viruses, sugarcane mosaic virus and maize lethal necrotic virus. In Kenya, the disease has been reported in most productive areas of western Kenya and the Rift Valley,

the country's breadbasket zones. In the wake of its spread through Kenya, several emerging seed companies were forced to plow under mature seed production farms and move their production to new sites. To ensure disease-free hybrid maize seed, companies often spray their crop on a fortnightly basis with expensive pesticides to reduce the disease pressure. This, plus obligatory use of expensive seed dressings, has increased the overall cost of seed production, which in turn has increased the market price of maize seed by up to USD 0.5 per 2 kg packet.

In a country that has depended on rain-fed seed production for generations, commercialization of maize seed varieties in Kenya today has become very challenging for local seed companies. With changing rainfall patterns, it has become highly risky to produce maize seed under rain-fed conditions. Only a handful of large-scale farms have the irrigation facilities needed to make them reliable outgrowers for emerging seed companies. The cost of center pivot systems is beyond the reach of small seed companies, so concerted efforts are required to build a database of all farms that have the potential and the resources needed to produce hybrid maize seed. One of the key roles of the PASS commercialization officers is to create this database of outgrowers to facilitate linking them with local seed companies. Negotiations are ongoing with three large outgrower farms that have the potential to scale up production under irrigation of the new maize seed varieties licensed to the small seed companies. The commercialization officer for Kenya has also been able to link seed companies

to National Irrigation Board-managed small-scale outgrower farms in Perkerra. Four Kenyan seed companies – Elgon Kenya, Olerai Seed Co, DryLand Seed Company and Ultravetis – are taking advantage of this irrigation scheme. In 2016, they produced a total of 1,200 MT of seed in Perkerra.

The question remains: Will emerging seed companies survive the high costs of seed production? Maize diseases have also been reported in Uganda and the government, through its Ministry of Agriculture, has enforced a policy requiring seed companies to treat their certified maize seed with Imidochloride before selling it to farmers.

Trials are currently being conducted by CIMMYT at its testing site in Naivasha, Kenya, and PASS commercialization officers are monitoring the emerging results to identify the more tolerant varieties for uptake by seed companies.

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7 Toward an African Green Revolution – Scaling Seeds and Complementary Technologies

Itai Makanda¹, Mulemia Maina², and Richard Jones³

AGRA's Program for Africa's Seed Systems (PASS) has been operating in a number of African countries, holistically building seed systems based on and through local structures. This has been discussed extensively in the previous chapters. Having recorded considerable success in generating new varieties and delivering quality seed to the African farmer, PASS took aim at increasing the impact of both its own and its partners' interventions through further investments to scale up proven seed and

complementary technologies, thereby lifting a significantly larger number of farmers out of poverty. This is being done through the Scaling Seeds and Technologies Partnership (SSTP), mandated to take seed and complementary technologies to scale in Ethiopia, Ghana, Malawi, Mozambique, Senegal, and Tanzania. SSTP was designed to support the New Alliance for Food Security and Nutrition (www.new-alliance.org) and is funded by the United States Agency for International Development (USAID). The New Alliance was launched to:

The PASS and New Alliance Partnership

At the G8 Summit at Camp David on 18 May 2012, President Obama announced the *New Alliance for Food Security and Nutrition (NAFSN)*. This alliance is a shared commitment and partnership between African leaders, donors, and private sector partners to achieve sustained and inclusive agricultural growth and raise 50 million people out of poverty by 2022.

NAFSN focuses primarily on catalyzing private sector investment across African agriculture value chains to meet 10-year agricultural production targets set by country members. The aim is to promote responsible private sector investment in country investment plans and thereby support the Comprehensive Africa Agriculture Development Programme (CAADP) as the guiding framework for agricultural transformation in Africa. The overall objective is *taking innovations to scale* and involves several enabling actions for sustainable yield improvements in national priority value chains, identifying core sets of technologies that will contribute to achieving those targets, and ensuring access to those technologies at sufficient scale.

This was a convergence point with the PASS theory of change, on seed and related technologies. Therefore, AGRA, in partnership with USAID, a NAFSN member, created the Scaling Seeds and Technologies Partnership in Africa.

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- Reaffirm continued donor commitment to reducing poverty and hunger;
- Accelerate implementation of key components of the Comprehensive Africa Agriculture Development Programme (CAADP);
- Leverage the potential of responsible private investment to support development goals;
- Help lift 50 million people out of poverty in Africa by 2022; and
- Achieve sustained inclusive, agriculture-led growth in Africa.

The New Alliance is a partnership in which member countries committed to specific policy reforms and investments, outlined in Cooperation Frameworks that accelerate implementation of national agricultural investment plans. The award of a cooperative agreement by USAID to AGRA to implement SSTP was to build on the foundation laid by earlier investments by AGRA (especially PASS), the Consultative Group on International Agricultural Research (CGIAR), national governments, and other development partners working on crop research and seed systems development in Africa.



The Scaling Seed and Technologies Partnership (SSTP), funded by USAID, invests in the production and marketing of seed of publicly-bred varieties by local seed companies. This includes the improved bean varieties shown here, developed by plant breeding teams at Chitedze Research Station in Malawi, and being produced by Multi Seeds Company, Ltd., which is led by Ibrahim Benesi.

The Case for Senegal

Senegal's seed sector can be divided in two.

The first sub-sector consists of the northern part of the country around the Senegal River Valley, which is characterized by irrigated rice intensification systems with reasonably good seed and accompanying inputs. The main crops are irrigated rice and vegetables and the use of fertilizer is very high.

The second sub-sector is in southern Senegal, where most farmers practice rainfed agriculture. The staple crops include pearl millet, sorghum, cowpea, maize, and upland rice. Availability of seed is mainly through the government's seed and fertilizer subsidy program, a centrally planned system that is widely viewed as outdated and inefficient. The quality of seed is mostly poor, and grain is often supplied as seed under the label of '*semences écrémées*' – grain that is labeled as seed without having gone through established seed production and quality control protocols. Fall (2011) concluded that the country's seed sector was in a complete state of collapse while the breeding function of the *Institut Sénégalais de Recherche Agricole* (ISRA) continued to limp along, such that no hybrid varieties have ever been offered and most varieties are over 20 years old.

Quality seed is so highly sought that all production is guaranteed to be sold, even before harvest and packaging. Quality seed is therefore an exclusive product available for the select few who can pre-order and pay for it in advance. In the Country Cooperation Framework under the New Alliance for Food Security and Nutrition, the Government of Senegal committed to, among other things, reducing budgetary level of agricultural input subsidies over 3 years from 0.5% to 0.3% of GDP by December 2015. SSTP interventions will complement the government's efforts by building a professional private seed sector that will aim to market quality and well-branded seed directly to farmers, in package sizes that are convenient and affordable for their needs. Seed companies will sensitize farmers on the need for using quality seed of superior varieties, as well as the importance of applying accompanying technologies, such as using fertilizer and row planting. Their goal is to expand access to quality seed to as many smallholder farmers as possible.

The Scaling Seeds and Technologies Partnership

The spirit of SSTP is in getting valuable technologies off the shelf and into farmers' hands. SSTP is helping New Alliance countries coordinate related but separate country, donor-financed, and private sector programs to strengthen the seed and complementary inputs sector, thereby promoting commercialization, availability, and adoption of technologies at scale. In particular, SSTP is working within countries to transition from state-dominated seed systems to systems that allow the private sector, including local businesses and non-profit organizations, to provide not only key services, but also strengthen the capacity of the state to carry out critical regulatory functions. In this regard, SSTP is assisting countries to coordinate strategies and programs to strengthen the seed sector and promote commercialization, distribution, and adoption of quality seed and related technologies that increase smallholder farmers' yields and improve their crops' resilience to climate change, thus taking the PASS model to scale.

Critical in its operation is technical and financial support to both public and private sector groups to deliver quality seeds and complementary technologies to smallholder farmers, improving the capacity of smallholder farmers to adopt quality seeds and technologies, and engaging governments towards improving policy and regulatory mechanisms for the delivery of quality seeds and technologies to smallholder farmers.

Approach to Scaling

SSTP's mandate is threefold:

- Improve capacity of public and private sector groups to deliver quality seeds and other technologies to smallholder farmers.
- Improve the capacity of smallholder farmers to use quality seeds and technologies.

- Improve policy and regulatory mechanisms for the delivery of quality seeds and technologies to smallholder farmers.

Scaling takes different forms and shapes, mainly depending on the commodity being scaled up and the organizational theory of change. The technologies or innovations to be scaled have to be easy to adopt, first and foremost, and be in line with the current scope of work and streamlined to manageable size (Kohl et al, 2017). Further, it must clearly serve a need such as drought tolerance, deriving economic benefit in the process, have a manageable risk, and a demand that remains largely unmet. Kohl et al (2017) also indicate characteristics such as value chain efficiency, where other areas of the value chain are being addressed and complementary services are readily available.

Many authors have developed schemes for scaling, including Cooley and Kohl (2006) and World Health Organisation (2010). The latter laid down nine steps for developing a scaling-up strategy. These are: (i) planning actions to increase the scalability of the innovation, (ii) increasing the capacity of the user organization to implement scaling-up, (iii) assessing the environment and planning actions to increase the potential for scaling-up success, (iv) increasing the capacity of the resource team to support scaling up, (v) making strategic choices to support vertical scaling up (institutionalization), (vi) making strategic choices to support horizontal scaling up (expansion/replication), (vii) determining the role of diversification, (viii) planning actions to address spontaneous scaling up, and (ix) finalizing the scaling-up strategy and identifying next steps.

SSTP employs three distinct steps in the scaling approach:

- Technology and zone identification;
- Value chain diagnostics; and
- Investments in specific value chains.

Technology and zone identification

The initial step is convening of a stakeholder meeting in the target country, bringing together government, farmers, private sector, CGIAR, and development partners. The objective of the stakeholder meeting is to identify successful technologies and innovations in seed and other technologies for scaling. Zones giving the major impact from scaling investments (“*bang for bucks*”) are also identified. This is done to align the SSTP investment with the country priorities as defined by the countries themselves, within the country investment plans under CAADP. For example, the stakeholder meeting in Ghana in February 2014

came up with the technologies and zones presented in Table 7.1.

Farmers around the world are constantly on the lookout for new technologies to help them increase their productivity, and Africa’s farmers are no exception. The major technologies identified in these meetings include superior varieties of priority crops such as hybrid maize, biofortified beans, orange fleshed sweet potatoes, and high-yielding disease resistant cassava; fertilizer blends that include micronutrients specific for different crops such as legume blend, cereals blend, cassava shooting and rooting blends, rhizobia, and others; agronomic

Table 7.1. Zones and technologies from the Ghana stakeholder meeting

Region		Crop					
		Cassava	Maize	Soybean	Rice	Yam	Cowpea
1	Ashanti	x	x		x	x	x
2	Brong Ahafo	x	x	x		x	x
3	Central	x	x				
4	Eastern	x	x		x	x	
5	Volta	x	x	x	x	x	

Crop	Seed technology	Complementary technologies		
		Agronomy	Mechanization	Extension/ICT
Cassava	Improved varieties Mini-cutting	Blended fertilizer		Reality TV/ Radio/ Cellphone
Cowpea	Improved varieties	PICS Spray Service Providers	Mechanical threshing	
Maize	Hybrid varieties	Blended fertilizer PICS/ZeroFly	Row planters Mechanical threshing	
Soybean	Improved varieties	Rhizobium inoculant Blended fertilizer	Row planters Mechanical threshing	
Rice	Improved varieties	Blended fertilizer Fertilizer deep placement	Direct paddy seeder Mechanical weeder Mechanical threshing	
Yams	Improved varieties	Blended fertilizer	Row planting on ridges Mechanical harvesting	

Table 7.2. General technologies and areas of SSTP intervention across the six countries

Seed Production	Seed Dissemination, Awareness Creation
<ul style="list-style-type: none"> • Breeder and foundation seed –NARS, private seed companies • Certified seed production – seed companies • Modest infrastructure—irrigation/storage • Technical and business services procurement • Linkage with other research institutes 	<ul style="list-style-type: none"> • Agro-dealer development • Demonstration plots • ICT extension – radio, cellphone, TV/Cinema • Extension agents training • Farmer training • Value chains integration
Other technologies	Policy related interventions
<ul style="list-style-type: none"> • Fertilizer- Blends, Rhizobium – demos/ distribution/recommendations/soil testing • Yield/value improvement through crop protection • Modest infrastructure development • Mechanisation • Improved agronomy – good agricultural practices • Propagation technologies 	<ul style="list-style-type: none"> • Operationalisation of Seed and Fertiliser Dialogue Platforms • Support to seed associations • Regional seed laws harmonisation • Regional fertilizer laws harmonisation • Technical procurement on policy • Following up on government policy commitments

approaches such as fertilizer deep placement, mechanical weeding/planting; and post-harvest yield loss reducing technologies, such as the Purdue Improved Crop Storage (PICS) bags, Aflasafe, and warehousing. The technologies identified and the general areas of intervention across the six countries are summarized in Table 7.2.

A good example of the zoning done by the countries can be found in Mozambique where the government has demarcated four major growth corridors: Nacala, Beira, Limpopo, and Zambezi Valley Corridors. Major investments are being targeted along these corridors and great strides can be achieved through synergies and leveraging such investments from government, private sector, and other development agencies. An example of such leveraging is given in the first success story.

Value chain diagnostics

According to Kohl et al, 2017; value chains need to be functional and capacity across the entire value chain must grow in tandem, for commercial scaling to succeed and in order to avoid constraints. Hence, once the technologies are identified, SSTP moves in to analyze the value chains of those technologies. The initial step is to identify the actors along the value chains. This includes knowing who is playing what part in technology development, distribution, and ultimately provision of services to farmers. At this stage, more focused consultations are held involving specific value chain actors. Issues discussed include what is working well, what is not working well, and what investments are needed for scaling. This will give an indication for SSTP on where to invest its resources to yield the greatest possible

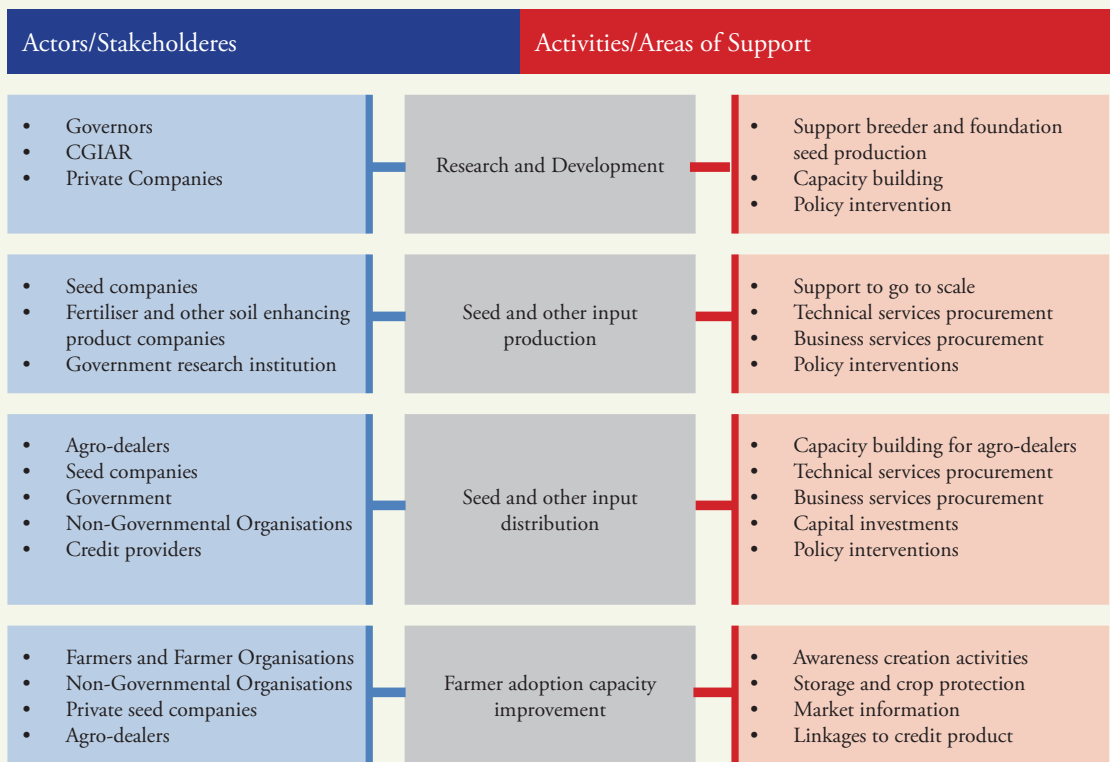


Figure 7.1. The area, value chain players, and activities accomplished towards achieving the SSTP and New Alliance goals

results. It also helps to avoid groups who are only searching for funding, without a long-term plan to make their operations sustainable.

An example is the Cassava Value Chain Meeting convened by SSTP in Blantyre, Malawi, in July 2014 (see photo). From such meetings, SSTP moves to the next step of investing in identified value chains.

Investments in value chains

Armed with the technologies, zones and identified critical areas for investment, SSTP provides grants through a competitive solicitation process, and supports these with business development services, technical assistance, policy reviews and dialogues.

The area, value chain players, and activities conducted towards achieving the SSTP and New Alliance goals are summarized in Figure 7.1. For seed, most investments are needed at the breeder and foundation seed (early generation seed – EGS) production stages because without EGS the rest of the seed value chain cannot function well. Certified seed production is dependent on the availability and quality of foundation seed. It is important to consider interventions at policy level, especially where gaps at this level lead to access issues. For example, the policies regarding foundation seed must be liberalized so that private seed companies can produce and sell to their counterparts (with appropriate quality control) in order to ensure greater access of quality certified seed by farmers.

Cassava value chain investment in Mozambique

Cassava is a highly versatile crop grown by smallholders in more than 100 countries. Its roots are rich in carbohydrates while its tender leaves contain up to 25% protein, plus iron, calcium, and vitamins A and C. Other parts of the plant can be used as animal feed, and livestock raised on cassava have good disease resistance and low mortality rates. On the negative side, however, cassava roots are both bulky – 70% water – and highly perishable. Also, the crop is susceptible to such pests as the cassava mealy bug, and to devastating diseases, particularly cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). These two viral diseases are spread both by insects and through sharing of diseased cuttings.

Commercial interest in marketing a bulky and perishable crop is understandably limited, even when disease-free cuttings are assured. Moreover, because farmers can propagate cassava themselves – despite the risk of spreading disease and reducing productivity – private companies see little value in dealing with the crop. For these reasons, cassava commercialization has remained at the ‘talk’ level for many years, until now.

In 2011, several positive developments came together, leading to successful cassava commercialization by smallholder farmers in Mozambique, and later to scaling up in Ghana and Nigeria. What led to this long-awaited success was an ingenious invention called the autonomous mobile processing unit (AMPU for short). AMPU was developed and deployed by the Dutch Agricultural Development and Trading Company (DADTCO), a private company. AMPU successfully transformed the cumbersome, water-laden roots into cake, which can be more conveniently stored, transported, and marketed. One of the earliest buyers to express interest in the new technology was SABMiller, the world’s second largest brewing company, which wanted to use cassava cake for brewing beer.

The next step was to identify a regular supply of quality cassava roots. This story actually started earlier. In 2010, AGRA made a grant to Constantino Cuambe, from the Mozambique Institute of Agricultural Research (IIAM), to breed disease-resistant cassava varieties. Constantino’s work led to the release of nine CMD- and CBSD-resistant varieties, four of which proved ideal for processing into cassava cake. Clean cuttings of these four varieties were supplied to a commercial farm called Corredor Agro, which multiplied them under contract with the International Fertilizer Development Center (IFDC), which disseminated the cuttings. The cuttings were disseminated by IFDC to farmers who had been trained in how to select clean cuttings, and the last stone was set in place to meet the growing commercial demand for cassava cake.

Once the value chain for cassava cultivation was in place, the next step was to scale up the process. In 2014, SSTEP (which is implemented by AGRA with support from the USAID) awarded three grants:

- IIAM – to expand the production of clean planting material
- Oruwera Limitada, a commercial seed company – to further multiply cassava from the material produced by IIAM
- IFDC – to scale up the training and dissemination of cuttings from Oruwera and to integrate farmers into the value chain through business development services

This investment will reach 100,000 farmers, one tenth of whom will be effectively integrated into the DADTCO/SAB Miller market system. DADTCO and Ingredion South Africa Office are in preliminary discussions to see how they can cooperate on cassava processing – improving not only rural economies, but also food security because cassava is a staple food crop in Mozambique.

The next area is investment into the actual production of certified seed by seed companies through capital injections, technical backstopping, business development services, or modest equipment investments. PASS has already established the Seed Enterprise Management Institute at the University of Nairobi where seed company personnel are trained. The institute has been mentioned in the preceding chapters.

At the distribution level, investments are made mainly in capacity building for agro-dealers, to enable them to reach larger numbers of farmers.

Lastly, investments are made to build the capacity of the farmer to adopt, use and benefit from the technologies. These investments include awareness creation activities through technology demonstrations, seed fairs, farmer

field days, ICT (television, radio, telephone) approaches – especially in extension service provision, and linkages to markets, thereby effectively integrating the farmers in the value chains. Lastly, investments are made to build the capacity of the farmer to adopt, use and benefit from the technologies. These investments include awareness creation activities through technology demonstrations, seed fairs, farmer field days, ICT (television, radio, telephone) approaches – especially in extension service provision, and linkages to markets, thereby effectively integrating the farmers in the value chains. An example of these investments made by SSTEP and scaling up the work of PASS investments in breeding and Dutch Government investments in the cassava value chain (through IFDC) in Mozambique, is given in the box entitled Cassava value chain investment in Mozambique.



Scaling up the supply of improved cassava varieties (developed by a team led by Anabela Zacarias, above right, of the *Instituto de Investigacao Agronomica de Mocambique*) by smallholder cassava farmers by the USAID-supported Scaling Seed and Technologies Partnership has proven effective in supplying thousands of additional farmers with cuttings of the new varieties, and led to the creation of new, value-added markets.

How Much Scaling?

Scaling up depends on the answer to the question: *How much scaling is required?* This question takes into consideration the time frame available and target yields set by the stakeholders. Government is mainly concerned with food and nutrition security. Commercial focuses on business development around the technology. Farmers are concerned with both food security and business around the commodities. In the SSTP countries of operation, governments have set yield targets within the NAFSN framework, aiming towards economic development with agriculture as a major pillar.

Thus, taking these targets and time frame into consideration, SSTP works backwards to determine how much of the scaling is required per technology to sustainably achieve the target

for the country or zone of operation within the life-span of the intervention. To illustrate this mode of operation, let's take the example of Malawi. That country's target is to produce 1 million MT of groundnuts per year. Given that the average yield of groundnut is 1 MT/ha (FAOSTAT, 2014), the country will need to plant 1 million hectares each year. With a seeding rate of 50 kg/ha, the certified seed required each year is 50,000 MT. This becomes the certified seed scaling target. Going further down the value chain, this amount of certified seed requires 50,000 hectares to produce (at 1 MT/ha yield), which in turn implies a need for 2,500 tons of foundation seed at a 50 kg/ha seeding rate. Therefore, SSTP will target its investments to scale up foundation seed to 2,500 MT and certified seed to 50,000 MT. The same logic can be used for fertilizer, rhizobia and crop protection technologies.

Public-Private Partnerships (PPPs) – Vehicles for Scaling

Delivery of seed and related technologies to farmers requires a concerted effort from many players working in a synergistic and complementary approach. Generally, the government is key as it provides the enabling policy environment for the other players, as well as generating technologies that are public goods. Under the PASS model, these technologies need effective and sustainable strategies if they are to reach farmers, and commercial seed companies have proven effective in this role. They have taken public varieties, multiplied them to produce certified seed, and sold them using their own selling points and network of agro-dealers (another key private sector vehicle for dissemination). In this whole matrix, development partners, represented by AGRA, have provided resources to ensure both the public and private sector can perform their roles effectively in the delivery of quality seed, thereby making a perfect PPP in the seed value chain.

Taking this relationship to scale, SSTP identifies weak links within this PPP value chain to most effectively target its investment and to operationalize the scaling effort in the most efficient way. Examples of these types of investments include support to research institutions, including the national agricultural research institutions and the CGIAR centers, to scale up the production of breeder seed. The supported institutions include IIAM in Mozambique; the Department of Agricultural Research Services (DARS) in Malawi, the International Centre for Tropical Agriculture (CIAT) in Tanzania, and *l'Institut Sénégalais de Recherches Agricoles* (ISRA) in Senegal.

The breeder seed is then sold to private seed producers and companies, which are supported by SSTP to bulk foundation seed. These include Oruwera Limitada in Mozambique, M&B in Ghana, ASPRODEB in Senegal, Aminata in Tanzania, among others. Other potential PPP areas under exploration include production of basic seed by a private sector entity on contract by the public sector, and delegated seed inspection and certification by the private sector with the support of the public certification body.

Policy Reforms

The development of a vibrant African seed sector will depend on an enabling policy environment. Governments and the regional economic communities – EAC, ECOWAS, SADC, and COMESA¹ – have made considerable progress in developing seed trade harmonization agreements. Unless these agreements are implemented, however, the ability of commercial seed companies to scale up the production and marketing of quality seed of superior varieties will continue to be hampered. SSTP is supporting the development of the COMESA Regional Variety Catalogue, and is supporting the implementation of accreditation where seed regulatory authorities will delegate seed inspection and quality control to companies that put in place proper seed quality control systems.

Preliminary Progress

The SSTP grants fall into the following seven categories that address the three SSTP objectives. These are:

¹ EAC = East African Community; ECOWAS = Economic Community of West African States; SADC = Southern Africa Development Community; COMESA = Common Market for Eastern and Southern Africa

- 1) Solving the issue of early generation (breeder and foundation) seed supply – both quality and quantity. The foundation seed is sold to partner organizations producing certified seed.
 - 2) Scaling up the production of certified seed of priority food crops identified through in-country consultations.
 - 3) Building the capacity of smallholder farmers to adopt improved technologies through awareness creation activities about the benefits of using quality seed of superior varieties and complementary technologies, including on-farm demonstration plots, television and radio programs, village cinema, brochures, pamphlets, and farmer field days.
 - 4) Provision of business development services to farmers to enable them to increase their profits from investments in inputs. These services include business linkages to input suppliers and output markets, training in sustainable agriculture, and capacity building in both technical and business skills.
 - 5) Strengthening the capacity of seed platforms and farmer associations to ensure effective linkages between seed businesses and farmers, as well as engagement with regulatory and other government bodies to create a more favorable policy environment for commercial seed companies.
 - 6) Creating enabling environments for seed and fertilizer trade in countries and across regions.
 - 7) Supplying small, modest mechanization to enable businesses and farmers to reap the full benefits of their investments and use of improved varieties and accompanying yield-enhancing technologies.
- Preliminary results about seed, extension, and other interventions are presented here as SSTP is still being implemented and final results are not yet available.

Seed Value Chain Interventions

To date, seed production stands at 33,276 MT, against a project target of 43,698 MT. Disaggregation by country is shown in Table 7.3.

Table 7.3: Quantity (MT) of improved seeds of different crops produced by country to date

Country	Crops	Seed Production	SSTP Target
Ethiopia	Maize, Wheat, Teff, Sesame, Chickpea	2,421	
Ghana	Maize, Cassava, Soybean, Rice, Cowpea, Yam	10,438	
Malawi	Maize, Cassava, Pigeonpea, Beans, Sweet potato, Rice, Groundnuts, Cowpeas	4,556	
Mozambique	Maize, Cassava, Soybean, Pigeonpea, Groundnuts	2,931	
Senegal	Maize, Sorghum, Rice, Groundnuts, Cowpeas, Millet	7,528	
Tanzania	Maize, Cassava, Soybean, Pigeonpea, Sorghum, Beans, Irish potato	5,402	
Total		33,276	43,698

Seed and Technologies Value Chains Policy Support

The policy interventions so far implemented are summarized in Table 7.4.

Table 7.4: Policy interventions to create an enabling environment for seed and technologies scaling up

Country	Activities
Ethiopia	<p>In Ethiopia, SSTP is supporting the Ethiopian Agricultural Transformation Agency (ATA) to scale up Direct Seed Marketing (DSM). The DSM directive has been drafted in consultation with the federal seed regulatory body and presented to the Ministry of Agriculture and Natural Resources (MoANR) Input Marketing directorate to advocate for policy change. The draft DSM directive has been discussed within MoANR at the command post level, and the next step will be to share the draft with the Minister. It is then expected that a working group will be established that includes the ATA seed team and Input Marketing directorate to refine the draft guideline. If this is approved, a directive for issuance and administration of competency certificates to engage in seed businesses will be developed. This will include mechanisms for improvement in quality assurance.</p>
Ghana	<p>In Ghana, SSTP has engaged the Crops Services Division of MoFA to digitize the seed catalogue for ease of access to varieties and variety attributes by stakeholders in the country and abroad. Preparation of relevant documentation is ongoing towards SSTP support. Under the National Seed Plan, regulations are being prepared to guide the production of foundation seed by private companies.</p>
Tanzania, Malawi, Mozambique and Ethiopia	<p>The four countries and one regional body (COMESA) have been supported to improve policies and regulations, mainly in fertilizer harmonization and seed regulation. Among these endeavors, 69 policies have been analyzed, 68 stakeholder consultations have been held and one draft revision produced. SSTP also supports the Seed and Fertilizer Platform general assemblies in Mozambique.</p> <p>Further, SSTP proposed to the African Fertilizer Agribusiness Partnership (AFAP) that they use data being collected under their existing project to develop The African Fertilizer Access Index (TAFAI), work that would be similar to that being done by Market Matters to develop TAFAI. In addition, the project is developing Legal Guides relating to fertilizer regulation in each of the four countries being targeted by this project.</p>

Country	Activities
Ghana, Tanzania, Malawi and Mozambique	<p>SSTP, in partnership with USAID and BMGF, undertook an early generation seed (EGS) study in these four countries. The reports have been finalized through stakeholder EGS study validation workshops in all the countries. The workshops reviewed the findings in an interactive manner to ensure that there was common understanding of the findings from the study and the recommendations emanating from the studies. Breakout sessions were held to allow for the interrogation of the different components of the findings.</p> <p>Key supply and demand bottlenecks identified in the EGS study were discussed, validated and prioritized by crops. In all four countries, these could be summarized as: a) lack of well-defined contracts and licensing regime in the industry; b) lack of clarity around policy and/or regulations on the role of the private sector in EGS production; c) inadequate quality control and assurance systems; d) limited investment in marketing and awareness creation; e) limited technical capacity of private sector to produce EGS; and f) poor demand forecasting due to inadequate data.</p>
Ghana Tanzania	<p>The program is undertaking a seed value chain purity study based on maize hybrids and OPVs in Ghana and Tanzania. Samples along the value chains have been collected for DNA-based Genetic Purity Assessment in Ghana and Tanzania. The purity assessment will help to diagnose and identify weakness in the seed value chain, and address them with an eye towards making sure farmers benefit from improved varieties while, at the same time, building confidence in quality seed of improved varieties. The findings of the assessment will inform the regulatory authorities and strengthen their operations.</p>

Overall Number of Farmers Reached Though SSTP Interventions

The activities and awareness efforts described, ranging from on-farm demonstration plots to ICT-based approaches using radio and television, have reached 936,687 households to date. This represents a program impact of 7.2 million people, a 94% movement towards the SSTP target of 7.6 million farmers.

Challenges and Lessons Learned

Seed policy remains the single most important challenge in scaling up seed access among smallholders. Government parallel seed distribution, generally managed under a subsidy program, often compromises quality and timeliness, and creates a large, quick and easy market for well-aligned private sector players to dispose of their seed (Jayne et al. 2013). This negates the spirit of direct farmer sales based on product quality, efficiency of distribution, and after-sales assistance to enable farmers to optimize the performance of the seed.

Foundation seed is sometimes produced by public sector entities, usually as a requirement of the law, and the same issues of poor quality, late delivery, and insufficient quantities arise. Conflicts of interest surface where one public body is responsible for quality control and another for seed production, without proper accountability. Increased private sector involvement in seed production calls for a greater number of seed inspectors and involves other logistical requirements.

Innovative ways to approach these types of second generation problems are needed. Well-coordinated PPPs, as described earlier, could offer a possible solution, but smart subsidies may well be a better approach. Private sector investment in agriculture could be increased through tax breaks on equipment, such as seed processors, or a voucher program that allows for branding of competing products that could enable farmers to acquire their choice of seed (and other inputs).

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8 Seed Policy

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Sub-Saharan African governments, looking to driving an agricultural transformation in order to bring about structural transformation, are now placing heavy emphasis on expanding private sector investment in agricultural input supply and output marketing in agricultural value chains, especially for smallholder staple food value chains. Under the New Economic Partnership for Africa (NEPAD) and the Comprehensive Africa Agriculture Development Programme (CAADP), African government leaders committed to good governance and African ownership of the agenda of accelerating economic growth and promoting jobs and food security (www.nepad-caadp.net). In addition, under the 2014 *Malabo Declaration on Accelerated Growth and Transformation for Shared Prosperity and Improved Livelihoods*, African leaders committed to putting in place conducive policy and institutional conditions and support systems for enabling private sector investment in agriculture, agribusiness and agro-industries, giving priority to local investors (African Union 2014).

Despite these commitments, however, many of the agricultural policies, laws, and regulations that African countries carry on their statutory

books and what they do in practice can be quite different. In fact, what we often see is that their actions deter rather than encourage private sector investment. Governments around the world intervene in agricultural input and output markets because of “market failure”. These market failures result from externalities, public goods (which are special cases of consumption externalities), natural monopolies, and information asymmetries. A set of such purposive interventions by a government constitutes a policy. However, government intervention may itself result in high costs of doing business, worsen welfare outcomes and result in policy failures. As the demand for improved seed has rapidly grown in Africa, the effectiveness of seed policies developed in a previous era of low demand have increasingly been overtaken by events.

The World Bank’s “ease of doing business index” ranks countries from 1 to 190 based on an evaluation of 41 indicators (World Bank, 2016). Countries that have high scores and therefore more difficult regulatory environments can reduce these high costs, improve their business environment and enable private sector investment by getting rid of “problem” policies, laws, regulations and taxes by mimicking the best “best practices” that are implemented by countries with low scores. To resolve market and policy failures, a nation-state and its authoritative governmental units need to continuously craft and re-craft policies, laws, regulations and administrative practices in order to put in place institutional arrangements that hold down transaction costs

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and guide self-interested agents to act in the interest of the larger community (Bromley 1993, 1995, and 1997; Bromley and Yao 2007). This is especially so because the economy is always in the process of changing over time in response to new technologies, resource scarcities, and preferences (Bromley and Yao 2007).

Because high-quality seeds of improved crop varieties and hybrids have led every Green Revolution, African governments are placing high priority on reforming seed policies, laws, and regulations in order to put in place the institutional preconditions for competitive private sector agricultural input markets and achieve the African Union's objectives. The purpose of this chapter is to:

- Review the historical experience of countries around the world to inform the debates of crafting enabling seed policies and regulations in countries targeted under the Program for Africa's Seed Systems (PASS);
- Document experiences gained by PASS from advocacy on seed policies and regulations, as well as policy analysis and messaging piloted under projects involving seed policy action nodes and hubs, and micro-reforms for African agribusiness; and
- Identify an agenda for policy research, analysis, and advocacy for African countries to domesticate and act on needed seed policy and regulatory reforms to enable smallholder farmers to capture the productivity gains offered by the new varieties resulting from the interventions of PASS and other programs.

Overview of Seed Policies, Laws, Regulations, and Administrative Practices

The World Bank (2007) classifies countries into four types:

- Developed countries (USA, Canada, Europe, Japan, Australia);
- Urbanized countries (Latin America, Central Asia, South Africa, much of Europe);
- Transforming economies (Southeast Asia, the Middle East and North Africa, Bangladesh, China, India); and
- Agriculture-based countries (mostly sub-Saharan Africa).

Countries at different stages of overall economic development are also at similarly different states of seed system development. Historically, seed policies, laws, and regulations were first developed and implemented in the USA and the EU to reduce transaction costs, to make markets work, and to protect seed growers, agribusinesses, farmers, and consumers by ensuring that seed is in satisfactory condition when delivered to farmers, that it exceeds minimum purity and germination standards, and that seed-borne diseases do not compromise crop establishment. The policies, laws, and regulations have guided the design of regulatory frameworks both in developed and developing countries throughout the world. The lessons from USA and EU seed system development established political and institutional foundations for the development and growth of private sector firms. The institutional rules included:

- Registration of seed businesses;
- Crop variety development, evaluation, release, and registration;
- Plant variety protection and plant breeders' rights (PBRs);
- Pre-basic, basic, and certified seed production;
- Seed certification and quality control;
- Agricultural extension, education, and awareness;
- Seed distribution and sale;
- Demand creation, promotion and adoption by farmers;
- Seed trade and phytosanitary services; and
- Biosafety and genetically modified organisms.

Table 8.1, at the end of this chapter, summarizes the key characteristics of seed policies, laws, and regulations across the four country types. We use as case study countries the USA and EU for developed economies; Turkey and South Africa for urbanized economies; Bangladesh and India for transforming economies; and Ethiopia, Ghana, Kenya, and Tanzania for agriculture-based economies. These countries were selected because they have a high proportion of total cereal area planted to maize, and their experience provides lessons for the PASS target countries. All 10 countries have in place the basic legal foundations and institutional arrangements of industrially organized seed industry systems. However, the countries differ sharply in the legal content and administrative practices and barriers to entry by private sector organizations, including private sector firms, farmer associations, cooperatives, and non-governmental organizations (NGOs).

Compared to agriculture-based economies, developed, urbanized, and transforming economies have liberal institutional rules for registering seed companies, variety registration, producing and importing seed, and marketing. In contrast, all governments in sub-Saharan Africa require approval by their ministries of agriculture to register seed companies, introduce new varieties, and to produce and certify, import, sell, and export seed. The bureaucratic procedures impose high transformation and transaction costs to start new seed companies, introduce new varieties (time, money, and uncertainty to test and register a new cultivar), and to produce, transport and market and export seed (Gisselquist et al. 2013). These policies and regulations limit introduction of varieties because of high fees, official national performance trials for variety performance – tests for value in cultivation and use (VCU), as well as tests to describe the variety's distinctiveness, uniformity, and stability (DUS). After evaluation through national performance trials, the varieties are recommended for release by national seed committees. The release committees decide to approve or disapprove varieties, thus controlling sale of seeds. These decisions are characteristically based on a few criteria – for example, yield gain above some check variety – that do not consider all the factors important to farmers, such as stress tolerance, grain quality, taste, appearance, and processing qualities. With few exceptions, this process takes a minimum of two years to complete, and often much longer. The involvement of government in virtually every phase of the development of new seeds is cumbersome and economically disadvantageous. Clearly, it would be far more efficient to transfer these activities to private firms.

The major lesson to be learned from the experiences of developed, urbanized, and transforming countries around the world is that African governments can confer significant benefits to agribusinesses, farmers, and consumers, and while doing so increase the flow of new cultivars and speed up a Green Revolution by relaxing seed policy and regulatory controls and removing strict bureaucratic procedures. Government decision-makers argue, however, that fake seed is a major problem. Farmers will get cheated, they say, if regulatory controls on cultivar introduction and seed production and certification are relaxed because farmers are illiterate and poor and there is a lack of competition among existing seed companies. With time, however, market-based processes will develop and governments can do away with compulsory variety release by national variety release committees, as well as compulsory certification.

Seed Policies, Laws, Regulations, and Administrative Practices in PASS Countries

The seed policies, laws, regulations, and administrative practices in countries targeted under PASS are becoming regionalized and globalized across natural food market sheds in Southern, Eastern, West, and Central Africa (Haggblade et al. 2012). Regionalization and globalization are being driven by falling trade barriers resulting from trade agreements between and among the regional economic communities (RECs):

- Common Market for Eastern and Southern Africa (COMESA)

- Southern Africa Development Community (SADC)
- East African Community (EAC)
- Intergovernmental Authority on Development (IGAD)
- Economic Community of West Africa States (ECOWAS)
- West Africa Economic and Monetary Union (UEMOA)
- Economic Community of Central African States (ECCAS)

Moreover, collaboration is increasing in crop variety research and development, registration, protection, seed production, marketing, and trade among countries under three sub-Saharan African sub-regional research organizations (SROs):

- Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA)
- Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
- *Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles/* West and Central African Council for Agricultural Research and Development (CORAF/WECARD)

Also, regional and global seed companies are increasingly coordinating joint investments in crop variety research and development, production, and marketing in different countries. Similarly, regional and global commodity trading and processing firms are integrating their origination activities. These interventions supply seed, fertilizer, and agrochemicals to farmers, who in turn purchase

agricultural outputs, often using a farmer group to cut costs. Another consideration: policy spillovers resulting from “smart” agricultural seed subsidies being implemented in some countries are having an impact on neighboring countries.

Seed policy and legislative frameworks vary greatly among regions. In the 1990s, four southern African countries – Malawi, South Africa, Zambia, and Zimbabwe – implemented seed policy and regulatory reforms, followed by Mozambique in the early 2000s.

In South Africa, the reforms enabled the transfer of seed certification, laboratory seed testing, and management of national cultivar trials to private companies, leading to the establishment of the South African National Seed Organization in 1989 and the Agricultural Research Council in 1992. Private sector investments in new cultivars were financially attractive because the government passed the Plant Breeders’ Rights (PBR) act in the 1960s. South Africa developed the capability of enforcing them by using effective techniques, such as restriction fragment length polymorphism (RFLP) fingerprinting.

In Malawi, Zambia, and Zimbabwe, governments gradually transferred responsibility for plant breeding, seed certification, and laboratory seed testing to private seed firms in the 1990s. In Zimbabwe, the government enacted a Plant Breeders’ Rights Act in 1973 and this induced private breeding of maize hybrids in the mid-1970s. Zambia and Mozambique both enacted a PBR law in 2007. Malawi drafted PBR legislation in 2009, but this has still not been passed into law. The seed industry is currently dominated by domestic and multinational private seed companies linked to international breeding (Table 8.2).

Until recently, mom-and-pop seed companies were rare, but lately growth in small- and medium-scale seed businesses has been significant. This has resulted from improved access to publicly bred varieties and inbred lines, production technology, marketing, and finance. PASS is supporting projects to develop domestic seed companies in 18 African countries. The growth of small and medium seed firms has also resulted from “smart” voucher-based seed subsidies, redeemable through agro-dealers in Malawi and Zambia, stimulating the demand for seed. By contrast, entry and growth of new small- and medium-scale seed firms has been constrained by the direct distribution of seed input subsidies by government.

In East Africa, Kenya and Tanzania implemented seed policy and regulatory reforms in the 1990s, Uganda in the early 2000s, and Rwanda and Ethiopia in the late 2000s.

Kenya started seed policy reforms in the 1970s by transferring maize breeding, foundation seed production, commercial seed growing, field inspection, laboratory seed testing, and seed marketing to the Kenya Seed Company. During the 1990s the government liberalized the seed industry and allowed domestic and multinational seed companies to engage in breeding, production, marketing and distribution of agricultural and horticultural seeds. Cargill Hybrid Seeds, Pannar, Pioneer Hi-Bred International, and Seed Co entered by testing and registering their proprietary hybrids.

In Tanzania, the government launched economic reforms in 1990 under which it deregulated the seed industry, decontrolled seed and commercial grain prices, privatized the parastatal seed company TanSeed, and created incentives to attract foreign companies. Cargill Hybrid Seeds

entered the seed industry in 1991 by introducing South African-bred hybrids that it had originally introduced in Malawi in the 1980s. Pioneer Hi-Bred International and Pannar began by testing their proprietary hybrids in official variety performance trials in 1993 and registering these on the official variety list. Pannar, Monsanto (which bought the Cargill business), and Seed Co developed their businesses by importing and selling seed in Tanzania that was produced in Zimbabwe and South Africa, and later in Zambia and Malawi.

Uganda implemented reforms starting in 1999 to privatize the Uganda Seed Project into a public company and then transform it. The government then liberalized the seed industry and encouraged entry of private seed firms.

The governments of Rwanda and Ethiopia are implementing seed policy reforms to increase private sector participation in variety development, evaluation, release and registration, production, certification, distribution and marketing of seeds. As in Southern Africa the seed industry is becoming dominated by regional and global private seed companies linked to international breeding (Table 8.3). Compared to the case of Southern Africa, the governments of East Africa still impose stringent controls on: crop variety development, evaluation, release and registration; pre-basic, basic and certified seed production; seed certification and quality control; and seed distribution and sale.

In West Africa, Burkina Faso, Ghana, and Nigeria have implemented seed policy reforms. During the 1990s, Nigeria implemented agricultural input reforms. In 1991, the Ghanaian government privatized the Ghana Seed Company and permitted private sector seed firms to engage in production and marketing

of certified seed to farmers. Beginning in 1999, Burkina Faso implemented seed policy reforms to transfer seed production and marketing from government organizations to private seed firms. In recent years, all three countries have implemented seed policy reforms to increase private sector participation in crop variety development, evaluation, release and registration; pre-basic, basic and certified seed production; seed certification and quality control; and seed distribution and sale. These reforms have stimulated the entry of global seed firms as well as small- and medium-scale seed companies (Table 8.4).

In Central Africa, the government of the Democratic Republic of Congo (DRC) recently enacted seed legislation (Katambayi 2010). Government research institutes and the National Seed Service dominate crop variety development, evaluation, release and registration; pre-basic, basic and certified seed production; seed certification and quality control. There are no formal seed companies. Seed multiplication is through contracts with farmer associations. Most certified seeds are distributed through free handouts by FAO, IFAD and NGOs. Farmers who are members of associations are supported to pack and sell seed to other farmers through rural village markets and agro-dealer shops. Because of poorly developed markets for certified seed of improved varieties, farmer associations producing seed prefer to sell to development organizations and NGOs for onward distribution to farmers. More recently, PASS began supporting the creation and growth of start-up private seed companies in Eastern DRC. To-date, five private seed companies have emerged and are marketing seed of improved crop varieties produced locally. Agro-dealer development programs are being supported

by specialized NGOs. IFDC has supported a certified seed production and marketing project in South and North Kivu through a grant linked to agro-dealers. The Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA) supported agro-dealers owned by farmer associations in selling certified seed produced by the associations, as well as fertilizer.

Experiences in Seed Policy Reforms

Before AGRA established a dedicated Policy and Advocacy Program in 2009, PASS advocated for seed policy and regulatory reforms that enable investment and growth of private sector seed businesses. Anecdotal evidence shows that these efforts were effective in informing and influencing policy through a “nudging process” that involved dialogue with the right people in the ministries of agriculture and national seed regulatory authorities. Meetings with government officials had a positive impact in Mali, Ghana, Tanzania, Mozambique, Uganda, Rwanda, and Burundi. Advocacy also had an impact in Burkina Faso, Malawi, Niger, Ethiopia and Kenya. Much of this work focused on variety release procedures and allowing private seed companies to produce breeder and foundation seed.

In Niger, private seed companies perceive fewer constraints than before the advocacy efforts were made; breeders are now able to get new and improved varieties released more quickly, and seed firms are now allowed to produce foundation and certified seed. In Tanzania, policy wins occurred in October 2015 when the Ministry of Agriculture issued licensing letters to three seed companies, which were selected through competitive bidding, authorizing

them to commercialize varieties and hybrids of publicly protected varieties. This legislative change was completed on 9 January 2017 when the Minister of Agriculture signed a circular on procedures for authorization for private seed firms to use seed of new, government patented varieties; this change was officially gazetted on 20 January 2017, allowing it to be implemented. Although Burkina Faso was initially slow in allowing private companies to produce foundation seed, the government has, since February 2016, permitted private firms to multiply foundation seed using pre-basic seed supplied by the *Institut de l'Environnement et de Recherches Agricoles* (INERA). Ethiopia has also introduced direct seed marketing and allowed private agro-dealers to sell certified seed of improved varieties and hybrids to farmers, which is having significant effects on seed supply, delivery of improved technologies to farmers, and national crop yields. Kenya as well has allowed private companies to multiply foundation seed of maize hybrids and beans.

One key challenge that now needs to be addressed throughout Africa is that governments must start financing breeders. Until now, donor partners, CGIAR centers, and AGRA have funded crop improvement research programs. Another challenge is that government officials need to change their attitudes and shift towards greater private sector support through tax incentives and removing barriers to entry by foreign private sector firms through Foreign Direct Investment.

Once AGRA's Policy and Advocacy Program was established, policy research and analysis and advocacy projects targeting specific and granular seed policies and regulations were implemented. Grants were made that: enabled the organization of policy networks and dialogue forums;

generated evidence for informing, influencing and improving the quality of government decision making; increased the demand for evidence by policy makers; and advocated for the implementation of better policies. The projects also institutionalized better systems for policy making, as well as monitoring and evaluation.

The Policy Program's first project was the establishment of Seed Policy Action Nodes, for which hubs were implemented in Ghana, Mozambique, and Tanzania between 2010 to 2015. This project targeted policy changes in seeds, soil health, markets, land access, and climate change. The Seed Policy Action Nodes and Hubs had an overall goal of creating an enabling seed policy environment across the three target countries and promoting the adoption of improved crop varieties by smallholders to increase household incomes and improve national food security. In Ghana and Mozambique, nodes were coordinated by public sector organizations. This is because when the nodes were established stakeholders argued that government organizations should lead them, as they are mandated to coordinate policy development.

The targeted reforms were aligned to the key seed policy commitments made by the country under the G8 Cooperation Framework to support the New Alliance for Food Security and Nutrition. Similarities exist among the countries in key reform outputs, policy reform successes, and enablers of policy reform success (Table 8.5).

The Policy Program's second project was the Micro-Reforms for African Agribusiness (MIRA), which was implemented in Burkina Faso, Ethiopia, Ghana, Nigeria, and Tanzania starting in 2014. This 5-year project targets the

reform of "problem" agricultural policies, laws, and regulations that constrain expanding private sector investment in agricultural input and output marketing that serve smallholder staple food value chains.

The goal of MIRA is to measurably improve policy and regulatory environments for investing in local agribusinesses that sell inputs to, or buy outputs from, poor smallholder farmers in Africa. The objectives are twofold:

- Strengthen the demand by the ministries of agriculture and other relevant government agencies for reform of policies and regulations that unintentionally limit private sector investment in agribusinesses in smallholder value chains.
- Support efforts by the ministries to reform policies and regulations that limit private sector investment in agribusinesses, promote reformed regulations, and enhance the capacity and commitment of ministries to continuously assess and reform policies that limit private sector investment in smallholder value chains.

To achieve these objectives, MIRA is using a consultative and learning-by-doing approach to obtain buy-in at high ministerial and private sector levels. Rapid reconnaissance studies were conducted to diagnose and assess the current landscape of agricultural policies, laws, and regulations and identify those that limit private investment in smallholder value chains, and those that need to be reformed. The studies found that there are several problems with seed policy, laws, regulations, and administrative practices (Table 8.6). These policies can be categorized as missing or ambiguous, economically flawed, excessive, or poorly implemented.

Based on the diagnostic studies, a pressing need was identified for micro-level policy and regulatory reforms that focus not only on what needs to happen, but also on how to increase capacity to undertake complex, highly technical, and politically sensitive tasks of reforming policies and monitoring their implementation. Specific and granular reforms were identified and prioritized with government counterparts and are underway in target countries (Table 8.7).

Although it is too early to draw rigorous statistical inferences about the impact, several lessons are emerging from qualitative assessments of projects being supported by AGRA:

- Policy and regulatory reforms are politically sensitive, and there is a need to first obtain buy-in into the reform agenda by senior government officials at the highest decision-making levels – permanent secretaries, ministers of agriculture, and parliamentary agricultural committees – and in the private sector as well – agribusiness leaders, farmers’ organizations, and representatives of civil society organizations;
- There is a need to build on continuing dialogue with relevant stakeholders, such as industry trade associations and public regulatory agencies, through participatory consultations and discussions to get views of a wide range of stakeholders and ensure consensus on reforms;
- The processes are based on learning-by-doing and involve complex technical, administrative and legislative processes and procedures that need to be followed to initiate, develop, and validate reform options, select optimal solutions, and push these through different stages of government decision-making and approval to implementation;
- Policy development and regulation are dynamic and keep changing even during the reform process. Thus, there is a need to provide technical expert analysis – subject matter analysis, cost-benefit analysis, regulatory impact assessment, estimation of total costs to government to implement the reforms, and legal analysis – and to write official documents and obtain formal official approval using strong evidence to facilitate better informed and faster decisions by policy makers;
- There is need to focus on the large, granular and specific reform challenges that are the “elephants in the room”, as well as on the assessment of reform solutions that private sector entities care about and are of importance to the government, and push these through the decision-making processes and stages of approval;
- There is need to build the capacity of policy makers to understand and target local small-scale stakeholders (small businesses, smallholder farmers, community leaders), as well as the needs of larger stakeholders (national, regional and international corporations). Private sector firms have strong incentives to push for reforms through the administrative and legislative decision-making processes;
- Because of the multi-sector nature of agriculture, there is a need for coordination within and across line ministries, departments and agencies; and
- There is a need to track progress and measure whether policy changes are

making a difference through routine monitoring and evaluation of impacts on market prices, production costs, volumes and values produced and traded, farm gate prices, and the choices available to farmers to manage risks.

Conclusion and Implications

African leaders and policy makers have committed to create and enhance appropriate policy and institutional conditions and support systems to facilitate private sector investment in agriculture, agribusiness and agro-industries. Because high-quality seeds of improved crop varieties and hybrids have led every Green Revolution, African governments are placing high priority on reforming seed policies, laws, and regulations to put in place the institutional preconditions for competitive private sector agricultural input markets.

A review of the historical experience of countries around the world shows that African governments can confer significant benefits to agribusinesses, farmers and consumers, increase the flow of new cultivars, and speed up a Green Revolution on the continent by relaxing seed policy and regulatory controls and removing strict bureaucratic procedures. The seed policies, laws, regulations and administrative practices in countries targeted by PASS are rapidly changing because of seed policy reforms. The lesson to be drawn is that there is a pressing need for micro-level policy and regulatory reforms focusing not only on *what* needs to happen, but also on *how*.

The key policy issue is for governments to remove barriers to private introduction of varieties from any source. This is because African seed markets are relatively small. Unilateral removal is as good as joint removal (for example, through a SADC, COMESA, or ECOWAS variety catalogue). Other issues that need to be addressed include: registration of seed businesses; biosafety and genetically modified crops; plant variety protection/plant breeders' rights and licensing; private seed companies' access to pre-basic and basic seed of publicly-bred varieties; early generation seed production; seed certification; seed distribution and marketing; consumer protection and fake seeds; seed financing, subsidies and taxes; seed imports and exports; regional trade agreements; and the implementation of seed laws and regulations currently on the books.

The power of policy and regulatory reform is demonstrated by important seed policy changes that have been made in different African countries during the past 10 years. These include variety registration and release, authorization for commercialization of publicly bred varieties and hybrids by private seed companies, breeder and foundation seed production by private seed companies, and allowing private agro-dealers to sell certified seed of improved varieties and hybrids to farmer. AGRA's investments in advocacy, policy analysis and research, and communication have facilitated the actions taken by governments to enable positive change.

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Table 8.1: Key characteristics of seed policies and regulatory frameworks across developed, urbanized, transforming, and agriculture-based country types

Country	MoA registration requirements for starting a seed company	To introduce a new variety, registration is:			To produce or access seed for wholesale delivery:			To sell seed:		
		Voluntary or automatic and low cost	Required, with discretionary approval after time and expense	MoA reg'n of contract farmers is:	MoA controls on seed imports are based on:	Seed certification is:	MoA reg'n of seed dealers is:	MoA approval of seed exports is:		
Bangladesh	Required but automatic (7 days, no charge)	Automatic for all but 5 notified crops	For 5 notified crops (rice, wheat, sugarcane, jute, and potato) MoA tests varieties for 2 years (VCU and DUS) then decides: when successful, registration takes circa 860 days and costs USD 878	Not required	<ul style="list-style-type: none"> Phytosanitary criteria Seed quality Registration required for 5 notified crops (Article 17, Ordinance) 	At the retail level for all species and varieties	Voluntary	Required	Required but automatic (7 days, no charge)	Required, based on seed quality (Article 17, Ordinance)
Ethiopia	Required based on criteria and discretionary judgement	-	For all crops, with discretionary decisions after 2 seasons' DUS and VCU tests, or 1 season for varieties registered in another country (however, Article 7 requires data from 2 seasons before official VCU tests)	Required based on criteria and discretionary judgement	<ul style="list-style-type: none"> Phytosanitary concerns Seed quality according to Ethiopian standards Variety registered in Ethiopia 	May be allowed; see next column		<ul style="list-style-type: none"> All seed must be certified or QDS Required field checks and lab tests for QDS are not clear Requirements for imported seed are not clear 	Required based on criteria discretionary judgement	Required; seed must meet the importing country's quality standards
European Union member countries	Required, but with minimal criteria (able to give information)	Automatic for varieties registered in any other EU country	If not yet registered in another EU country: <ul style="list-style-type: none"> For field crops, 2 years VCU tests and DUS For vegetables: 1 year DUS test, no VCU 	Required but with minimal criteria (able to give information)	<ul style="list-style-type: none"> Phytosanitary issues Seed quality equal to EU standards (except for unprocessed seed from specific countries) 	For all vegetable seeds		For all field crop seeds	Required, but with minimal criteria (able to give information)	Required, based on the importing country's rules (where there are no such rules, seed must meet EU quality standards)

Country	MoA registration requirements for starting a seed company	To introduce a new variety, registration is:			To produce or access seed for wholesale delivery:			To sell seed:	
		Voluntary or automatic and low cost	Required, with discretionary approval after time and expense	MoA reg'n of contract farmers is:	MoA controls on seed imports are based on:	Seed certification is:	MoA reg'n of seed dealers is:	MoA approval of seed exports is:	
Ghana	Required (Article 31, Act); draft regulations focus on growers and do not clarify criteria for registering a seed company	The act (but not draft regulations) allow automatic registration based on regional agreements	For all crops including vegetables (except for varieties from regional lists) based on VCU and DUS tests by an independent authority Regulations do not say how many seasons of tests are required	Required, with MoA discretion to approve based on 'adequate and suitable' farmland and equipment (Article 21, Regulations)	Importers must be registered; seeds must have: <ul style="list-style-type: none"> Phytosanitary certificate Quality certificate Percentage of a registered variety (except seed imported for own use) 	Voluntary Not for any crop, but the situation is not entirely clear	Required For all crops; all packaged seed must give date of certification (Article 30, Regulations); MoA may accredit private parties to certify seed (Article 13, Regulations)	Required but not an obstacle; Ghana has circa 2,000 dealers retailing seed	Required <ul style="list-style-type: none"> Exporter must be registered with MoA Seeds must be tested Seeds must have a phytosanitary certificate
India	Required but automatic (nominal fee)	Voluntary for all species	-	Not required	<ul style="list-style-type: none"> Phytosanitary criteria Seed quality for sale in India The label states the variety or kind of seed Seed import for cotton, wheat, and some other crops is allowed only by government 	For all crops, except for varieties released by public research	For varieties released by public research	Required but automatic (nominal fee); states may waive the requirement	Required <ul style="list-style-type: none"> Seeds must meet India's quality standards Labels must state the variety or kind Essential Commodities Act allows GOI to limit seed exports for food crops, fruit, vegetables, and jute for other reasons

Country	MoA registration requirements for starting a seed company	To introduce a new variety, registration is:		To produce or access seed for wholesale delivery:			To sell seed:		
		Voluntary or automatic and low cost	Required, with discretionary approval after time and expense	MoA reg'n of contract farmers is:	MoA controls on seed imports are based on:	Seed certification is:		MoA reg'n of seed dealers is:	MoA approval of seed exports is:
Kenya	Required, based on onerous and vague criteria and high fees	Voluntary for vegetables	For all field crops and pastures based on 2 seasons VCU and DUS, except 1 season only for varieties registered in Burundi, Rwanda, Tanzania or Uganda	Required but with minimal criteria and low fees	<ul style="list-style-type: none"> Phyrosanitary issues Seed quality Food crop and pasture seeds must be of a registered variety Whether there are enough seeds of the variety in Kenya 	Voluntary For vegetables	Required For all field crops pasture crops	Required, but with minimal criteria and nominal fees	Required, based on seed quality
Tanzania	Required, with some detailed but workable criteria	No	For all crops, including vegetables, MoA asks for 2 years DUS and 1 year VCU tests followed by discretionary decision	Required, but without onerous criteria	<ul style="list-style-type: none"> The importer must be registered Seeds must have a phytosanitary certificate Certificate of quality (regulations do not specify the quality) Variety must be named 	The minister may allow, but the situation is not clear	Required for all crops, including vegetables, unless the minister allows otherwise	Required, but without onerous criteria	Required, based on <ul style="list-style-type: none"> Registration of the exporter Presentation of import permit from the importing country The variety must be named
Turkey	Required (available documents in English do not show the criteria)	No	Required for all crops After 1982 reforms, MoA allowed companies to do their own VCU tests and accepted almost all submitted varieties Currently MoA requires 2 years of VCU and DUS tests	Required (available documents in English do not show the criteria)	<ul style="list-style-type: none"> Phyrosanitary issues Registered varieties (except for seeds to be used to produce for export) OECD certification or ISTA certificates for vegetable seed 	For vegetables	For all field crops	Required (available documents in English do not show the criteria)	Required, based on seeds meeting Turkey's seed quality standards

Country	MoA registration requirements for starting a seed company	To introduce a new variety, registration is:		To produce or access seed for wholesale delivery:			To sell seed:		
		Voluntary or automatic and low cost	Required, with discretionary approval after time and expense	MoA reg'n of contract farmers is:	MoA controls on seed imports are based on:	Seed certification is:		MoA reg'n of seed dealers is:	MoA approval of seed exports is:
USA	Required but automatic (for USDA to assign a code to use on labels)	For all crops	Required, with discretionary approval after time and expense	Not required (but states may require)	Phytosanitary criteria	Voluntary For all crops	Required For some varieties, but the requirement comes from the owner of the variety, not from government	Not required (but states may require)	Not required
South Africa	Not required; however, premises for cleaning, packing, and sales must be registered based on common-sense criteria	Required but automatic (1 year of DUS is a low-cost formality)	See left.	Not required	<ul style="list-style-type: none"> Phytosanitary concerns; Seed quality Whether the variety is registered 	For all crops unless a breeder says otherwise	For varieties for which the breeder asks that certification be required	Not required, but registration of premises is required (based on minimal criteria)	Required, MoA may ask for seed tests before deciding to allow or not (neither the Act nor the Regulations specify what tests may be required)

VCU = value in cultivation and use; DUS = distinctiveness, uniformity, and stability

Table 8.2: Characteristics of maize seed industry in Southern Africa

Characteristic	South Africa	Zimbabwe	Zambia	Malawi	Mozambique
Large-scale seed firms	DuPont Pioneer/Pannar, Monsanto, Sensako, Seed Co/Limagrain	DuPont Pioneer/Pannar, Seed Co/Limagrain	DuPont Pioneer/Pannar, Monsanto/Dekalb, Seed Co/Limagrain, Syngenta/MRI	DuPont Pioneer/Pannar, Monsanto/Dekalb, Seed Co/Limagrain, Syngenta/MRI	DuPont Pioneer/Pannar, Sementes De Mocambique (Semoc)
Small- and medium-size seed firms	(22) Advance Seed, All-Gro, ARC-Grain Crops Institute, Barenbrug, Capstone Seed, Cradock Saad Verspreiders, DMS Genetics, Free State Co-op, G.W.K., Hygrotech, Klein Karoo, Bemarking, Link Seed, Madzivhandila, McDonald Seeds, National Seeds, N.W.K. Co-op, Oos Vrystraat Kaap Bedryf Bpk, Peu, Procell, Senwes, Starke Ayres	(18) ARDA, Agpy, AgriSeeds, Capstone, East West Seeds, FSG, K2, Klein Karoo Seed, National Tested Seeds, Prime Seeds, Pristine, Progene Seeds, Reapers, Sandbrite Seeds, Savana, SIRDC, TESEK Zadzama-tura	(6) AFGRI, Capstone, Clay and Carol, Klein Karoo Seed, Kamano, Progene	(7) Association of Smallholder Seed Multiplication Action Group (ASSMAG), Capstone, Demeter, Funwe, Pantochi, Peacock, SeedTech	(19) IAP - Insumos Agricultura E Pecuaria, Sementes De Nam-pula, Matuel Comercial, Agro Comercial, Olinda Fondo, Nzara Yopera, Bonimar Agro-Comercial, JNB – Empreendimentos, Ikuru, Lozane Farms, Mozfood, Dengo Comercial, Manica Mbeu, IAM, Mocotex, Phoenix Seed, Sementes de Angonia, Ka Chilenge Investimento (KCI), Companhia Do Zembe
Maize area harvested (ha)	2,699,000	960,000	1,074,658	1,650,000	1,572,009
Annual seed sales (tons)	50,327	22,000	18,000	12,000	9,000
Adoption (%)	0.93	0.92	0.84	0.36	0.29

Table 8.3: Characteristics of maize seed industry in Eastern Africa

Characteristic	Kenya	Tanzania	Uganda	Rwanda	Ethiopia
Large-scale seed firms	Agri-SeedCo/Limagrain, Bayer, DuPont Pioneer/Pannar, Kenya Seed/Simlaw Seed, Monsanto/Dekalb, Seed Co/Limagrain, Syngenta	DuPont Pioneer/Pannar, Monsanto/Dekalb, Seed Co/Limagrain, Syngenta	Monsanto/Dekalb, Kenya Seed/Simlaw Seed, Seed Co/Limagrain, Syngenta	DuPont Pioneer/Pannar, Kenya Seed/Simlaw Seed, Seed Co/Limagrain,	Advanta, Ethiopian Seed Enterprise (ESE), DuPont Pioneer/Pannar Seed, Seed Co/Limagrain, Syngenta
Small- and medium-size seed firms	(15) ACDI-VOCA (Kenya Maize Development Programme), Dryland Seed, East African Seed, Faida, Freshco Kenya, Farmchem Seedlinks, Fresh Produce Exporters of Kenya (FPEAK), Hygrotech East Africa, Kenya Highland Seed, Lagrotech, Leldet, Olerai, Sacred Seeds, Savana Seeds, Western Seed	(18) Agricultural Seed Agency (ASA), Agriseed Technologies, Bajuta International, Brac, Bytrade, East African Seed, IFFA Seed, Kibo Trading, Kibo Seed, Kipato Seed, Krishna Seed, Meru Agro-Tours, Mount Meru Seed, Northern Seed, TANSEED International, Tropical Seed, Suba Agro, Southern Seed	(21) AK Oils & Fats, Akuku Farm Seeds, Amla Seeds, Arolim Seeds, CAII, East African Seed, El-Shaddai International, Farm Inputs Care Centre Uganda (FICA), General & Allied, Grow More Seeds and Chemicals, Masaba Seed, Masindi Seed, Mount Elgon Seed, Mount Meru Millers, NASECO, Otis Garden, Pearl Seeds, Rial Seeds, Safari Seeds, Supa Seeds Africa, Victoria Seed	Farmer associations and cooperatives, Rwanda Agricultural Development Agency (RADDA), Rwanda Seed Company	(35) public and private companies, including Amhara Seed Enterprise, Oromia Seed Enterprise, Tigray Seed Enterprise, Somali Seed Enterprise, South Seed Enterprise, Anno Agro-industry, Gaaddisaa Goobanaa, Hadia Seed, cooperatives/union, NGO community based seed schemes
Maize area harvested (ha)	2,100,000	4,120,269	1,000,000	292,326	2,069,267
Annual seed sales (tons)	24,694	26,270	10,000	1,200	16,000
Adoption (%)	0.47	0.32	0.40	0.21	0.31

Table 8.4: Characteristics of maize seed industry in West Africa

Characteristic	Nigeria	Ghana	Burkina Faso
Large-scale seed firms	DuPont Pioneer/Pannar, Green Agriculture West African, Maslaha Seeds, Monsanto, SeedCo/Limagrain, Premier Seeds	DuPont Pioneer/Pannar, Monsanto/Dekalb, Seed Co/Limagrain, Syngenta	Monsanto/Dekalb, Kenya Seed/Simlaw Seed, Seed Co/Limagrain, Syngenta
Small- and medium-size seed firms	(33)Alheri Seeds, Asmau Memorial, Boman Seed, Champion Seeds, Da-All Green, Daddo Seed, Dan Agro Industrial Company, Delta agric. Procurement Agency, Elite Seed, Girmal Agric. Company Services, Green Sands Technical, Gold Agric, Inganchi Seed, Institute of Agric Research and Training, Jikur Seed, Maina Seed, Manoma Seeds, Mathtech Agro, M'Billa Farms, Subsidiary Sabore(EPZ) Farms, Nagari Seeds, Nyam Agric Ventures, Notore Seeds, Ogun State Agro Service Corporation, TAK Agro, Terratiga Seeds, Tony Best Agric. Centre, West African Cotton Company, Rosemary Venture, Salami Farms, Savannah Seed, Seed Project Company, Value Seed, Wadata Seeds	(17) Agric Comercial Services, Alpha Seeds, Antica, Antuqua Wa, Big Ajar, Faranaya Agric, Heritage Seeds, Jafel Agro, Lexbog, M & B, Mabert Seeds, Mafor Seeds, Meridan Seeds, Savannah Seeds Services, Virine Ventures, Wienco, Yonifah	(12) Agro Production, Entreprise de Production et de Commercialisation de Semences Ameliores Certifiees, FAGRI, Faso Agriculture et Intrants, Federation de Groupments de Producteur de Nalaya (FGPN), Membre de la chamber regionale d'Agriculture at Nationale, NAFASO, GMPS / SAPHYTO, PADAWA NUNA, Union Departementale de Producteur Semenciers, Union Nationale des Production Semenciers de Bukina (UNPS)
Maize area harvested (ha)	5,200,000	1,023,459	950,000
Annual seed sales (MT)	8,501	2,798	5,000
Adoption (%)	0.08	0.14	0.26

Table 8.5: Seed policy projects being implemented by action nodes

Dimension	Ghana	Mozambique	Tanzania
Goal	Create an enabling seed policy environment to promote the adoption of improved crop varieties by smallholder farmers to increase household income and national food security.	Create an enabling seed policy environment to promote the adoption of improved crop varieties by smallholder farmers to increase household income and national food security.	Increase agricultural productivity and household income through improved public policies to enhance private sector participation in staple food seed production and marketing.
Coordinating organization	Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA)	National Directorate of Agrarian Services (DNSA) of the Ministry of Agriculture (MINAG)	Department of Crop Science and Production, Sokoine University of Agriculture
Members	Directorate of Crop Services, Plant Genetic Resources Research Institute (CSIR-PGRI), Crops Research Institute (CSIR-CRI), Savanna Agricultural Research Institute (CSIR-SARI), University of Ghana, Legon, University for Development Studies (UDS), Grains and Legumes Development Board (GLDB), Seed Producers Association of Ghana (SEEDPAG), Ghana Agri-Input Dealers of Ghana (GAIDA), Apex Farmers Organization of Ghana (APFOG)	Agricultural Research Institute of Mozambique (IIAM), USEBA, UNAC (Farmers' Organization), Directorate of Economics (Directorate of Policy), Beira Corridor Group, DNER, Mozambique Seed Trade Association (MOSTA)-Solucoes Rurais, National Dialogue Platform for Seed Sector, Ministries of Trade & Industry, Finance, Science & Technology, Foreign Affairs, Environment	Tanzania Seed Trade Association (TASTA), Agriculture Seed Agency (ASA), Ministry of Agriculture, Food Security and Cooperatives (MAFC), Economic Social Research Foundation (ESRF), Tanganyika Farmers Association (TFA), Agriculture Council of Tanzania (ACT), Sahelian Agricultural Research Institute (SARI), Research on Poverty Alleviation (REPOA)
Objectives	<ul style="list-style-type: none"> Support implementation of the Seed Law as contained in Part II of the Plants and Fertilizer Act, 2010 (Act 803) Improve seed production conditions of private seed enterprises Facilitate development and implementation of policies that enhance the uptake of improved varieties in the Northern breadbasket areas Facilitate development of strategies to ensure seed quality assurance consistent with international standards 	<ul style="list-style-type: none"> Facilitate implementation of national seed strategy and regulations Increase participation of private seed production Enhance uptake of improved varieties in Beira breadbasket region by evaluating the implementation of voucher seed subsidy Facilitate the development of seed quality assurance system consistent with international standards Review PBR (2007) and align with UPOV and SADC 	<ul style="list-style-type: none"> Improve national seed policy strategy, Seed Act and Regulations Facilitate the implementation of policies so as to enhance private sector participation in production and marketing of basic seed Determine supply and demand of improved seed of staple food crops with a view of increasing use of improved seeds

Dimension	Ghana	Mozambique	Tanzania
Targeted policy reforms	<ul style="list-style-type: none"> Variety release, seed certification and marketing regulations PBR and access to basic seed of publicly bred materials and foundation seed production by private companies Seed subsidies Seed certification – ISTA, Orange International Certificates, OECD 	<ul style="list-style-type: none"> Seed strategy Government tender-based seed subsidies (except for emergencies) Seed regulations PBR regulations Seed enterprise assessment for basic seed production 	<ul style="list-style-type: none"> Access to pre-basic and basic seeds of publicly bred varieties by private seed companies Harmonizing roles of seed regulating authorities (TPRI, PHS, Seed Unit) Incentives for breeders to purify and maintain public bred varieties Review taxation system in seed industry (Cess, Levies, VAT)
Key seed policy commitments under G8 Cooperation Framework	<ul style="list-style-type: none"> Develop regulations to implement the new seed law (seed registry system, protocols for variety testing, release and registration, authorization to conduct field inspections, seed sampling, seed testing, standards for seed classification and certification) Develop new agricultural input policy for fertilizer and certified seed use (defined role of government in fertilizer and seed marketing) Defined role of government's CSIR and Grains & Legumes Board Defined role of private sector in breeding). 	<ul style="list-style-type: none"> Revise and implement national seed policy, including systematically cease distribution of free and unimproved seeds except for pre-identified staple crops in emergency situations and allowing for private sector accreditation for inspection Implement approved regulations governing seed proprietary laws which promote private sector investment in seed production (basic and certified seed) Revise and approve legislation regulating the production, trade, quality control and seed certification compliant with the SADC seed protocol requirements. 	<ul style="list-style-type: none"> Lift taxes (cess, VAT) on seeds and seed packaging Revise Seed Act that aligns plant breeder's rights with the International Union for the Protection of New Varieties of Plants (UPOV) system Reduce time required to release new varieties of imported seeds from outside the region Authorize qualified private sector companies to produce foundation seed under proper supervision and testing Achieve ISTA and OECD seed testing accreditations to enable regional and international seed sales

Dimension	Ghana	Mozambique	Tanzania
Major activity areas	<ul style="list-style-type: none"> • Develop regulations to support implementation of the Seed Law contained in the Part II of the Plants and Fertilizer Act, 2010 (Act 803) • Support private seed enterprises to improve seed production including foundation seed production • Facilitate dissemination and adoption of improved seeds by smallholder farmers by improving seed subsidies • Create awareness among policy makers, parliamentarians and small-scale farmers on the benefits of improved seeds • Support the development of seed quality assurance systems 	<ul style="list-style-type: none"> • Review seed strategy and regulations and develop action plan for implementation • Improve private seed companies' participation in seed production • Advocate for policies and incentives for seed enterprises • Facilitate development and implementation of policies that enhance the uptake of improved varieties in the Beira Breadbasket areas • Facilitate development of strategies to ensure seed quality assurance consistent with international standards • Facilitate development of quality assurance system 	<ul style="list-style-type: none"> • Review the status of seed industry • Conduct stakeholders' workshop on status of seed industry • Support review of seed policy, acts and regulations • Conduct stakeholders' meetings for awareness of reviewed seed policies, acts, and regulations • Design a monitoring and evaluation system to track the effectiveness of the revised policy, acts and regulations • Conduct surveys to establish overall demand and supply of certified seeds of staple food crops and users • Conduct survey of the existing basic seed producers, users and importers to establish the status of basic seed production • Review regulations for effective product licensing agreements on germplasm transfer
Key reform outputs	<ul style="list-style-type: none"> • Seeds (Certification and Standards) Regulations developed and ratified • PBR Incentives created to motivate enterprises in seed production and marketing • Adoption rate of certified seeds increased • Seed quality assurance systems reviewed to international standards and institutionalized 	<ul style="list-style-type: none"> • Provision of seed regulations started 2012 approved February 2013 by Council of Ministers • Disseminated through 2500 pamphlets, 120 Seed Regulation Manuals and 3 regional workshop, radio and public television, 100 seed companies and stakeholders' meetings • PBR reviewed to align with UPOV & SADC Protocol approved March 2014 by Council of Ministers 	<ul style="list-style-type: none"> • Gaps in existing seed policy, acts and regulations identified • Reviewed seed policy, acts, and regulations in place • Increased levels of awareness to reviewed seed policy, acts, and regulations • Better monitoring and evaluation systems to track effectiveness of revised seed policy, acts, and regulations established • Seed stakeholders' forum formalized • Memorandum of understanding between MAFC and LGAs on implementation of seed issues

Dimension	Ghana	Mozambique	Tanzania
Major policy reform successes	<ul style="list-style-type: none"> Development, validation, approval and enactment of Plants and Fertilizer Act 803 in 2010. Development, validation, drafting and approval of the Seeds (Certification and Standards) Regulations. Seed regulations were aligned to the ECOWAS seed regulation from 11-15 May 2015. Attorney General's office presented regulations to MOFA for final approval on 19 October 2016. The Minister of Agriculture finally approved, signed and sent back regulations to Attorney General's office on 31 October 2016. AG forwarded the regulations to Parliament on 2 November 2016 National Seed Council inaugurated National Seed Policy was approved and adopted by Government on 11th July 2013. Effective date of the Policy (Entry into force): 1st August 2013. Accreditation of National Seed Testing Laboratory (NSTL) by the International Seed Testing Association (ISTA). Plant Breeders Bill (still in parliament) 	<ul style="list-style-type: none"> Seed Regulation approved by Council of Ministers in February 2013 For implementation of the Seed Regulation operating procedures updated of the internal regiment for National Seed Committee (CNS) and Sub-Committee of Registration and Release of Varieties (SLRV) and approved by committees in May 2014 Decree on PBR of 2007 reviewed to align with UPOV and SADC and approved by Council of Ministers as Decree Regulation of protection of new plant varieties in March 2014 National Program for Strengthening for Seed Chain developed and approved by Minister of Agriculture Blanket government-run seed subsidy replaced by a voucher program that was piloted in some districts in five provinces (Manica, Nampula, Zambezia, Sofala and Tete) 	<ul style="list-style-type: none"> Amendments in Seeds Act No. 18 of 2003 some sections (8, 14 and 15) repealed and new additions made to section 8A, 14A and 22A (CAP. 308) Seed industry strategy and action plan used by Ministry of Agriculture to inform decisions to open up production of foundation seed to the private sector Bill for an Act to establish the Zanzibar Seed Act of 2015 draft comments Seed quality control measures, inclusion of District Authorized Seed inspectors, Local Government Authorities, Prime Minister's office and Regional Administration which were not included in Seeds Act No. 18 of 2003, d to

Dimension	Ghana	Mozambique	Tanzania
Key enablers of policy reform success	<p>Within – NMIs committed to working together</p> <p>Beyond – Legislators willing to collaborate on policy reforms; support from other key agencies (e.g. Attorney General's Department); Ministers of Food and Agriculture provided full support for policy reforms</p>	<ul style="list-style-type: none"> • Government policy investor-friendly Agricultural Promotion Centre (CEPAGRI) & Investment Promotion Centre (CPI) • Policy champions Director of DNSA and Department of Policy, Directorate of Economy • Involvement of key actors and stakeholders in seed chain coalescing in MOSTA and National Dialogue Platform for Seed Sector • Engagement of the private sector in ensuring the provision of improved seed to the farmers. 	<ul style="list-style-type: none"> • Seed professionals in the node • Financial regulations at the host institution • Cooperation from MAFC and SPAN collaborators • Political will • Agricultural initiatives • Global support for agriculture

Table 8.6: Types of “problem” seed policy, laws, regulations and administrative practices in Southern, Eastern, and West Africa and their consequences for agribusiness and farmers

Types of policy and regulatory problem	Area	“Problem” policy/regulation	Consequence
Missing or ambiguous	Southern Africa	Private companies now allowed to produce basic seed but no changes in law and regulations.	Private seed companies have access to pre-basic and basic seed of publicly bred varieties but there is no seed? Not clear. Available seed is not pure. Private seed companies incur lost sales, revenue and profits. Farmers fail to get access to certified seed of improved varieties and fail to increase productivity, profitability, incomes, and food security.
	Eastern Africa	Without ISTA and OECD accreditation, seed companies unable to export to neighboring countries.	Private seed companies have poor incentive to expand production because smaller domestic market rather than regional market. Contract growers have fewer opportunities to increase output and income.
	West Africa	No Plant Variety Protection (PVP) legislation, regulations ratified by the International Union for the Protection of New Varieties of Plants (UPOV).	Seed companies not introducing best performing proprietary varieties because cannot recover costs if stolen. Seed companies lose potential sales revenue and profit. Farmers not capturing benefits of increased yields, profitability and income.
Economically flawed	Southern Africa	The government, development partners and NGOs involved in free seed distribution (droughts, floods) and subsidized seed in emergency and non-emergency situations.	Private companies lose profits and fail to invest in market services. Poor quality seed distributed to farmers; seed fails to germinate and farmers waste their investments in land preparation and weeding.
	Eastern Africa	Government dominance of pre-basic and basic seeds limits private sector participation	Private firms not allowed to produce foundation seed for private sector seed multiplication. This limits supply of certified seed and increases seed costs, limiting adoption and benefits to farmers.

Types of policy and regulatory problem	Area	“Problem” policy/regulation	Consequence
	West Africa	The government contracts seed producers to produce seed for seed subsidies and sells at 50% market price to pre-selected beneficiaries with vouchers through agro-dealers in competition with seed companies	Seed firms and agro-dealers own stock. Unless they sell this first, they cannot sell at all because not subsidized. Limited sales, revenue, profits to seed firms and agro-dealers and investment in services. Farmers get low-quality seed, low yields, low profits, low income.
Excessive	Southern Africa	Government has stringent controls on variety testing, release and registration, and seed certification. No accreditation of private seed inspectors or private laboratories.	Private seed firms do not expand investments in seed inspectors and private laboratories. Demand on government experts to test and evaluate varieties and to conduct field and laboratory tests for seed certification exceeds capacity and resources. This results in poor quality seed marketed to farmers. End result: farmers do not use seed of improved varieties.
	Eastern Africa	Variety testing and release only through government researchers and national variety release committees only test for VCU and not DUS can take 3–4 years.	Delays in delivering new technologies to farmers and new income streams.
	West Africa	Agro-dealers require separate registrations to sell seed, fertilizer and pesticides. Private agro-dealers find multiple registrations cumbersome and time-consuming and have proposed a one-for-all registration procedure.	Multiple registrations, repeated annually, add time and cost to registration procedures and may discourage some agro-dealers from completing all the registrations (and selling the full range of inputs). Farmers may find that certain agro-dealers do not carry certain agrichemicals or other inputs.
Poorly implemented	Southern Africa	Seed subsidies poorly implemented. No planning. No strategy.	Seed subsidies although expand opportunities for private companies to increase revenue and profits, killing the seed industry. Private seed firms reduce investment because of uncertainty of government purchases and what they are going to sell. Farmers wait for cheap or free seed.

Types of policy and regulatory problem	Area	“Problem” policy/regulation	Consequence
	Eastern Africa	The subsidy program is poorly implemented so farmers often do not obtain high-quality seed of improved varieties.	Seed subsidies crowd out private sector producers of seed and traders. Smallholders unable to access high quality seed of improved varieties.
	West Africa	Limited capacity of public sector to produce breeder and foundation seed, inspect and certify seed production, and monitor the seed trade. But government organizations insist on controlling.	Private seed firms produce limited foundation seed. Certified seed production expanding slowly. Farmers unable to access sufficient quantities of high-quality, high-yielding seed varieties. Cereal crop productivity stagnant. Farmers fail to capture benefits of new technologies.

Table 8.7: The evolving agenda for seed policy research and analysis and advocacy in Southern, East, and West Africa

Challenge	Mozambique	Tanzania	Ethiopia	Nigeria	Ghana	Burkina Faso
Registration seed businesses	X	XX	XXX	XXX	XXX	XX
Variety development, testing, release and registration	XX	XX	XXX	XXX	XXX	XX
PVP/PBR/IPR	X	XX	XXX	XXX	XX	XXX
Biosafety and GMOs	XX	XX	XX	XX	XX	X
Access to pre-basic/basic seed	XX	XX	XX	XX	XX	XXX
Seed certification	XXX	XXX	XXX	XXX	XXX	XXX
Seed distribution	X	XX	XXX	XX	XX	XX
Consumer protection/Fake seeds	XX	XX	XX	XX	XX	XX
Subsidies/taxes	XXX	XXX	X	XX	XXX	XXX
Financing	XXX	XXX	XXX	XX	XXX	XXX
Seed imports/exports	X	X	XXX	XX	XX	XX
Regional trade agreements	X	X	XX	XX	XX	XX
Implementation of existing laws and regulations	XXX	XXX	XXX	XXX	XXX	XXX

XXX = Very important; XX= Important; X = Not important



9 Results Measurement and Learning

Sam Amanquab¹

Measuring AGRA's initial overarching goals of reducing food insecurity of target farmers by half and doubling the income of 20 million smallholder families while setting 18 countries on the path to a Green Revolution has been and remains a complex undertaking. Without question, a robust monitoring and evaluation (M&E) system is needed – one that can plausibly determine whether AGRA's investments in diverse interventions are yielding the desired changes among the target beneficiaries – and if the interventions are indeed working and what can be done to lubricate the process to ensure effective results delivery.

A robust performance measurement system that has the capability of establishing what AGRA's investments are producing and how efficiently implementation translates resources into results is paramount. Critical to this system is its ability to additionally demonstrate the difference these interventions make at each key level: household, community, country and sub-region.

AGRA's M&E system is set up to respond to such needs by capturing results in real time, with a focus on both the intended and unintended, as well as positive and negative impacts of AGRA's interventions. Beyond providing credible evidence that informs management decisions, the M&E system helps ensure accountability to stakeholders, while shaping AGRA's strategic planning and risk management.¹

Measuring PASS Performance

The mandate of AGRA's Program for Seed Systems in Africa (PASS) is to establish seed systems that deliver improved varieties of staple crops to smallholder farmers in an efficient and sustainable manner. But doing so on a large scale – an initial program area of 13 countries that quickly expanded to 18 countries – meant that we needed to devise a system through which activities taking place on a very local level could be made visible in near-real time at a central level in a way that facilitated responsive management of resources. Such a system was put in place, and proved effective over the full lifetime of the program.

The PASS theory of change was based on the premise that enhancing human capacity to develop improved crop varieties while equipping National Research Institutions to support participatory breeding that rely on a strong farmer involvement will result in the development of crop varieties that create farmer demand that will incentivize private seed companies to commercialize and deliver these seeds to farmers. Increased farmer adoption of improved seeds, coupled with the application of recommended management practices, will result in higher yields and lead to improvements in household productivity and food security (Figure 9.1).

¹ M&E Program Officer – West Africa, Strategy, Monitoring and Evaluation, AGRA

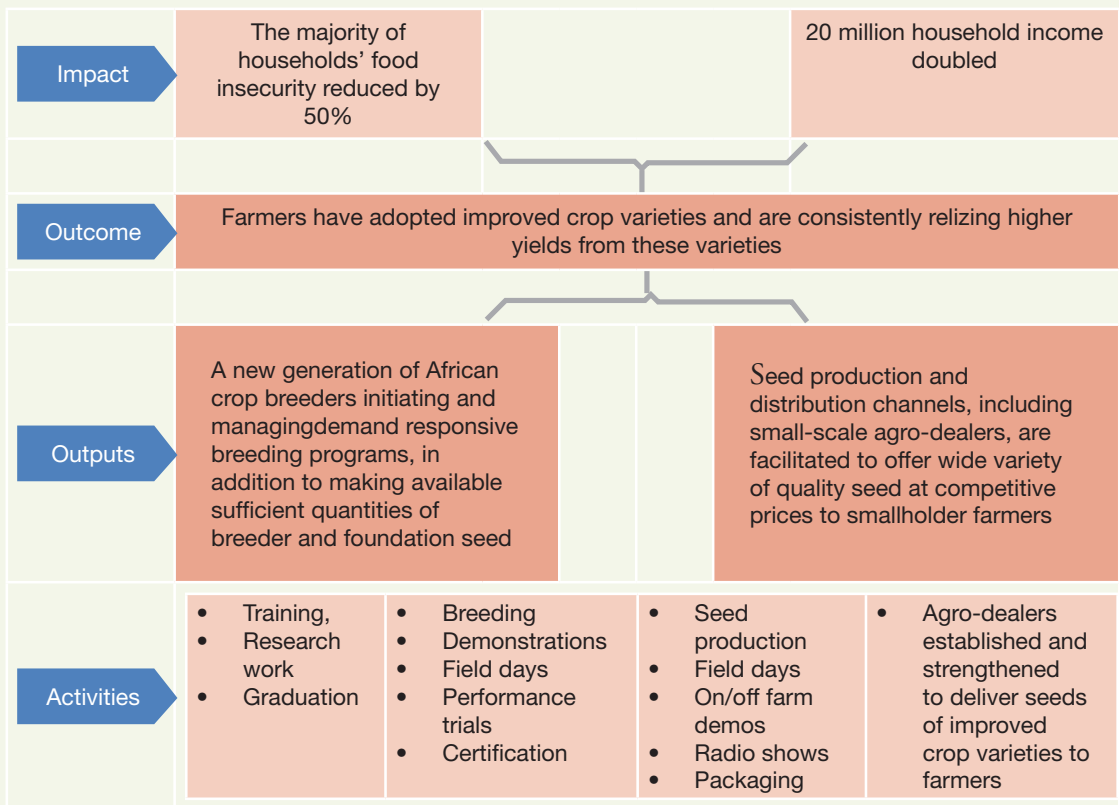


Figure 9.1: PASS theory of change

Monitoring

PASS monitoring covered the entire lifespan of its grants. Monitoring was primarily conducted by PASS program officers working with the M&E Unit. It involved collecting, analyzing, and communicating performance data to understand how investments were being deployed and to gauge the impact from the outputs of activities, but it also involved AGRA staff serving as cheerleaders and empathetic advisors to local teams, many of whom were tackling challenges they had never before faced in their professional lives. Output level indicators developed jointly with the program officers were assiduously tracked using data sheets to assess project level performance.

Monthly, quarterly, and half-yearly data on process and output indicators were collected by grantees using agreed methods and tools. Output data were stored in the PASS database and appropriate reports were generated for different stakeholders. A critical component of the monitoring system was a data quality initiative that sought to assess and document the quality of reported data, as well as the data collection methods, tools, and approaches used by project implementing teams. Data quality has different meanings to different stakeholders, depending on their goals and objectives (Wang & Strong 1996).

While emphasis has been placed on completeness of data and its accessibility in other instances

(Ashley 2013), AGRA's definition of data quality focused on its "fitness to use" – a multi-dimensional concept that assesses the relevance (in terms of validity, accuracy, reliability, timeliness, precision and integrity) of data and the characteristics that affect how it can be used. Through data collection procedures set up with each grantee, PASS was able to construct a dashboard of results that was updated quarterly and allowed managers to visualize what was taking place on the ground in each country. Over the medium term, this data allowed management to make key decisions regarding investments. One example of this use of data was when management recognized a growing gap between the number of varieties released and the number actually being commercialized and reaching farmers. In response, management created a commercialization unit staffed by two full-time specialists. Another example was when agro-dealer training and certification appeared to be outpacing seed production. The widening gap between numbers of agro-dealers and total seed supply was backed up by anecdotal accounts of agro-dealers failing to secure seed suppliers to stock their shelves.

To validate project performance data, the M&E Unit engaged external consultants to conduct independent assessments of the data systems among sampled projects in four countries. Such assessments, coupled with regular analysis of monitoring data, allowed the PASS team to make informed programmatic and strategic adjustments to the program to ensure it was responding to emerging challenges and risks while being on track towards achieving its overarching objectives.

Embedded within the monitoring framework were the regular grantee capacity building exercises that equipped project implementation

teams with requisite skills to collect, store, analyze and report on performance data. This training has annually benefitted over 120 project implementers in 18 countries.

Performance Reviews

Mid-Term Review – Key Findings

The Mid-Term Review of PASS Phase I was commissioned in 2010 to assess the program's achievements, best practices, and challenges to inform future strategic directions. The Review, which covered a representative sample of 143 PASS projects in 9 countries, determined that considerable progress had been made on key performance indicators. The Review established that PASS had:

- Supported training of 83 PhD and 119 MSc students from 11 countries in 10 universities across sub-Saharan Africa;
- Assisted national research institutions to intensify breeding and release of 93 new varieties, 65 of which had been commercialized;
- Facilitated the production of more than 12,000 MT of certified seed by 2009 – far more than the 3-year cumulative target of 5,000 MT – and that this achievement was due to its support of 35 private local seed companies, 4 public sector companies, and 8 farmers' associations and cooperatives; and
- Enhanced the capacity of 9,000 agro-dealers, with 7,000 of them certified by 2009. Trained agro-dealers had sold 46,000 MT of seed and 235,000 MT of fertilizer.

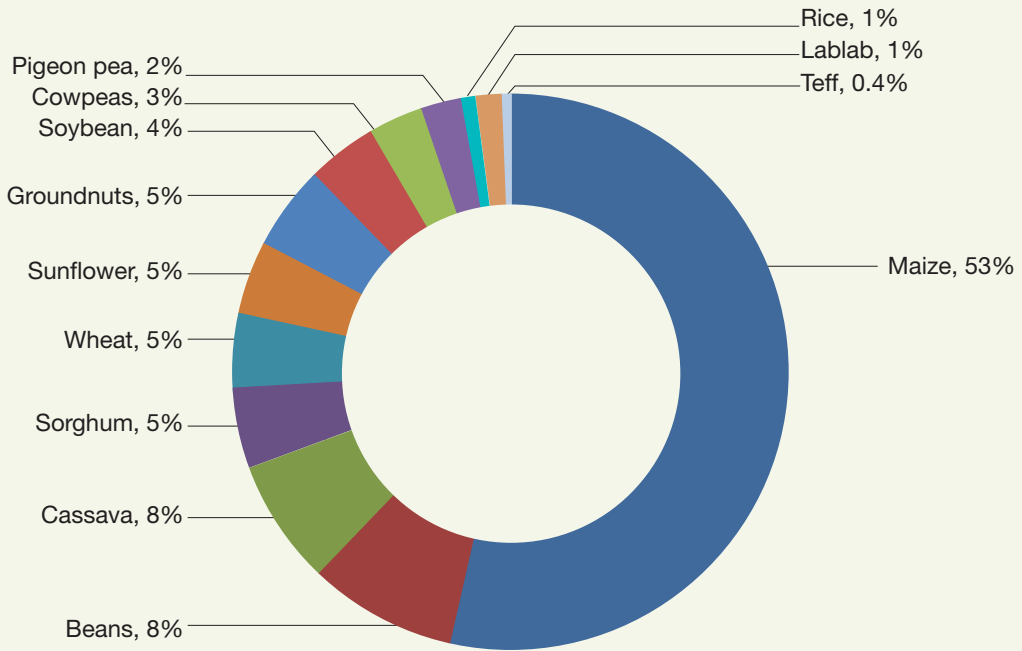


Figure 9.2: Percentage by crop of new crop varieties produced.

Source: PASS Mid-term Review

Meanwhile, the major limiting factors to seed production were identified to be:

- Inadequate supply of foundation seed;
- Weak extension services; and
- Low capacity to enforce regulations and policies.

The review also established that although the capacity of agro-dealers had clearly been enhanced, capacity challenges still faced those that had been sampled, and therefore the Review recommended periodic refresher training to deal with the dynamics of the trade.

At the household level, 73% of the 1,542 farmers interviewed in seven countries (Ghana, Kenya, Malawi, Mali, Nigeria, Tanzania and Uganda) in areas with heavy concentration of PASS-supported agro-dealers and seed companies

confirmed using improved seed. The highest proportion of farmers using improved seed was in Kenya (93%) and the lowest in Mali (42%).

Just under a third (30%) of the surveyed farmers reported using improved varieties in one season, while 42% planted improved seed over 2-4 farming seasons across the nine countries.

Half of farmers surveyed said they planted seed from their own harvest (54%). Nineteen percent bought seed from agro-dealers, while 17% acquired seed from other farmers or local markets.

Some 42% of farmers indicated that they obtained information on crop varieties from their fellow farmers and 34% from extension services. Other sources were radio/TV (19%) and agro-dealers (16%).

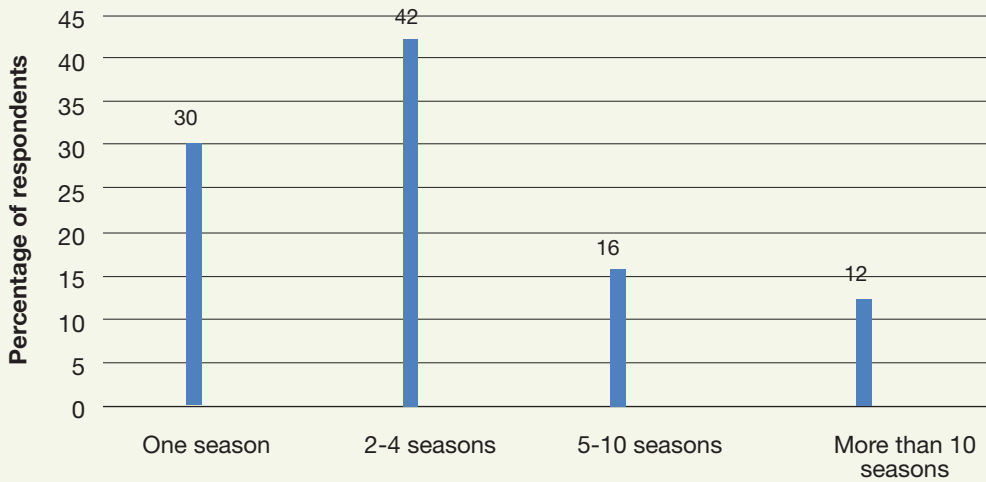


Figure 9.3: Period farmers have been growing new varieties across surveyed countries

Source: PASS Mid-term Review

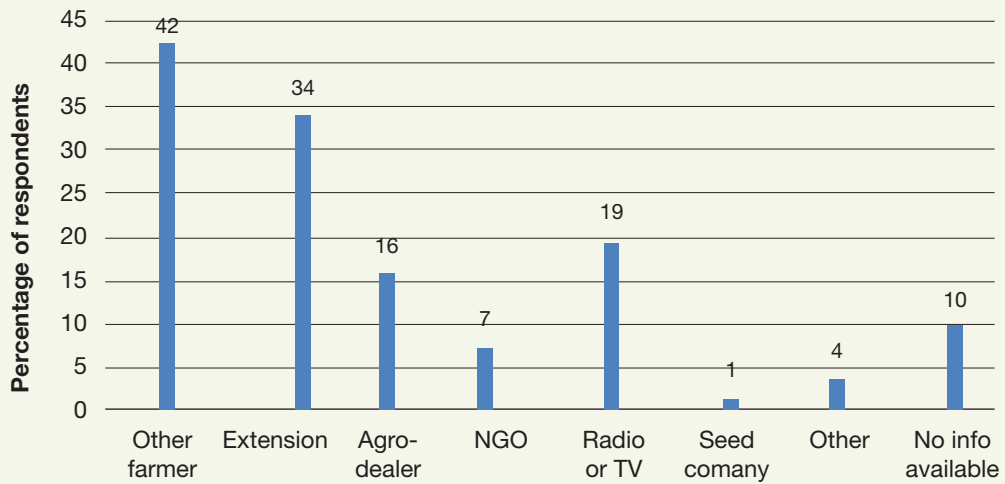


Figure 9.4: Source of information on new varieties across surveyed countries

Source: PASS Mid-term Review

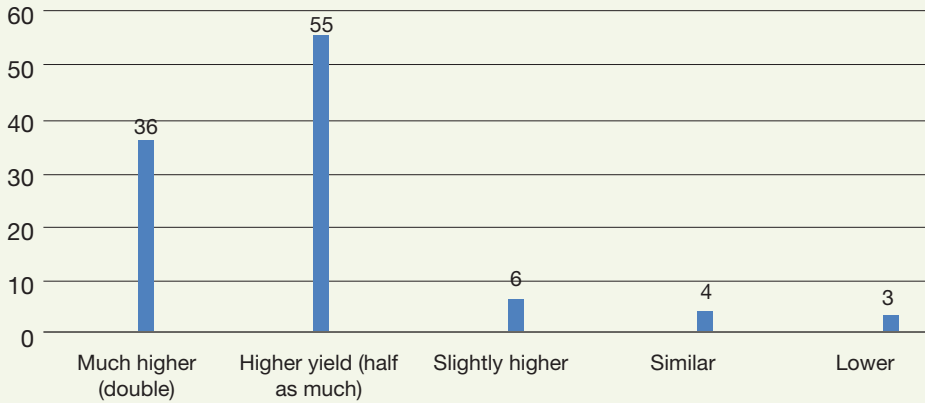


Figure 9.5: Yield perceptions across survey countries
(Source: PASS Mid-term Review)

Regarding fertilizer, however, extension services were the biggest source of information (41%), followed by other farmers (30%) and agro-dealers (24%).

Ninety-one percent of the surveyed farmers indicated higher yield levels were achieved because of using seed of improved varieties instead of the local varieties; 36% of the 91% doubled their yield levels while 55% saw a 50% increase on their previous yield.

End of Phase 1 Evaluation – Key Findings

The evaluation of PASS Phase I was commissioned in 2012 with the objectives of assessing the extent to which program objectives were achieved, test the underlying hypotheses, assess the cost- effectiveness of program activities, and assess the likelihood of achievements being sustained over the medium to long term. The evaluation covered 12 of the 13 original PASS target countries. Mali was omitted due to political

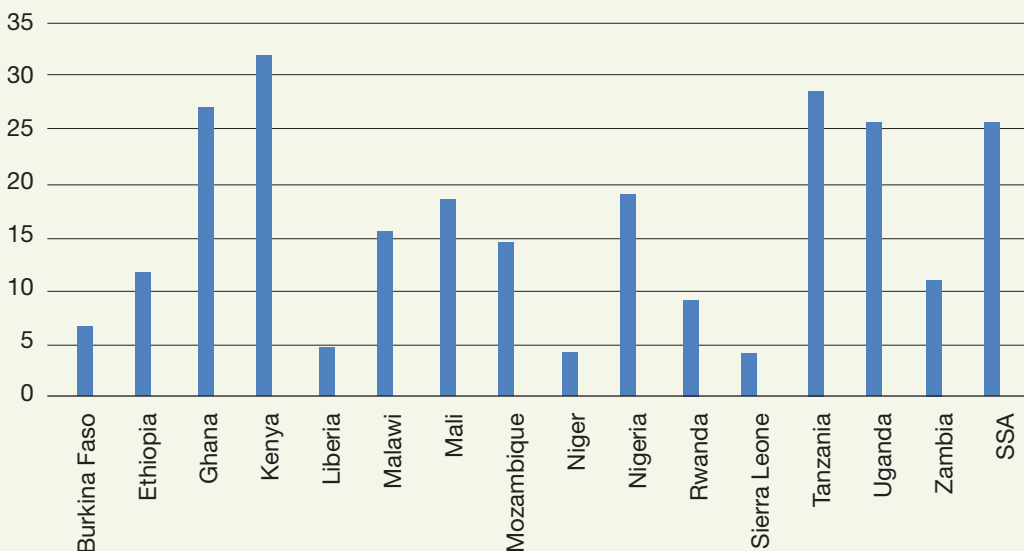


Figure 9.6: Number of PASS grants
(Source: PASS Phase 1 Evaluation)

insecurity at the time in that country, while Liberia, Sierra Leone, and South Sudan were exempted because PASS initiatives were then at the formative stage.

In Phase 1, PASS implementation issued more than 260 grants worth over USD 115 million across the four sub-programs in 13 countries.

Training program

The evaluation of Phase I established that the training sub-program had, by 2011, enrolled students from 15 countries: 44 PhD students at the University of KwaZulu Natal's African Centre for Crop Improvement (ACCI), and 36 MSc students at the West African Centre for Crop Improvement (WACCI) at the University of Ghana. At the MSc level, 175 students from 10 countries had been enrolled, 38% of them female – 73 students had graduated by the end of Phase I.

Breeding program

According to the evaluation, PASS-supported breeding activities had significantly raised the profiles of individual breeders within their own national programs. It was also evident that national breeding programs had become much more dynamic and were attracting new young researchers into the field. These benefits were particularly pronounced where national program breeders assisted in training of MSc candidates. Training at Makerere University was cited as an excellent example of such collaboration.

The evaluation identified as a strong point the unique breeding approaches that involve farmers in setting breeding objectives, variety selection, and promotional activities to create demand for new cultivars. These approaches, which also engage private local seed companies in commercialization, were flagged as scalable models that can help trigger a Green Revolution in sub-Saharan Africa.

Although PASS was considered highly successful in involving farmers in the release of varieties, linkages between breeders and seed companies was found to be a weak area that should be strengthened.

As shown in Figure 9.7, among the 14 staple crops for which new varieties were released, maize led with 85 releases or 25% of the total. Next was cassava with 62 varieties (18.6%), then rice with 47 (14.1%) and beans with 35 (10.5%). The highest number of varieties were released in Mali (65), followed by Kenya (62), Mozambique (41) and Uganda (33).

Progress in variety commercialization differed between countries, as shown in Table 9.1.

Table 9.1: Variety releases and varieties commercialized between 2007 and 2011

Country	Achievements, 2007-2011	
	Varieties Released	Varieties Commercialized
Burkina Faso	10	0
Ethiopia	9	7
Ghana	14	10
Kenya	62	48
Malawi	23	11
Mali	65	11
Mozambique	41	31
Niger	0	0
Nigeria	4	3
Rwanda	25	22
Sierra Leone	16	8
Tanzania	27	20
Uganda	33	33
Zambia	4	4
Total	333	208

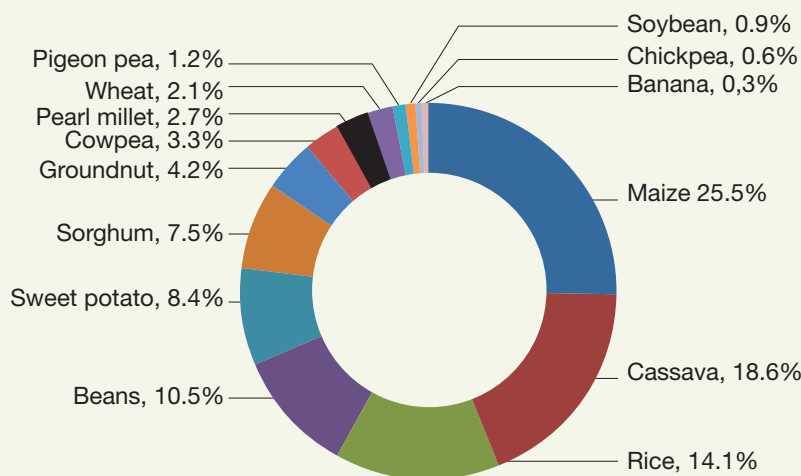


Figure 9.7: Variety releases by crop, 2007–2011 (Source: PASS Phase 1 Evaluation)

Seed production

The seed production sub-program supported 84 private local seed companies in 13 countries to produce over 57,000 MT of seed for 13 crops in 2012. Maize accounted for about half of the seed produced (Figure 9.8). However, there

was increased interest in production of seed for “orphan” crops such as soybean and sunflower, which are often neglected by the larger or multinational companies. Regarding the access to credit initiative intended to help local private seed companies, the African Seed Investment Fund had, by the end of the first phase,

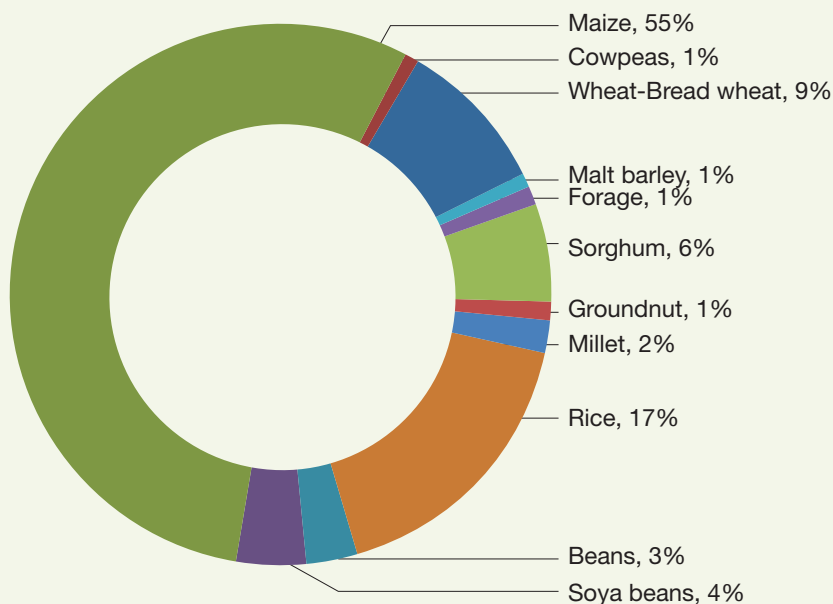


Figure 9.8: Percentage of crop varieties produced by the seed companies in 2011 (Source: PASS Phase 1 Evaluation)

committed USD 11.4 million. It had disbursed over USD 5.8 million to seven private local seed companies in the East Africa sub-region.

Despite the huge strides made by the seed production sub-program over the first 5 years of implementation, several persistent challenges were highlighted that needed to be addressed. These included inadequate foundation seed, the inability of seed companies to meet the increasing demand for improved varieties among farmers, and continued lack of awareness among farmers regarding the value of improved seed.

Agro-dealer development

The agro-dealer development program had trained and certified 6,987 agro-dealers in 9 target countries by the end of Phase 1. Increased agro-dealer capacity building activities contributed to a rise in the number of agro-dealers accessing loans to 4,635 by the end of the first phase. These milestones translated into increased sales of fertilizer (855,865.34 MT) and improved seed (373,251 MT) by PASS-trained agro-dealers in the 9 target countries – Burkina Faso, Ghana, Kenya, Malawi, Mozambique, Nigeria, Tanzania, Uganda, and Zambia.

Household surveys were conducted in these countries to establish the adoption levels of improved crop varieties. Owing to the challenges of setting up a rigorous impact evaluation design capable of delineating and quantifying the impact of PASS initiatives, a modified and less rigorous design was used. Two contrasting sites, defined by agro-ecological potential, were selected in each country for the study.

In Malawi, Mozambique, Tanzania and Zambia, it was possible to delineate geographical areas with agro-dealer activities from those without. This made it possible to undertake a household

survey involving 400 sampled households in each country to compare areas with and without interventions.

The evaluation established that in the East Africa sub-region (Kenya, Tanzania, Uganda), 70% of the sampled households grew improved maize varieties, 18.3% improved rice varieties, 41% improved bean varieties, and 9% superior cassava cuttings.

In West Africa (Burkina Faso, Ghana, Nigeria), 48.7% of the households used improved maize varieties, 44.3% grew improved rice varieties, 7.7% planted improved sorghum varieties, 39% planted improved cowpea varieties, and 22.3% planted improved groundnut varieties.

In Southern Africa, 67.7% planted improved maize while 11.3% grew improved rice. About a third (30%) of the sampled households in the region planted improved bean varieties, 20.7% planted improved cowpea varieties, and 31% planted improved groundnut varieties.

Regarding farmer access to information about inputs, 40.5% of the farmers surveyed in Burkina Faso, Malawi, Mozambique, and Zambia reported that radio, television and agricultural shows were their most common sources of information on new varieties.

Fellow farmers remained a critical source of information to 39.5% of these farmers. In Kenya, Tanzania, Ghana and Malawi, extension agents also played a key role in getting useful information on inputs to 29.5% of the farmers surveyed, reflecting the continued importance of the service, particularly for women farmers.

Agro-dealers were cited as a key source of information on new maize seed varieties for 48% farmers in Kenya, 41% in Nigeria, 33% in Mozambique and 22% in Tanzania. The high

proportion of farmers sourcing information from agro-dealers in Kenya and Nigeria was linked to efforts by the agro-dealer development program to strengthen the capacity of agri-input traders.

Regarding yield performance and farmer preferences, most of the respondents in each country indicated that they either would definitely continue (or were likely to continue) growing improved varieties because they met their expectations in terms of yield and other characteristics.

The proportion of farmers who positively expressed views on improved varieties ranged from 39% in Kenya to 93% in Ghana for maize, from 61% in Tanzania to 100% in Malawi for rice, and from 67% in Tanzania to 100% in Uganda for beans.

Most cowpea farmers said they would continue to grow improved varieties, with the proportion ranging from 80% in Mozambique to 100% in most other countries.

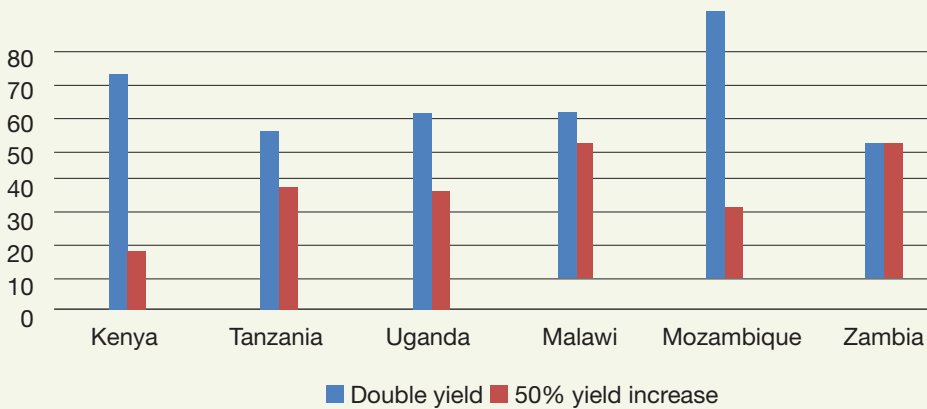


Figure 9.9. Sampled maize variety performance along seed supply chain
(Source: PASS Phase 1 Evaluation)

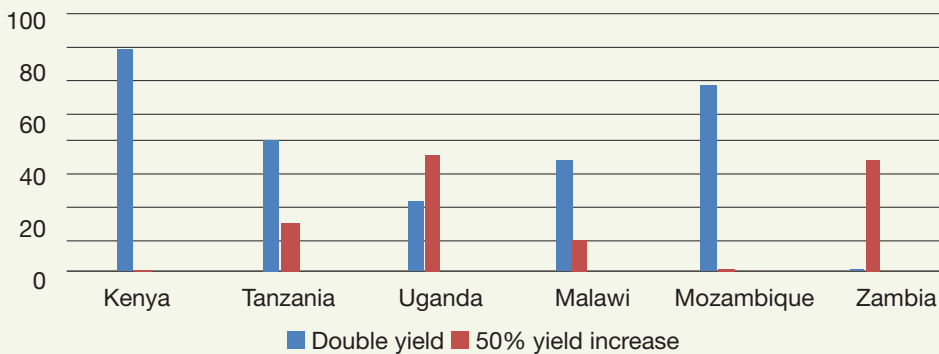


Figure 9.10: Sampled rice variety performance along seed supply chain
(Source: PASS Phase 1 Evaluation)

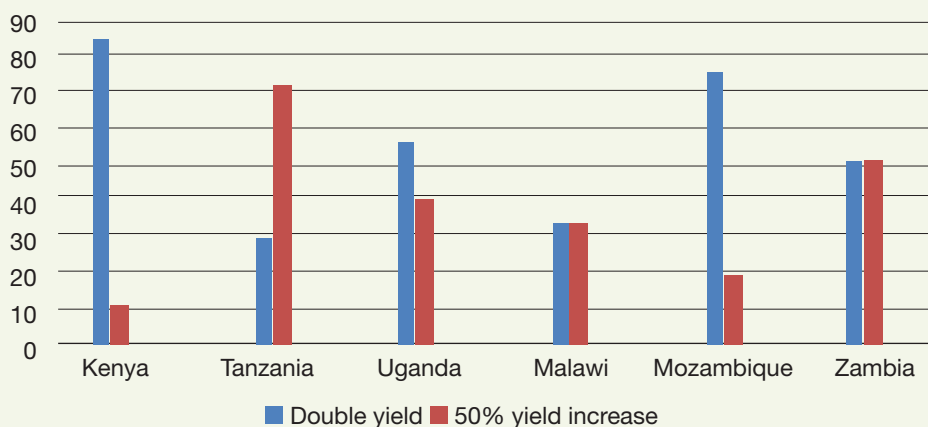


Figure 9.11: Percentage of surveyed bean farmers and yield changes
(Source: PASS Phase 1 Evaluation)

The evaluation’s overall conclusion confirmed that the PASS approach to improving food security by embedding the research process into broader downstream development activities had strengthened the program’s capacity to innovate. PASS had achieved successes but also faced challenges that had to be addressed, including weak linkages among key stakeholders with complementary information.

PASS variety traceability study

As at the end of 2013, PASS had supported the release of over 450 improved varieties of 15 different staple crops in 16 sub-Saharan countries. In 2014, PASS commissioned a variety traceability study to assess the performance of PASS supported varieties along the seed supply chain in 6 countries (Table 9.2). The study tracked randomly selected samples of 59 released varieties in six countries – Burkina Faso, Ghana, Kenya, Malawi, Mozambique, and Uganda. These countries accounted for over half of the total PASS-supported variety releases.

The “snowball method” was the key approach adopted in tracking the varieties from National Agricultural Research Institutions, through the seed companies and NGOs that multiplied the seeds, to agro-dealers who supplied them to farmers.

Of the 59 varieties sampled, 36 (61%) were taken up by multipliers. Thirty-three varieties (55%) were found to have reached farmers through formal outlets, and an additional 16 (27%) through informal channels.

Uganda had the highest number of varieties moving through the seed supply chain to the users. Eight of the 9 varieties tracked had been taken up and mass produced by 18 seed companies and other multipliers. All 9 varieties were being planted by farmers.

Efforts in Ghana produced similar results. Thirteen of the 17 varieties tracked had been commercialized by 6 seed companies, and 9 were being planted by farmers.

Table 9.2: Crop varieties tracked by country

Country	No. of varieties tracked	No. of tracked varieties with seed companies	Tracked varieties with seed companies (%)	No. of tracked varieties with farmers – the formal process	Tracked varieties with farmers – formal channels (%)	No. of tracked varieties with farmers – informal channels
Kenya	10	3	30%	3	30%	7
Uganda	9	8	88%	9	100%	0
Mozambique	8	1	13%	1	13%	7
Malawi	9	5	56%	5	56%	2
Ghana	17	13	76%	9	53%	0
Burkina Faso	6	6	100%	6	100%	0
Total	59	36	-	33	-	16

Source: PASS Traceability Study, 2014

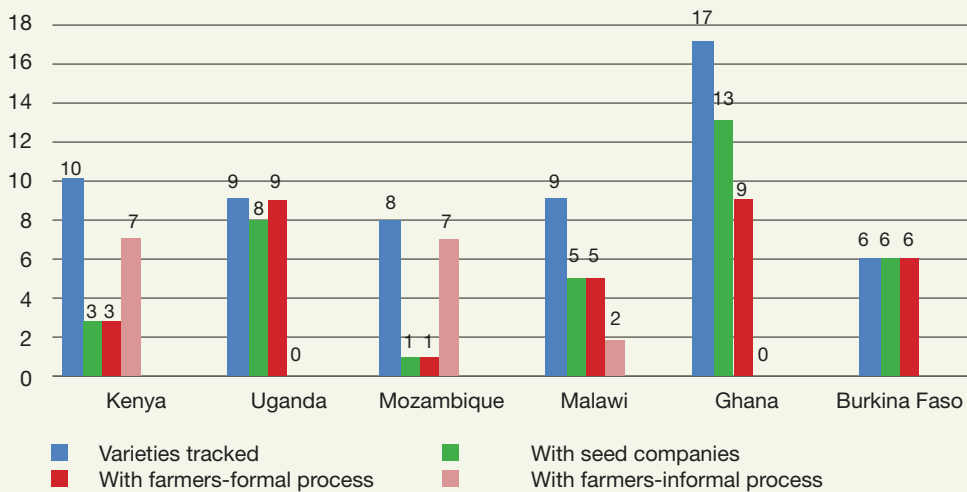


Figure 9.12: Sampled varieties’ performance along seed supply chain

(Source: PASS Traceability Study, 2014)

In Burkina Faso, all 6 varieties were being handled by two seed companies, and all 6 were found in smallholder farmers' fields.

The situation was different in Mozambique, where farmers by-passed the seed companies. Although farmers were planting 7 of the 8 varieties, only 1 variety was being multiplied by seed companies. This pointed to informal channels as the main source of seed.

Overall, more than 45,000 MT of seed was produced by the 40 seed companies that multiplied the target varieties in the 2013 planting season across the six target countries. Figures 9.13 to 9.16 illustrate the yield performance of some of the varieties sampled for the study.

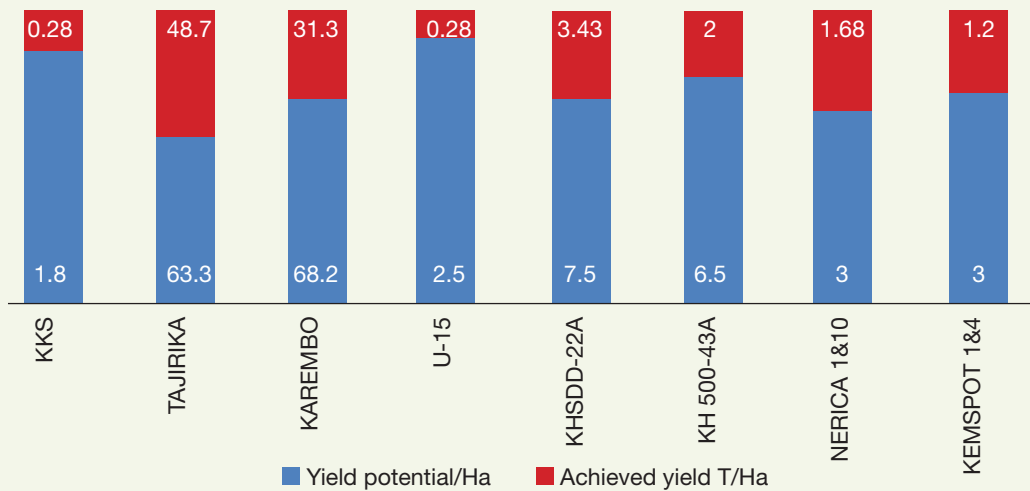


Figure 9.13: Yield performance – Kenya
(Source: PASS Traceability Study, 2014)

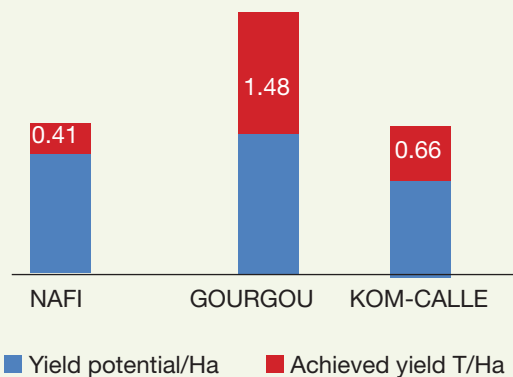


Figure 9.14: Yield performance – Burkina Faso
(Source: PASS Traceability Study, 2014)

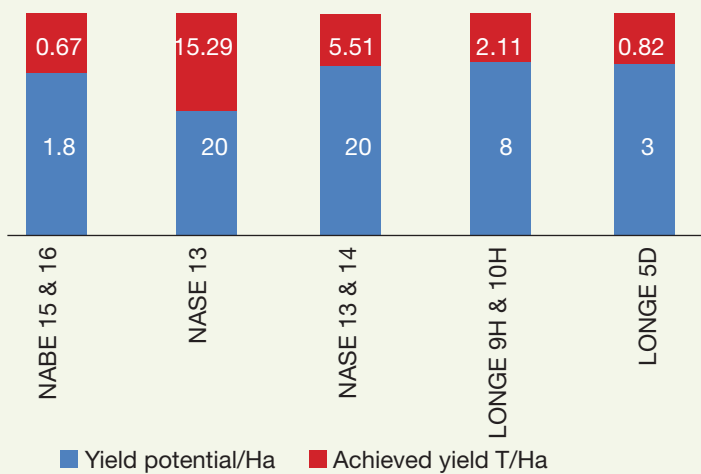


Figure 9.15: Yield performance – Uganda
 (Source: PASS Traceability Study, 2014)

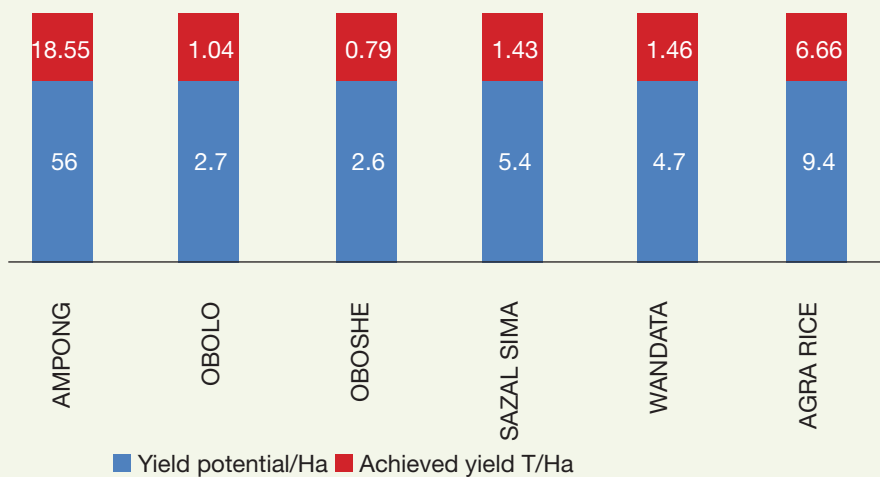


Figure 9.16: Yield performance – Ghana
 (Source: PASS Traceability Study, 2014)

Conclusion: A Parting Observation

The evidence presented in this chapter shows that despite the complex challenge of tracking PASS performance in a varied and dynamic terrain, the M&E system deployed was robust and sufficiently responsive to allow ongoing

adjustments in strategy to be made, and that this was key to maintaining a high return on investment. A key issue that remains to be addressed is how PASS investments and resulting outcomes are reflected in wider assessments of smallholder agricultural productivity in the target regions and countries.

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10 It's the Seed

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The challenges inherent in supplying Africa's rapidly growing population with sufficient food are complex, widely distributed, and urgent.

Proposed solutions must be applicable on a large scale while still maintaining their relevance and attractiveness to smallholder farmers who produce most of the continent's food under a very wide range of local conditions. It is also increasingly apparent that, to really take root, proposed solutions must embody opportunities for local agribusiness entrepreneurs, because there simply isn't enough aid funding to ensure that Africa's farmers have access to the improved technologies they need.

When PASS commenced operations in 2007, the supply of improved seed to smallholder farmers was but one among many interventions African governments, donors, and private business people considered when attempting to increase food security on the continent. Indeed, in the absence of strong evidence to show that one intervention was more valid than another, agricultural development initiatives were scattered across a terrain nearly as vast as the African agricultural landscape itself. Yet average crop yields across Africa were in free-fall, and the world was desperate for an answer.

Various narratives were employed to explain African agriculture's failure to launch: its soils were too poor; its farmers were too bound by tradition; rural infrastructure was too limited;

governments were too weak, and the policy environment was too problematic to facilitate modernization of the agriculture sector.

To all these explanations for the low and declining productivity of African agriculture, PASS had a single reply: "It's the seed."

Looking back at this audacious oversimplification of what is clearly a complex, interwoven set of tasks, it is understandable that PASS elicited many strong reactions, surprise, and even suspicion. AGRA and its backers were accused of employing "silver bullet" approaches where these clearly had not worked before. Some even claimed that the organization was actually a "Trojan Horse", whose real purpose was to ease the entry of corporations into African agriculture. And, to be fair, what serves as a solution to low yields on individual farmers' fields does not automatically translate to food security on a national level. There are many other sub-sectors that need to be developed, including commodity markets, extension systems, and fertilizer supply chains, to name a few. But giving farmers access to higher-yielding, more responsive seed improves the prospects for all of these. The delivery channels developed for seed can deliver many other technologies, messages, and ideas. Moreover, the flow of knowledge operates in both directions.

Perhaps only a crop breeder, with his or her requisite eye for ecological anthropology, could recognize seed as the culprit. Crop breeders – the well-trained ones, at least – seek first to understand the rationale behind farmers'

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current technologies and production practices, including their crop varieties. In understanding the combined forces of local agro-ecology, local methods of food preparation, and the markets, they come to recognize both the genius – and the detriments – of local crop varieties’ growth patterns. They continually re-discover that farmers are smart and holistic in their management of resources, but still eager to try new alternatives. Most importantly, they come to understand the potential and the hard limitations imposed on farmers by the local interplay of environments, economics, and dietary needs, and they see a way forward, beginning with the supply of higher-yielding, locally adapted crop varieties. These are the forces that led to the creation of PASS.

In terms of presentation, the original PASS business plan resembled many others like it – long narratives, multiple graphs, over-simplified maps, and spreadsheets filled with notional figures. But what lay behind the plan was a series of unique, compelling field observations and conversations held with farmers and with local businesspeople. Also critical to the plan’s insight were several encounters with aging seed veterans of previous Green Revolutions in Asia, Latin America, and North America – individuals who still spoke excitedly about the first time they had extended new seeds to local farmers, and the revolution that had followed. Those observations and conversations invariably led to the same conclusion: “It’s the seed.”

The bold decision made jointly by The Rockefeller Foundation and the Bill and Melinda Gates Foundation to finance the PASS plan set in motion a multi-faceted journey of discovery to the heart of food production systems across a large part of the continent. Along the way,

all the major constraints cited previously were encountered, and many others besides. Each country presented its own unique set of challenges and opportunities. Together with some of the program’s real successes have come some genuine failures. In the telling of this story we have endeavored to be honest about both.

Among the unfinished tasks of PASS, there is the dilemma of who will reliably supply adequate stocks of foundation seed to Africa’s growing number of private and independent seed companies. Access to regular, dependable funding among national crop breeding teams is likewise far from assured. Farmer awareness and access to better seed remains very uneven in most countries.

Nevertheless, from the outset and throughout the PASS journey, three opportunities seemed destined to overcome the many setbacks and constraints:

- First and most importantly, farmers were intensely interested in the new seed and, once convinced of its relevance to them, they wanted it. Farmers responded in the millions by bringing their hard-earned cash to agro-dealers to purchase the new seed, and they continue to do so season after season.
- Second, in every country where PASS operated, local entrepreneurs emerged from a wide range of backgrounds to take up the challenge of establishing seed companies. With time, many of them were revealed to be truly intrepid business people driven by their vision and a conviction that farmers large and small were in need of their seed.

- Third, hundreds of public sector African plant breeders, often working in obscure locations on underequipped research stations, kept up a steady stream of new varieties that grew more vigorously, tolerated drought, and resisted pests and diseases that had plagued farmers for years. These new varieties also satisfied local market preferences. Beyond proving the ability of Africa's crop breeders, these innovations provided the impetus for private seed companies to invest in seed production and marketing.

Ten years later, seed is no longer considered but one among many entry points for dealing with low agricultural productivity in Africa. While no definitive study has yet been produced and no success has been declared, average crop yield data across Africa are shifting upward for the first time in many decades, and the conventional wisdom is that the supply of seed of higher-yielding crop varieties is playing an important role. It seems clear that enough seed has been sold, enough yield data collected, and enough positive buzz has been created to convince the world at large that the supply of improved seed to local farmers is a reliable means of reversing declining crop yields and rural hunger, and of alleviating poverty in Africa.

Through the diligent efforts and inventiveness of its thousands of partners, the PASS team of program officers managed to convert a USD 150 million initial investment into 600 improved crop varieties, 109 private, independent seed companies producing 128,000 MT of improved seed annually, and nearly 25,000 agro-dealers opening their shops to the public daily. Seed companies continue to sell out their stocks, and

Africa's farmers are applying more fertilizer than ever before. Direct cause or happy coincidence? The consensus appears to be that there is a link.

But therein lies a very real dilemma. In a world where quick solutions reign supreme, narratives about problems of immense scope change overnight, and donor agencies continue to revamp and re-focus their strategies, it is critical to recall the sheer size of the task of supplying 70 million African farmers with the right seed, year in and year out. This task is far from complete.

For AGRA, the evidence coming from the ground is clear: The importance of establishing functional, responsive seed systems in every African country is now well past the proof of concept stage, and is a matter of national importance. Africa's farmers have spoken, and they want regular access to quality seed of improved, adapted varieties and other technologies. Many thousands of smallholder farmers have shown that they can double, triple, and even quadruple their harvests, provided they have access to the right seed, fertilizer, and other inputs. They are now insisting on better access to national and regional markets for their produce.

Inevitably, the structure of national seed systems will vary, depending on the major staple crops, the level of involvement of governments in ensuring supply, and the stage of development of the seed system itself. Nevertheless, experience so far in Africa has shown that many elements must be in place to ensure the continued development of seed systems. These include:

- A critical mass of private seed companies engaged in the production, processing, packaging, and direct marketing of seed of improved crop varieties to smallholder farmers;

- A large number of private agro-dealers who stock seed from a range of dependable, registered seed suppliers and based on farmer demand;
- An active group of public and private extension providers who demonstrate the value of improved seed in combination with fertilizer and improved crop management practices;
- A well-funded national crop breeding institute capable of developing new varieties of the most important food crops and producing breeder seed of improved varieties;
- A foundation seed supply system open both to public and private actors but operating under the supervision of the national seed regulatory body;
- A functioning seed regulatory body that oversees seed certification and intervenes to prohibit the sale of fake seed; and
- A national plan for the education and replenishment of plant breeders and crop scientists capable of staffing the above-mentioned groups.

In view of the realities of life in Africa today this “wish list” of institutions and actions may

seem overly-optimistic. But given the amount of resources available through governments and donor agencies, and given the urgency of Africa’s food supply challenge, it does not seem too much to ask. Indeed, the authors of this book firmly believe that if the daily suffering of people currently unable to secure access to sufficient food, the mounting costs of delayed economic development in rural areas, and the real threat to future stability of Africa’s nations were to be taken into consideration, this list of deliverables would be considered a small price to pay.

Equally important, we believe that the experience of the PASS initiative across 18 sub-Saharan African countries, while far from being a total success, has provided sufficient evidence that this kind of functioning, growing seed supply system is achievable in virtually any African country where peace and some level of predictability of daily life are present. We sincerely hope that this sharing of experiences over the course of ten years provides a useful, transparent, and hopeful blueprint for action in all countries where the power of improved, adapted seed is yet to reach local farmers. Those farmers are central to overcoming food insecurity in Africa. They have shown their willingness to innovate, work hard, and take reasonable risks to produce more food. We absolutely must not let them down.

For Africa to provide sufficient food for a growing population, its farmers must have access to quality seed of high-yielding crop varieties. Toward this aim, in 2006, The Rockefeller Foundation and the Bill and Melinda Gates Foundation came together to create the Program for Africa's Seed Systems (PASS) to support the breeding of improved, adapted varieties of Africa's most important food crops and build private, demand-driven seed supply systems to serve the seed needs of smallholder farmers in 13 African countries.

PASS was an initiative of the Alliance for a Green Revolution in Africa (AGRA). It eventually operated in 18 countries, reaching an estimated 15 million farmers with new, higher-yielding seed.

This is the story of that work, as told by the people who led the program. More than that, the book shines a light on a new generation of determined African agricultural scientists, seed entrepreneurs, agro-dealer shop owners, and others who overcame major challenges to help farmers increase their harvests, and make significant contributions to Africa's unfolding Green Revolution.

The PASS Journey describes a new style of initiative which represents a departure from the typical development project, and focuses instead on building applied scientific knowledge, business opportunities and local know-how, creating new markets which grow to serve the critical needs of Africa's most important people; its farmers.

