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ASSESSING DIRECTIONS FOR COWPEA R&D IN USAID'S FEED THE FUTURE PROGRAM IN MOZAMBIQUE

By Tom Walker, Benedito Cunguara, and Cynthia Donovan

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Acronyms

CESE	Center for Socio-economic Studies
CIAT	International Center for Tropical Agriculture
IAI	National Agricultural Survey in Mozambique
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IIAM	National Agricultural Research Center in Mozambique
IPM	Integrated Pest Management
LERS	Land Equivalent Ratios
MEAS	Modernizing Extension and Advisory Services
MSU	Michigan State University
MYAPS	Multi-Year Assistance Program
NGO	Nongovernmental Organization
RISING	Research In Sustainable Intensification for the Next Generation
TIA	National Agricultural Survey in Mozambique
TLII	Tropical Legumes Project
USAID	United States Agency for International Development

Introduction

Cowpea is extensively grown throughout Mozambique on small farms. More land is planted to cowpea in Mozambique than in any country in East and southern Africa; Mozambique ranks 4th in cowpea cultivated area in Sub-Saharan Africa (Alene et al. 2015). Nonetheless, it is still very much a subsistence food crop – only 10% of production is sold – therefore cowpea presents more challenges in increasing production than any other food crop in USAID's Feed the Future Program in Mozambique.

These challenges are by no means insurmountable, but they highlight the need for care in choosing investments wisely to increase the odds that progress can be made on Feed the Future's objectives of enhancing food security, reducing poverty, and improving nutrition via increased production from investments in cowpea crop improvement and extension. We begin by discussing the challenges in improving cowpea productivity. Then we describe past investments in cowpea research and technology transfer by USAID, the Government of Mozambique, and other donors. Those investments have laid the building blocks for tackling the challenges addressed in the first section of this brief report. Armed with information on the uniqueness of the production and market contexts and with evidence on past performance of cowpea productivity, we identify what appear to us to be the three most viable options for future investment in cowpea R&D.

Past investments, especially those since 2007, have given some grounds for optimism. Estimates from the recent 2014 (TIA/IAI) nationally representative rural household survey of small and medium farms suggest that cowpea production in Mozambique is trending upward. Production has increased by about 30,000 tonnes (equivalent to 40% of the total) between 2006-2008 and 2012-2014 (Ministry of Agriculture & Food Security 2015a and 2015b). In the past decade, national cultivated area has oscillated in the narrow band of 350,000 to 375,000 hectares annually. Therefore, almost all the increase in production can be attributed to rising productivity per hectare from very low yield levels. Productivity enhancement has been the focus of cowpea R&D, broadly interpreted to include both research and extension. About half of the increase in production has occurred in Nampula, the center of cowpea research and extension activity, where yields at 400 kg/ha are still low by international standards but are now among the highest in the country.

Cowpea's Challenging Production and Market Aspects

Information on a crop's production, postharvest, and market characteristics is necessary for evaluating feasible and desirable options for investment into research and value chain development as well as institutional support (e.g., extension). The constraints and opportunities for cowpea are assessed from two relative perspectives: (1) food crops in general and pulse crops in particular in Mozambique and (2) cowpea in Mozambique vis-à-vis other countries in Sub-Saharan Africa.

Constraints

After the staples, maize and cassava, cowpea is the most geographically diversified food crop grown in Mozambique. About half of the country's four million small and medium farm households plant cowpea annually. It is extensively grown in 6 of Mozambique's 10 agro-ecological zones. Regionally, rural households in the South, Center, and North of the country each cultivated more than 100,000 hectares in 2014 (Ministério da Agricultura e Segurança Alimentar 2015b). Planted area approaches or exceeds 10,000 hectares in all ten provinces. Nampula is the most extensive producing province, but it only accounts for about 25% of national area and 33% of production. Cowpea is also widely dispersed across districts within provinces. Sub-regions of specialization in cowpea production have not yet emerged or are not readily visible.

Since the cessation of hostilities in 1992, demand for cowpea has not qualitatively changed. It is a subsistence crop that maintains a low profile in domestic and international trade. Cowpea is cultivated on poor soils, usually in more drought-prone environments throughout Mozambique. In terms of total cultivation area, it ranks in the top 5-6 food crops roughly on a par with rice, groundnut, and, more recently, pigeonpea. However, low production volumes averaging only 65 kg per household annually and unattractive sales prices about 50% of those of common bean and groundnut erode its economic importance. Nationally, yields are equivalent to about 250 kg per hectare; and only about 10% of production is sold. The vast majority of cowpea-growing households still consume all their on-farm production.

However, the value of production of cowpea is underestimated because leaf production is unaccounted. As we discuss later in this section, cowpea leaves are also consumed and marketed in urban areas.

The absence or low level of market penetration applies to both domestic and international trade. Unlike common beans, cowpea does not benefit appreciably from cross-border trade with Malawi. Unlike pigeonpea, cowpea is not prized in the Indian market, which is the largest global importer of pulses, valued at about 2.5 billion USD annually. Cowpea imports, mainly from Brazil and Madagascar, comprise only about 0.3% of all pulses entering into India.

In West Africa, cowpea hay fed to cattle is an important by-product of production. In years of drought the value of cowpea hay can easily exceed the value of grain. The demand for cowpea hay in Mozambique is generally low as cattle densities are very low except in the South and in Tete. The negligible importance of large livestock further diminishes the potential economic importance of the crop. However, cowpea leaves are prized in fresh consumption and that use, analogous to a leafy vegetable, partially offsets the opportunity cost of not using it for animal fodder. In some locales, leaves are the primary output, and grain is regarded as a by-product (Chiulele et al., 2011). Producers that live very close to cities and towns can sell leaves in nearby markets. Whereas the harvesting of fresh leaves can decrease grain yield (Saidi

et al. 2010), it can lead to greater systems productivity if cowpea is row-intercropped with maize. Little is known about the importance of cowpea fresh leaf production and consumption in Mozambique.

Cowpea is more heavily attacked by insect pests than any other primary or secondary food crop in Mozambique. Unlike diseases, insect damage cannot be ameliorated via varietal resistance for most pests of economic importance. Farmers have to resort to insecticides, biopesticides, or to integrated pest management practices. For some Lepidopteran pests, such as podborers, there is no substitute for 2-3 applications of insecticide that can double yields even on farmer's poor soils in drought years. Pest damage in storage can also exact a high toll on the harvested crop. Improved pest management in production and in postharvest handling and storage would significantly improve cowpea yields and consumption.

Eventually, as they have in cotton, Bt technologies will be deployed to tackle the chronic problem of insect damage in cowpea. However, Bt varietal testing in pulses is not imminent any time soon globally let alone in Sub-Saharan Africa.

In addition, cowpea is attacked by Alectra, yellow witchweed. This parasitic weed can be a major problem on cultivated cowpea fields in Mozambique (Steve Boahen, personal communication, 2016).

Because of weak market demand for the crop, private-sector interactions with farmers and other nodes in cowpea value chains are tenuous. Arguably, the private sector is less interested in cowpea than in any other food crop in the USAID Feed the Future portfolio (until Bt cowpea varieties become a reality). Aside from marketing insecticides for input use, there are few if any incentives for the private sector to be involved in promoting cowpea.

Attributes

Almost 50 years of international R&D on cowpea improvement by IITA and its national partners has shown that the crop has many positive features that help counterbalance the constraints described above. Cowpea is a cost-effective source of protein for poor people, a source of soil N for cereals and oilseeds via N fixation, and a drought-tolerant species. Its short duration makes it a crop that can fit easily into existing cropping systems. In North and Central Mozambique, early maturity confers a large advantage to smallholders. They can plant cowpea later than other crops when labor and draft and mechanical power for sowing is less constraining. Short duration is prized in an era of increasing climatic change especially if information at the start of the rainy season is effective in leading to mid-season corrections.

Cowpea is versatile in terms of it major end uses. Grain, fodder, and dual-purpose varieties are readily available. Types run the gamut from spreading to erect and can easily be accommodated in mixed cropping, which is traditionally practiced in Mozambique. In particular, row intercropping and/or strip cropping maize with cowpea is a robust cropping system in some production environments. In these sub-regions, maize/cowpea intercropped can be more productive than proportional areas planted in monoculture, especially when drought is severe.

Cowpea is prevalent in the Mission's Feed the Future Zone of Influence in Zambezia, Nampula, and Manica provinces. Cowpea looms large in the 23 districts encompassing Feed the Future's Zone of Influence

(Payongayong, 2013). [1] At 53%, it ranked second in terms of incidence of farmer households growing the crop (behind maize (74%) among 13 food crops in 2011/12).

Although a low level of market penetration is mostly a curse for scaling cowpea production, it does have a silver lining. Any productivity benefits that are realized should lead directly to favorable nutritional outcomes as the bulk of consumption takes place on-farm.

Past and Investments in Cowpea R&D

Research

Since the early 1980s, legume scientists at the national agricultural research program (earlier know as INIA and now consolidated as IIAM) have evaluated cowpea germplasm for varietal release. Mozambique has released more varieties of cowpea than any other country in East and Southern Africa. Six of Mozambique's 25 releases are derived from IITA parental or bred materials (Alene et al., 2015). In 1992, Mozambique assumed the responsibility as the project coordinator for the regional grain legume improvement program (SADC-GLIP). That network resulted in the release of IT82E-18 (known as IT 18) and five other varieties in the Timbawene family.

Nonetheless, until recently, an impressive record in varietal output had not translated into adoption in farmers' fields. In 2009, use of modern varieties was estimated at only 11% of cultivated cowpea area. IT 18 was the leading improved variety planted on 8% of cowpea area in Mozambique. At 23% of total cultivated area, cowpea was one of the food crops characterized by a lower uptake of improved varieties in Sub-Saharan Africa (Alene et al., 2015). Mozambique ranked in the lower adoption tier among the 15 countries producing cowpea.

The MYAPS

During the past two decades, USAID invested heavily in Multi-Year Assistance Programs (MYAPS) as an engine for rural agricultural development in Mozambique. The MYAPS were implemented by NGOS in well-defined geographic regions of Mozambique. Their development agenda emphasized (1) Interventions to improve uptake of good nutrition practices, (2) Interventions to improve uptake of agricultural practices and (3) Linkages between agriculture and nutrition (Swanson, 2013).

The general development orientation of the MYAPS is highly complementary to the more focused cowpea development efforts described below. For example, many farmer associations were organized and registered. Although hard to quantify, the MYAPs also were responsible for the diffusion of improved cowpea varieties, such as IT 18, together with better quality seed materials.

Tropical Legumes

The Tropical Legumes Project (TLII) was funded by the Bill & Melinda Gates Foundation and operated in several countries in Sub-Saharan Africa and South Asia supporting R&D on Grain Legumes between 2007-2014. Unlike the MYAPS, Tropical Legumes is narrowly focused on improving the welfare of poor rural households in Sub-Saharan Africa and South Asia via increasing productivity of grain legumes. The

[1] E. Payongayong. 2013. Report on the Implementation of the Gross Margins Survey of 2012, MSU, Maputo, Mozambique. 23 pages.

program was carried out by IITA with a wide array of national partners. Major achievements in Mozambique in cowpea include:

1. The screening and selection of high-yielding, drought-tolerant lines in a dual-purpose background that produced relatively large quantities of both grain and leaves were emphasized. Three varieties were released in 2011 (Abate 2012).
2. Over 770 tons of seed of improved varieties were distributed to farmers between 2008 and 2014 (CIAT/ICRISAT/IITA 2015). The peak year of delivery was 2013 when 254 tons, sufficient to plant 4% of national production, were distributed.
3. Alternative models of seed delivery were forged. The program worked with 121 community seed producers in Phase I. The TLII project demonstrated that community production of improved varieties was successful, but its sustainability depended on development of successful seed associations with links to the formal seed sector. Over 9,000 small seed packets were distributed to cowpea growers.

TLII focused on the breeding and selection of varieties but the major work on screening, testing, and identification of adapted lines released in 2011 was carried out under the USAID Mission's PARTI initiative that is described below. In terms of attribution, 25% of the work could be attributed to TLII and 75% to PARTI. The two projects complemented each other's efforts.

The IITA Soybean and Cowpea Project

This USAID-funded project was carried out by IITA and its partners in five priority Feed the Future districts from 2009-2014 (IITA 2015). Although its seed production of improved varieties of about 30 tons pales in comparison to what was generated in Tropical Legumes, this project was impressive in the following aspects:

- Technology validation focused judiciously on a few key components, such as improved varieties, optimal plant populations, and planting dates that varied somewhat from district to district;
- Technology transfer was inclusive with seed partners ranging from a private-sector company to NGOs to District Departments of Agriculture;
- Training of extension agents and farmers figured prominently in technology transfer and is reflected in large numbers for Feed the Future indicators including both farmer beneficiaries and extension staff;
- Five cowpea recipes for dried leaves and grain were demonstrated with an aim towards improving household nutritional status. A total of 24,212 (18,639 women and 5,573 men) community members participated in the training and demonstrations in new recipes for enhancing consumption of cowpea and soybean which was also covered in the USAID grant to IITA.

Identifying Future Selective Investment Options for the Feed the Future Program

Unlike pigeonpea and soybean development in Mozambique, area expansion is not expected to play an influential role in contributing to growth in cowpea production. The introduction of erect varieties may be accompanied by some area expansion from farmers who had abandoned the crop associated with and restricted to traditional spreading varietal types. But this effect is likely to be small. With limited market

possibilities and the already large numbers of farmers cultivating the crop, cowpea R&D needs to retain its current focus on improving productivity per hectare. [2]

Before discussing specific investment priorities related to yield enhancement, we need to briefly address the donor, partner, development, extension, and research landscape in 2016. IITA appears to be a reliable, responsive partner with a good track record and a sustained country presence in Mozambique. However, the Tropical Legumes Program is no longer operational in Mozambique; cowpea in Mozambique is not one of its priority crop-by-country combinations in the 3rd Phase of this long-term. It unlikely that another donor other than USAID will step up to support cowpea research and technology transfer with the thoroughness that characterized the Tropical Legumes Program. The divestment from Mozambique for budgetary reasons strengthens the case for another grant to IITA for USAID given that the earlier project that has generated positive outcomes in several dimensions.

The district-wise allocation of, by now, over 800 tons of seed distributed by IITA and its partners is an important piece of information for decision-making on priorities for future investments in cowpea R&D. If substantial amounts of seed were destined to farmers in Feed the Future districts, then the priority for development work shifts to early adoption research on the uptake of improved varieties to draw lessons on what worked and why in the Feed the Future districts. The issue becomes one of what gaps remain to be filled.

If only small quantities of that seed have found its way to cowpea-growing households in Feed the Future districts, then the argument is stronger for a repetition of the USAID-funded IITA Project in other Feed the Future heavy cowpea-growing districts preferably in other agroecologies in the North and Center of Mozambique so that lessons on technology adaptability can be drawn. Hence, establishing the congruence between the distribution of seed production in Feed the Future districts is a necessary step in identifying the way forward.

In the medium term, improved varieties and improved management practices on row spacing are the main validated components that are capable of leveraging enhanced productivity outcomes in farmer fields. Response to phosphorus is too location specific to be recommended (IITA 2015). Moreover, farmers will not apply inorganic fertilizer to cowpea unless they have sufficient access to fertilize all their cash crops. Presently, fertilizer is only used on a very small minority of cowpea fields in Tete where fertilizer availability is greater than in any other province in Mozambique (Mather et al. 2014). In this regard, soils research in the USAID-supported Legumes Innovation Lab is relevant because deposits of rock phosphate and dolomite have been found in Mozambique opening up the possibility of improving access to and reducing the cost of phosphorus and lime (Legumes Innovation Lab 2015). If that possibility is ever realized, phosphorus and lime applications, especially on acid soils, become an increasingly viable option for contributing to productivity growth not only of cowpea but also of other food crops in Mozambique.

[2] Cowpea is planted in association with other crops, most commonly maize and cassava. Changes in their supply response may indirectly affect cowpea area.

Results of trials from the USAID-IITA Project in the Feed the Future districts also suggest that the largest potential productivity gains will be made from switching from local to improved varieties. Gains from substituting the most recent elite materials tested for IT 18 are not nearly as large as first generation varietal change. Indeed, IT 18 was still the heaviest yielding cultivar across the Feed the Future districts in which it was tested (IITA 2015). Newer materials in the pipeline have other valuable attributes but their yield potential does not seem to be appreciably higher than IT 18 or IT 16, two improved varieties characterized by wide adaptability in Sub-Saharan Africa. Therefore, it is likely that technology transfer efforts will face diminishing returns in districts where earlier released IITA-related varieties have diffused. When Bt pest-resistant cowpea becomes a reality, productivity gains will again become sizable justifying widespread investment in extension throughout Mozambique. But Bt cowpea is not yet visible in the pipeline.

Evaluating the Uptake of Cowpea Technologies Demonstrated in the USAID-Funded IITA Project

In deciding on investment options, arriving at an understanding of the degree of success of the USAID-IITA Project is a logical first step irrespective of the geographic allocation of seed by the Tropical Legumes Project. Assessing early acceptance of demonstrated technologies in the four to five districts where the IITA Program operated from 2009-2014 is now the priority. What is the level of adoption of improved varieties among farmers who knew about them and had access to seed in the research and outlying communities? Is the level of adoption in female-headed households the same as in male-headed households? If not, what can be done to enhance varietal availability for female-headed households? What are the perceived strengths and weaknesses of the improved varieties relative to local varieties and relative to each other especially IT 18? What is the uptake of management practices on planting density and time of sowing? Which partners were most effective in distributing seed to farmers? Why are some methods of delivery more successful than others? Did seed production and delivery strengthen formal and informal seed system and their interactions? What is the use of the cowpea recipes that were demonstrated? How can they be improved?

The above are standard queries in early adoption research, which is an area that most donors do not do a good job in answering on a routine basis so that information on past outcomes is fed into future programming (Abate 2012). This work could be carried out by a staff presence from CESE in IIAM jointly with a crop and/or social scientist from IITA.

Ideally, early adoption studies should be undertaken 2-3 years after the project has closed to be able to reliably gauge uptake. That means that a rapid appraisal survey could be implemented as early as March-May of 2016 when the crop is in the field or in March-May of 2017 after most of the project dust has settled.

Repeating the USAID-IITA Project in Other Feed the Future Districts

Extending validated and accepted technologies to other priority Feed the Future districts where cowpea is important, especially those in other producing agroecologies in the North and Center where no interventions were carried out in the USAID-supported IITA Program, is a logical next step in technology transfer. Such an effort becomes a very viable investment option if the substantive results of the early

adoption research are broadly favorable -- threshold levels of early acceptance are satisfied -- and if appreciable quantities of seed have not made their way into these districts of interest from the Tropical Legumes Program.

Consumption of cowpea as a leafy vegetable in Mozambique is one area that distinguishes cowpea use from much of the rest of Africa, particularly West Africa which is the center of continental production. In replicating the earlier work, at least one Feed the Future district should be selected where leaf consumption looms large as the primary objective for cultivating the crop. Focusing explicitly on leaf consumption in on-farm R&D could result in generating technologies that are most apt for this use or in confirming conventional wisdom that components, such as dual-purpose varieties, are effective in addressing in both leaf and grain aspects of cowpea production and consumption. Additionally, including at least one of the heavier leaf-consuming districts opens up the opportunity to assess the actual and potential importance of cowpea leaves to the nutrition of vulnerable groups in the Feed the Future target population. It also gives researchers a venue for estimating the effects of typical leaf harvesting regimes on grain yield.

Prior to the initiation of this spatially replicated initiative, it is desirable to assess the preferences and perceptions of cowpea producers. IITA has already carried out baseline surveys in this area; however, that information needs to be systematized across the Feed the Future priority districts. A quick and highly focused assessment needs to be conducted of production constraints and consumption priorities. This rapid appraisal could be complemented in a few Feed the Future districts by participatory varietal selection of genotypes showing considerable variation in traits to assess the demand for varietal characteristics. Revising the existing baseline information should be a good starting point for this diagnostic research. Although not in the Feed the Future zone of influence in the South of Mozambique, the 2011 assessment by Chiulele et al. could be an excellent prototype to follow.

Factoring in several other considerations could make for a more viable replication. The farmer associations formed in the MYAPs could be mobilized as partners provided their earlier work overlaps with the districts of interest.

More emphasis could be placed on strip cropping maize and cowpea (2 rows of maize with 4 rows of cowpea or another alternative arrangement) especially in drier locales where the two crops are likely to be planted at about the same time. In USAID's Africa RISING Program, strip cropping is gradually gaining in popularity in Ghana replacing the desirability of sole-cropped maize-cowpea rotations in the same field with rotations of maize and cowpea planted in the same rows. One or more districts should be chosen where the potential for productive maize/cowpea intercropping is higher than in the 2009-2014 Project. From a systems vantage point, maximizing agronomic or economic productivity in the form of Land Equivalent Ratios (LERS) or Economic LERs may be more meaningful for farmers than attaining the highest levels of either maize or cowpea yield.

Expanding and Deepening Pest Management Options for Cowpea

The uptake of improved varieties and planting recommendations is a necessary first step in improving cowpea productivity on small farms. Without improved pest management, it could also be the last step. For example, aphids and bruchids ranked as the 2nd and 3rd most important constraints after drought in

limiting productivity in the 3 districts where assessment work was carried out in the South of Mozambique (Chiulele et al. 2011). Pest infestation may be less severe in the Center and North of Mozambique than in the South, but the absence of cost-effective measures of pest control is likely to represent the binding constraint on further increases in cowpea productivity in large areas of Feed the Future's zone of influence.

Spraying insecticide two to three times is often the most and only cost-effective option for pest management in cowpea in Sub-Saharan Africa. In the aforementioned regional project of the USAID Africa RISING Program, applying insecticides two to three times doubled yields from 450 kgs/ha to 900 kgs/ ha in on-farm trials during 2013-2015 in 25 communities in three sub-regions in Northern Ghana. No other intervention was as cost effective in enhancing cowpea productivity. Biopesticides, such as neem, were not nearly as effective in raising productivity. Some farmers in a few of the communities were already following this limited insecticide spraying regime before the initiation of the project.

The USAID-funded Legumes Lab is also investing in integrated pest management (IPM) options in West Africa. In general, IPM solutions can be highly localized and are not competitive with limited insecticide use; the punctual use of limited quantities of inorganic insecticides needs to feature as a component in an IPM program.

Cowpea pest control in Mozambique is problematic because availability of insecticides is limited -- less than 5% of small farmers use them -- and because harvesting cowpea piecemeal throughout the growing season as a leafy vegetable is important in some sub-regions. Coming up with viable options that are both practical, without significantly increasing scarce labor time, and that are cost-effective is a challenging proposition. Although progress in the past has not been marked in this area, the damage pests annually inflict on production calls for some investment.

Conclusions

This report to the USAID Mission in Mozambique takes stock of recent developments in cowpea production and consumption and assesses future prospects for the crop in the context of the Feed the Future Program with an eye towards directions for investment in 2016 and beyond. With regard to cowpea research and extension, the decision facing the Mission boils down to the following question: Does the work of the Gates Foundation's Tropical Legumes Program and USAID's grant to IITA effectively address the bulk of the needs of smallholder beneficiaries in the priority Feed the Future districts? Or more specifically, has the 800 plus metric tons of seed that IITA and its partners have distributed nationally (at the farm level) since 2008 sufficiently filled the profile for potential adoption in the Feed the Future Zone of Influence? If the answer to this question is affirmative, then the Mission should probably continue to invest in another Feed the Future priority crop like pigeonpea that is characterized by strong demand but that has received limited support from international donors and the Government of Mozambique.

If the answer to the sufficiency issue about seed distribution for generating favorable outcomes in the Feed the Future Zone of Influence is negative or if critical missing gaps are identified in an overall positive landscape, then the Mission should entertain the possibility of investing in a spatial replication of its IITA Project that was funded from 2009-2014. Several potentially important features for fleshing out the lean and very cost-effective skeleton of the earlier project were highlighted for consideration in this report.

The closing of the Tropical Legumes Program in Mozambique adds support to reinvesting in cowpea R&D because the likelihood of another donor picking up where the Bill & Melinda Gates Foundation left off is small.

In any case, the funding of a focused early adoption study with IITA and IIAM to draw lessons from the past investment in cowpea research and technology transfer is a priority in the districts where the IITA Project was operational. Early acceptance research, supported by USAID, becomes all the more valuable if IITA and the Gates Foundation have not yet realized a thorough quantitative evaluation of adoption outcomes stemming from its Tropical Legumes work in Mozambique.

USAID's support of cowpea R&D in Mozambique has many of the ingredients of a modest but important success story. It is rare to encounter technological change in what is mostly a subsistence food crop. Success is attributed to the work of IITA and its partners and is jointly shared by two donors, USAID and the Bill & Melinda Gates Foundation. Results from one well-conducted early adoption study of technology uptake are needed to complete the recipe for informative impact assessment.

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