UPoCA PAPERS

Unleashing the power of cassava in Africa…are we there yet?

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Abstract
Cassava has long been expected to play a key role in rural economic growth in Africa, but has it happened yet? Although research partnerships have produced elite cassava varieties with 50% more yield potential and have demonstrated technologies to improve processing and increase marketing of cassava, the sub sector is constrained by low productivity and marketing difficulties. In DR Congo, Ghana, Malawi and Sierra Leone, for example, the actors in the cassava value chain are yet to respond to trade opportunities estimated in 2007 at 59 million through the replacement of imported wheat flour with locally produced high quality cassava flour. Industrial demand for cassava would also aggravate hunger and poverty if yields did not increase from current national averages of 5 to 19 t/ha to the more than 25 t/ha expected from released varieties under low input agriculture. In 2008, USAID and IITA initiated the project *Unleashing the Power of Cassava in Response to Food Price Crisis* (UPoCA) as a multi-country and inter-institutional partnership enabling the cassava sub sectors to realize their full potential in rural economies. The UPoCA project covers DR Congo, Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, and Tanzania and draws on prior research results to increase on-farm cassava productivity and value adding processing for markets. By the end of 2009, smallholder beneficiaries associated with 55 partner organizations and 11 agriculture-related firms established 306 community for cassava stems multiplication sites and root production farms totalling 10,097 ha with 58 improved varieties. Through experiential learning at 24 hands-on short-term courses, 345 men and 142 women learnt improved techniques in cassava production, processing, product development, and packaging/ labelling and eight technologies were introduced to rural communities. The evolving UPoCA achievements show that a longer-term cassava research for development partnership platform of this nature will enable the cassava subsectors to contribute significantly to rural economic growth in Africa.

Keywords: Cassava, UPoCA, productivity, value addition, income

Introduction

Cassava has long been recognized as a staple food crop with potentials as a base for raw material base for a wide range of processed products. Over the past three decades, cassava development research by IITA and its partners in Sub-Sahara Africa (SSA) has significantly enhanced these features in the crop. In the mid-1990s, IITA and partners focused on cassava crop improvement research for development activities within the component research programs and two subregional networks: EARRNET in Eastern Africa and SARRNET in Southern Africa. Through a combination of conventional and new approaches, the partnership developed improved cassava varieties that combine multiple pest/disease resistance with superior postharvest qualities and improve the yield potential in many locations (Okechukwu and Dixon 2008). At least 165 improved varieties have been released in 26 countries (Dixon et al. 2010). The availability of these elite cassava varieties with the potential for 50% more yield reflects the vision of an expanded future role for cassava in food, feed, and industrial applications. However, the cassava sector in SSA has been and continues to be constrained by low on-farm productivity and marketing difficulties.

A vital step to increase on-farm yields/ productivity is to promote value addition targeting diverse markets in schemes to commercialize the crop, enabling it to contribute significantly to poverty reduction strategies. Available research results suggest that generally a 1% increase in crop yield will reduce the number of people living under $1 by 2 million in SSA (Thirtle et al. 2003). Persistant challenges to the realization of the food and market potential of the crop relate largely to a lack of sustainable mechanisms for the area-wide scaling-out of proven research results. Problems with the distribution of planting material of elite varieties mean that farmers continue to grow local low yielding varieties. Smallholder farmers in Africa also lack access to the knowledge and equipment which could add value to their harvests, and skills to use them. Smallholders also lack access to diversified markets. To help address these productivity problems, IITA's R4D partnerships have helped to enhance cassava yield stability and productivity through an Africa-wide biological control program which halted devastating losses caused by alien invasive pest species (Neuenschwander, 2001;Yaninek et al., 1993; Neuenschwander et al., 2003), and reversed a crisis situation.

In recent years, the challenges have been addressed by multi-country projects which facilitate shifts from the traditional processing techniques associated with low value and poor quality products towards linkages for value added processing(Mahungu et al, 2010; Sanni et al., 2010). A number of such initiatives have been instigated mainly by the recent global food price crisis, and focus on using previously developed best-bet production, processing and marketing approaches and innovations to ensure sustainable cassava value chains and markets. For example, in 2008, USAID's famine trust project Unleashing the Power of Cassava in Response to Food Price Crisis (UPoCA) was initiated as a 2-year transitional multi-country set of activities for cassava subsectors to realize their potential in rural economies. USAID and IITA selected cassava as a commodity that can contribute decisively to on-going efforts to promote rural economic growth with farmer benefits for urban populations. The UPoCA project, implemented by IITA through a inter-institutional partnerships in DR Congo, Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, and Tanzania, draws on prior research results to increase on-farm cassava productivity and value adding processing for markets.

The purpose of the 2-year (2009 and 2010) UPoCA project is to provide an adequate supply of cassava products at economically affordable prices through the availability of improved varieties, production, and processing. For this purpose, UPoCA proposed in the rapid mass propagation of improved and high yielding cassava varieties; promotion of farm gate and value adding processing of cassava for food and markets; and training of farmers in improved cassava production techniques. The expected impact from the achievement of these objectives would be that cassava yield increased by at least 30% more than baseline figures, reduced fluctuations in food availability and prices through increased cassava productivity would be reduced, encouraged by value adding and utilization at levels. This would lead to a) enhanced household and national food security, b) increased income, c) improved wellbeing and nutrition for beneficiary populations.

This paper presents an overview of progress of the UPoCA project towards its purpose and is based on implementation experiences in the seven project countries. The paper concludes by indicating emerging R4D areas needing attention to more effectively move towards the full achievement of the project's purpose.

Materials and methods

The strategy to implement the UPoCA project draws on prior cassava research results and experiences to promote end users' access to technical innovations developed elsewhere and increase the range and applicability of cassava technologies and practices. Based on these experiences, project implementation uses a programmatic approach in which activities are anchored firmly at community levels with direct action by key actors in the cassava value chain to have an impact on the communities.

At project inception, IITA initiated consultative discussions with key partners in each of the seven countries with the view to organizing and holding national and regional project implementation planning workshops. At national consultative workshops IITA's link scientists introduced the project to a wider range of stakeholder groups; participants discussed elements of the project, harmonized views on needs, and drafted national work plans and budgets. By end of the series of national workshops, IITA identified potential National Coordinators for recruitment, noted project implementation partners in the country, and established the project management team.

The set of national consultative workshops culminated in a regional project planning workshop 1921 January 2009, at IITA-Ibadan, Nigeria, for joint implementation planning by 26 participants from IITA and various partner institutions in the seven project countries. The specific objectives were to enhance communication, understanding and commitment among project leaders in the search for common ground and harmonize views on problem and opportunity analysis; define more precisely project targets performance indicators, and related targets by which to measure project achievement; and to streamline national project work plans to reflect a common understanding of the regional focus in project implementation. Workshop presentations and general deliberations took place in plenary sessions whilst details were worked out in smaller working groups. The views of beneficiary groups as captured at national consultative activities were provided in through country reports presented at the regional workshop. By a process of brainstorming, ranking of constraints, and discussions, the workshop specified priority issues and secured consensus on the three immediate results areas in the USAID/IEHA results framework for the project

To assure effective scaling-out for greater impact within available resources, the project reviewed proposed plans on operational sites and the use of households as the unit to track technology spread. In view of the discussions, the project reduced the number of administrative regions for field activities, according to felt needs, e.g., from 10 to 6 States in Nigeria, 12 to 6 Districts in Sierra Leone, 8 to 4 Districts in Malawi, 13 Districts in 2 regions in Ghana. Also, in recognition of the fact that households differ in composition and size even within same localities, participants agreed that it would be most practical to track technology spread by individual farmers and processors. On vulnerability indices, participants agreed that the target beneficiaries to be listed would generally be poor small holders and at least 35% of them would by default fall in one vulnerability class or more.

Workshop participants identified the following scaling-out approaches to strengthen community capacity and effect positive changes in agricultural performance:

- Selecting operation sites based on a combination of criteria including a) prior cassava R4D; b) participation in the project's baseline surveys; c) partnership opportunities with other on-going activities funded by agricultural development agencies; d) probability of synergies in efforts with other agencies; e) beneficiary interest in cassava production and processing; f) existing cassava processing activities.
- Building end-user ownership of processes through listing direct beneficiary groups and individuals associated with the partner stakeholders group with on-going investment in community outreach activities.
- Building cadres of national ToT expertise consisting of change agents with primary responsibility to facilitate experiential/hands-on learning of technologies by beneficiaries mostly associated with the project's partner organizations.
- Disseminating technologies with allied information resources to beneficiaries over large areas for increased cassava productivity and value-added processing.
- Facilitating experiential/hands-on learning to increase informed decision making in cassava production and value added processing by direct beneficiaries.
- Promoting interconnectivity among value chain actors, especially between producers and processors, in attempts to encourage the development of cassava enterprises

Using mass media communications to increase national and global visibility of cassava utilization pathways, the nature of constraints and "best-bet" available interventions.

Results

Project inception: Consultative planning workshops identified nine major areas of constraints undermining cassava profitability in the countries. Participants proposed and agreed on interventions deserving project investment to address these problems (Table 1) and develop a detailed plan to guide operations. The plan specified activities; performance indicators and related targets, resource allocation, timelines in implementations, and the responsibilities of experts/agencies to be involved in the project implementation. Key actors on location-specific implementation activities included producer groups with an emphasis on women, the youth, and other vulnerable groups), agro-processors/private sector, government and NGO agencies. Project management teams introduced the project to USAID missions and it was formally launched in the countries. In Ghana and Sierra Leone the launching ceremonies were hosted and chaired by representatives of the United States Embassies in the countries. Table 2 summarizes the achievements based on agreed targets by indicators. By the end of September 2010, the project scored well (72.7%) on 16 out of 22 indicator targets agreed upon during the regional implementation workshop. The following results expand on achievements made in key activities.

Expanded on-farm productivity: To improve on-farm productivity, 58 elite varieties were planted by smallholder farmers associated with 55 partner organizations and 11 agriculture- related firms. The partners established 380 community multiplication fields for cassava stem on 643 ha and planted 11,540 ha of cassava farms. GIS projections, based on passive spread at 5 km/year from each of the introductions sites, indicate that these varieties will spread to populations within buffer zones of 79,500 km2 in 2010 and 107,500 km2 in 2011. Following training on competitive cassava production techniques in Sierra Leone, the resource persons and participants used the training experience to develop a user-friendly methodology for yield assessment for use by project partners to measure yield in their farms. In addition to measuring root yields, the methodology allows for the estimation of the plant population (for use in advising farmers on the appropriate plant spacing required for higher yields) and root rot incidence (to advise on researchable areas to promote the sustainability of yields. The UPoCA protocol for yield data collection is being used to estimate root yields by the project- trained field agents and farmers. By the end 2010; these were the achievements.

- UPoCA-DRC collected yield parameters on 150 farms in seven territories and five provinces: Maluku (Kinshasa province), Bulungu and Idiofa (Bandundu), and Mbanza Ngungu and Seke Banza (Bas Congo province), Kisangani hinterland (Orientale province), and Ngandajika (Kasai Oriental province). One hundred and thirty fields were investigated. The average age of the cassava farms was 12.1 months for farms planted with improved varieties and 13.1 months,for those planted with landraces. The average number of tuberous roots per plant in fields totally planted with improved varieties was 4.4 roots/plant compared with 2.7 roots/plant in fields totally planted with landraces (2.70 roots/plant). Average root yields were estimated at 18.9 t/ha when improved varieties only were planted and 9.4 t/ha when landraces only. Root yields tended to be higher in the rain forest of Orientale,and Bas-Congo provinces.
- In Ghana, cassava root yield from 13 Districts was 24.06 t/ha for variety Abasafitaa,and ranged from 4.44 to 35.88 t/ha; 9.37 to 31.68t/ha; 3.07 to 57.5t/ha; and 6.5 to 33.25t/ha for varieties Afisiafi, Bank-yehemaa, Esambankye and Tekbankye respectively.In Sierra Leone, yield data were collected from 240 farmers' fields in 12 districts. Farm age at harvest averaged 12 months (range: 9 to 24 months); farm size averaged 1.2 ha (range 0.1 ha to 18.2 ha); plant populations averaged 13,157 stands/ha (range: 2,800 to 35, 600 plants). Root yield averaged 13.5 t/ha and varied widely between 1t/ha to 36.6 t/ha. Root rot incidence also varied widely from none to 25.4% of roots lost to the disease. Highest root yields (>15 t/ha) were in forested districts.

Capacity devolution: UPoCA project introduced smallholder beneficiaries through training to the economic potential of the crop and to cassava crop management practices. The training curriculum was covered five integrated short-term courses. The courses were a) principles and applications of Global Positioning Systems; b) techniques for profitable cassava production; c) processing cassava into food and industrial products; d) packaging and labelling cassava products for markets; e) planning and managing a small cassava processing enterprise. Forty hands-on courses were delivered in the seven project countries. Through these courses, 915 men and 782 women learnt improved techniques and skills in cassava production, pest management, processing, products development, quality compliance, packaging and labelling of products and business planning. Box 1 profiles one of the courses delivered. Through these courses, the project introduced to rural communalities one biopesticide for control of the variegated grasshopper (Zonocerus variegatus), five different examples of low-cost cassava processing equipment (motorized graters, hydraulic press, hammer mill, mechanical sieves, gari roasting bays), one improved sun-drying shed, and one steam dryer for drying cassava flours. This activity involved equipment upgrades, especially with stainless steel to replace mild steel in the cutting and grinding edges of graters and hammer mills.

Across the seven countries, beneficiary groups leant how to produce a wide range of primary cassava products and their derivatives, the majority of which were hitherto either known but crudely prepared or unknown in the target communities. These products included odorless fufu flour, high quality cassava flour (HQCF), gari, soya fortified gari, starch, tapioca granules, composite bread with 10% to 20% HQCF, diverse cassava snacks (e.g.., chin-chin, meat ball, root fritters, croquettes, cocktail tit-bits, donuts, egg rolls, cookies, cassava queen cakes, strips and meat pie.

To strengthen the capacity of trained participants the project sourced and disseminated at least five technical and training support materials. Additionally, the project collaborated with other cassava initiatives at IITA (e.g., CFC cassava project in Tanzania, USAID cassava projects in Nigeria) to co-produce and/or draft the following new learning materials to help improve the skills of end-users:

- Improved cassava variety handbook described 59 improved cassava varieties being grown by farmers in Nigeria and some other UPoCA countries.
- A cassava processor's guide book on quality management in the production of HQCF.
- Swahili translation of the IITA cassava recipe book. This will increase the subregional visibility, effectiveness, and impact of IITA.
- A manual for agribusiness training in Ghana. A manual on managing a small business for cassava processors in Nigeria

Box 1: Profile of ToT course delivery,

Country: Sierra Leone

Course title: Cassava processing and product development and utilization

Duration: The training was conducted 9 to 12 June, 2009.

Pre-course evaluation: About 15% of the participants had a background in food-related processing activities or certification. Most of them were unaware of new cassava products and approaches to add value to the existing traditional products, quality requirements from cassava products and processing machines, fortification of cassava products for nutritive quality, and essential factors to be considered in product development.

Participants' expectations: Most participants were expected to have a skill gap analysis of the problems encountering in producing quality cassava products, what methods they should introduce to their beneficiaries to add value to cassava, what are new in equipment sourcing, operation and maintenance, how best they could embark on product development, how they could actually produce high quality cassava products and infant foods.

Objectives: The course was conducted to enable UPoCA partner organizations (GOs and NGOs) in Sierra Leone to train, coach, and guide on postharvest, processing, product development and machine specifications.

Synopsis: Resource persons were drawn from IITA-Nigeria, the University of Agriculture, Abeokuta, Nigeria, and Njala University, Sierra Leone. The course covered cassava postharvest (general remarks, storage Losses, key constraints, storage methods, and management issues); cassava processing (uses of cassava, processing purpose, equipment, adding value and processing methods); cassava value chains (characteristics, benefits, marketing challenges); new products (market research, new food products, food preservation, grades and standards); cassava for nutrition (fortified products, quality assurance, food legislation); hands on practical (group level); interactions (group discussions, plenary discussions, experience sharing, and course evaluation)

Learning methods: Resource persons employed participatory approaches for information sharing, video show, power point display, group interactions, practical demonstrations and observations during the workshop.

Achievements: Twenty-nine (29) participants trained in trouble shooting & and in five types of processing equipment to produce cassava products - Motorized cassava grater, screw press, motorized hammer mill, sieves, product drying platforms; processing of HQCF, starch, soya fortified gari and fermented fufu flour to ensure income generation, industrial applications, and process improvement. During the 4-day training, participants were able to produce four primary products from cassava storage roots: HQCF; soya-fortified gari; fermented cassava flour (for instant fufu); High Quality Cassava Starch (participants made Tapioca, a roasted wet cassava starch, from the high quality starch). Additionally, participants used the IITA cassava recipes booklet to produce seven secondary products by fortifying HQCF with a range of locally available animal and plant protein sources. The food products developed from HQCF were croquette (christened CAFICO by the participants); cocktail tidbits (christened "teeth-bites"); donuts; chin-chin; complementary food (baby food); fritters; egg roll. No imported wheat flour was used in any of the products. The cassava food products stand to have a positive impact on household and national food security.

Post-course evaluation: Participants were able to produce HQCF, fufu, starch and their derivatives. They also produced nutrient-based cassava soy products deriving joy in adding value to by products from cassava and soybean. In all, the groups performed excellently in practicals and had a sense of fulfilment. From their post-workshop evaluation reports.

Support to enterprises: To support the institutional base of emerging cassava enterprises requesting advice for value added cassava processing, the project provided technical assistance and support to a number enterprises, projects, and agencies in the countries, e.g.:

Linking farmers to processors: Famers were linked to markets to assure sustainable supplies of raw materials for processing in a number of cases. In Nigeria, for example, cassava growers in Niger State were linked by the project to a buyer, Ekha Agro company,. The agreement was brokered with the aim of easing the negative effects of cyclical glut and price fluctuations in the cassava production chain. The MoU provides that the Niger State Cassava Growers Association will cultivate 5,000 ha a in the 2009/2010 season using improved varieties under the technical supervision of the UPoCA project in Nigeria. Ekha Agro guaranteed through a purchase order for 200t/day of fresh cassava roots for one year at the agreed farm gate price. In Sierra Leone, the Pujehun Growth Center (Pujehun district) and Kpandebu Growth Center (Kenema District) were linked to 72.3ha and 94.6ha farms respectively, the farms were within 20km radius of the factories to assure sustainable raw material supply. The Pujehun Growth Center was also linked to Union Trust Bank which provided a one-year loan equivalent to \$10,000 for the purchase of raw materials and packaging materials, and to Home Food and Drinks Ltd as a primary market outlet for the cassava products on sale in the capital city, Freetown. Also in Sierra Leone, Quifel Natural Resources (an international agri-business firm initiating agri-business in the country) was assisted to analyze soil samples collected at sites the firm has leased to grow cassava on a commercial scale. The soils were very acidic with pH of 3.8 to 4.3 and natural fertility status at the site was very low with organic carbon content under 1.04%. Mineral fertilizer application at N: 125 kg; P205: 30 kg; K2O: 150 kg per ha was recommended for the cassava farms. Calcium Phosphate fertilizer to reduce soil acidity was also recommended.

Linking fabricators to processors: A total of 12 equipment fabricators were linked to cassava processors in the seven countries. In DR Congo, the project linked selected processors to ACOMMERCONGO, AGRIMAC and BENIBOOD/FABRICATION, the three most important processing equipment fabricators in the country. In Nigeria, Memis Construction Ltd, and Fataroy Steel Industry Ltd, were linked to processors in Oyo state, producers of gari. In Tanzania, Entremech engineering was linked to the project to manufacture quality cassava processing machines, with technical backup from IITA Tanzania. Similarly in Sierra Leone, Ken Metal Works was trained jointly by the UPoCA and CFC projects in the country and linked to development agencies and processors for the manufacture of quality graters, hydraulic presses, and hammer mills.

Technical advice on management and technical issues: Technical advice was provided on management and technical issues in cassava processing. In Malawi, the assistance involved equipment upgrades and flour/starch drying facilities is assisting four processing centers: Masimbe Investments (produces cassava starch), Mbwandimbwandi Gardens, Kasiya Maliro investments and Chisi Investments all producing HQCF. In Sierra Leone, for example, the project advised a World Bank-supported Rural and Private Sector Development Project of the Ministry and Agriculture, Forestry, and Food Security/Ministry of Trade and Industry on management and technical issues in cassava processing by FBOs at 32 processing sites that were being established. The technical advice covered a) type and capacity of equipment for the intended processing systems (e.g., root peelers, chippers, graters, presses, sieves, gari roasters, packaging materials, and transport issues); b) a standardized equipment list for processing cassava into various products, such as gari, starch, and flour (this focused on functional linkages in equipment assembly for cassava products production; and c) appropriate designs for civil works structures housing facilities for cassava processing (this involved re-tooling existing buildings, appropriate factory design to house multi-purpose cassava factories, factory hygiene, and crop-livestock integration.

Quality management and compliance status: Quality management and status of compliance were undertaken in Ghana, Mozambique, and Tanzania to assess the quality and safety problems encountered in the countries. In Ghana, the project worked with Caltech Ventures Ltd. to improve quality management and compliance in cassava processing. In Tanzania six and Mozambique, five rural-based small-scale processing enterprises were assessed. The quality and safety challenges encountered at these sites were largely indicative of the general quality-related problems of cassava processing in Ghana. The principal problems related more to the adherence of failure to good manufacturing and hygienic practices than lack of process control. The lapses in adherence to good manufacturing practices/GMP included the lack of adequate drainage systems and other facilities for handling waste; free flow of liquid waste into the bush; non-availability of hand washing facilities specifically designated for the purpose; absence of changing rooms for the production staff; staff not wearing jewelry during processing operations; staff not wearing recommended protective clothing during processing; absence of hygiene rules for visitors; absence of adequate tools for cleaning and sanitation of the facilities; absence of written standard operating systems; absence of a specific officer responsible for sanitation and hygiene or quality issues; and inadequate cleanliness of net screens, ceilings, and overhead fixtures in the processing halls. A major constraint to processing identified in Mozambique was the lack of the processing machines for making high grade products in the local market. . As a result, the processors used manual processing methods which resulted in low production capacity and low quality of products, especially gari and flour. Related to quality management was assistance from national standards bureaux, e.g., the project worked with Sierra Leone Standards Bureau (SLSB) to draft standards for the four products (Tui and fufu flour), gari, HQCF, and cassava chips) for consideration by the appropriate technical committee of SLSB.

Sale of cassava products: Market studies were limited to perception surveys on the opportunities and constraints faced by actors in the cassava value chains namely, traders, consumers, and agro-processors for producing and marketing cassava in Mozambique and Sierra Leone. The preliminary data showed that concerted efforts to commercialize the products were rare in the countries. Market data collection guidelines developed by the project were yet to be effectively implemented in a way that would produce verifiable data in any of the seven countries.

Project visibility: Global visibility of the project was promoted through at least 39 web news sites (Box 2) backed by print articles, radio, TV broadcasts, field days, and visits by dignitaries to activity site covering project activities across the countries. Initially, a 6-page illustrated flyer was developed to introduce the project to diverse audiences. The flyer titled Combating the food crisis through science traced the causes of the food price crisis; introduced the response of USAID/IITA partnership on cassava; explained the UPoCA implementation strategy; outlined the special benefits to be derived from the project; and featured a cassava entrepreneur who typified a range of capacity building challenges facing the development of cassava value chains at rural levels.

In Ghana, information on the rapid multiplication of cassava and product development and compliance with standards was broadcast on six radio stations and information centers in the project's implementing districts/ municipalities. The radio stations and information centers were Nkwa FM, Assin North Municipality, Aboaso Information Center, Bekwai Municipality; Edwenase Information Center, Bekwai Municipality; Onyame Akwan Dooso Information Center, Adansi North District; Asomdwoe Information Center, Adansi North District; and Oheneba Information Center, Obuasi Municipality. In Sierra Leone, project beneficiaries and a few partners engaged in community radio broadcasts on cassava through 15-30 minutes (daily) Farmers' Talk program of Cotton Tree News (CTN); http://www.cottontreenews.org/ CTN is funded by the European Union, Ireland, and Germany and produced and broadcast by Fondation Hirondelle, Media for Peace and Dignity, in partnership with Fourah Bay College at the University of Sierra Leone and the United Nations Integrated Peacebuilding Office in Sierra Leone (UNIPSIL). CTN links with Star Radio in neighboring Liberia

In the last two quarters of the project, UPoCA partners collaborated with IITA Regional Communications Office to initiate a series of UPoCA People stories in flyer forms highlighting success, opportunities, and challenges faced by project beneficiaries in the countries

Project visibility was further increased through at least 11 field days and site visits by dignitaries e.g, Regional Farmers' Day exhibition and in Ghana, WFP/FAO World Food Day Commemoration in Sierra Leone; cassava open days organized by the project beneficiary groups in DR Congo (e.g., GROPAM, FDM, CARITAS-Matadi, CRAFOD and PRODI), Nigeria (Ido LGA council of Oyo State), in Malawi (Press Agriculture's Estate 87; activity site visit to UPoCA Nigeria by Congresswoman Sheila Jackson Lee, member of the United States House of Representatives, 18th District, Texas with officials from USAID Nigeria and of other USAID-sponsored Projects in the country; and by a joint team of JICA/Japan and Cameroon scientists planning for cassava commercialization and food security in Cameroon.

Box 2: UPoCA project web news sites

http://accra-mail.com/index.php?option=com_content&view=article&id=29900%3Asierra-leone-gets-another-cassava-processing-center&catid=70%3Aafrica&Itemid=219; http://allafrica.com/stories/200909280929.html; http://allafrica.com/stories/200910071019.html; http://article.wn.com/view/2009/07/20/Cassava_to_be_used_for_food_security_in_Africa/; http://gbcghana.com/news/25367detail.html; http://neocassava.blogspot.com/2010/12/cassava-commercialization-boosts.html; http://news.yahoo.com/s/afp/20100907/sc_afp/nigeriafarmfood_20100907160411; http://www.africanews.com/site/53m_to_improve_cassava_nutrition/list_messages/23949; http://www.agriculturalreviewonline.com/Newsjan18_2011.html# ; http://www.brazzavilleadiac.com/index.php?action=depeche&dep_id=37360&oldaction=liste&regpay_id=0&them_id=24&cat_id=&ss_cat_id=0&LISTE_FROM=0&select_month=0&select_year=0; http://www.businessdailyafrica.com/Company%20Industry/-/539550/669036/-/u6g86mz/-/; http://www.businessghana.com/portal/news/index.php?op=getNews&news_cat_id=&id=110258; http://www.france24.com/en/20100907-rooting-out-hunger-africa-making-darwin-proud; http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=187272; http://www.ghanaweb.com/GhanaHomePage/regional/artikel.php?ID=178723; http://www.iita.org/c/document_library/get_file?uuid=090abce1-4b69-48fd-a17f-f3e60f7bfd98&groupId=25357; http://www.iita.org/c/document_library/get_file?uuid=49618539-fc7b-475f-a13f-3f3e5897a5f7&groupId=25357; http://www.iita.org/c/document_library/get_file?uuid=49767cff-f2f4-4c39-a471-aba0ef05482a&groupId=25357; http://www.iita.org/c/document_library/get_file?uuid=4dcbbcd2-2cf0-43cb-ac6a-041f40170b6a&groupId=25357; http://www.iita.org/c/document_library/get_file?uuid=4fe2f507-1f81-46ff-82ed-9c5d477b21ef&groupId=25357; http://www.iita.org/c/document_library/get_file?uuid=ba1a5449-8af5-4d58-867b-076305f31722&groupId=25357; http://www.iita.org/c/document_library/get_file?uuid=c96258c6-58e3-4f93-b31a-ef2b0e653a68&groupId=25357; http://www.iita.org/cms/archBulletin/1970%20-%2026%20June%202009.pdf; http://www.iita.org/cms/archBulletin/1984%20-%202%20October%202009.pdf; http://www.iita.org/cms/archBulletin/1996-%2025%20December%202009.pdf; http://www.iita.org/cms/archBulletin/2024%20-%205%20July%202010.pdf; http://www.iita.org/cms/details/news_feature_details.aspx?articleid=2858&zoneid=342; http://www.individual.com/story.php?story=108044837; http://www.mg.co.za/article/2010-09-07-rooting-out-hunger-in-africa-and-making-darwin-proud; http://www.modernghana.com/news/268144/1/nigerian-farmers-to-get-improved-cassava-planting-.html; http://www.nationmw.net/index.php?option=com_content&view=article&id=11019:project-unleashes-high-yielding-cassava-seed&catid=11:business-news&Itemid=4; http://www.news.sl/drwebsite/publish/article_200511523.shtml; http://www.news.sl/drwebsite/publish/article_200512529.shtml; http://www.ngrguardiannews.com/agro_care/article01//indexn3_html?pdate=260709&ptitle=Cassava%20Farmers%20Now%20To%20Get%20Stable%20Market,%20Mitigate%20Seasonal%20Glut&cpdate=270709; http://www.punchng.com/Articl.aspx?theartic=Art2010031816152853; http://www.reliefweb.int/rw/rwb.nsf/db900sid/JALR-8BSJZX?OpenDocument&query=IITA; http://www.reliefweb.int/rw/rwb.nsf/db900SID/SHIG-83NG6K?OpenDocument; http://africanpress.wordpress.com/2010/03/18/nigerian-farmers-to-get-improved-cassava-planting-materials/; http://www.wallstreet-online.de/diskussion/1137033-12131-12140/news-around-the-world; http://www.youtube.com/user/IITAPUBLISHING#p/a/u/1/sJCpLonP150.

Discussion and Conclusion

The historical view of cassava as “a poor man's crop” in SSA limits efforts to fully exploit the crop's commercial potential as a raw material in food, feed, and industrial products. This view exists because poorer households are marginalized and often live in marginalized areas, the same areas where cassava can perform well within farmers' food security coping strategies. This affiliation suggests that the development of market opportunities for cassava can improve food security and contribute substantially to poverty alleviation, especially among resource-constrained households. Ensuring food security and sustained productivity requires adequate technical and manpower resources on the ground to effectively bring about positive changes in the performance of agricultural sub sectors. International networking and collaboration helps to enable national programs to have ready access to such resources.

UPoCA project achievements provide evidence that the project is stimulating the emergence of rural enterprises for value added processing of cassava and cassava products development for wealth creation. During implementation, project activities did not deviate from addressing the key constraints identified at implementation planning workshops. Whilst the project scored excellently on 72.7% of the planned 22 indicator targets, it should be noted that the percentage delivery data on yield indicators is from sites from DRC, Ghana, and Sierra Leone only.

Reliability in the supply of raw material at a competitive cost will largely determine the viability of processing operations. The numerous seed and root production farms will continue to serve as sources for the rapid horizontal spread of new/improved varieties. This will enable individual and producer groups to supply themselves with healthy planting materials of the varieties. The reduction in dependency on external suppliers of planting material would reduce unit costs and timeliness of delivery. This could be an essential step to boost rural entrepreneurship in cassava. Another essential is the higher yield for raw material supplies, and the data from DR Congo, Ghana, and Sierra Leone indicate the average root yield from farms with improved varieties were above the 2007 national average yields of 5 8 t/ha in the respective countries. While in some cases productivity has been increased through the use of improved varieties, intensive agronomic mentoring will improve the observed plant population and reduce yield variations, enabling farmers to further increase on-farm productivity of the varieties.

To strengthen their viability as partners to agribusinesses, the farmers/farmers groups would need to acquire the organizational and managerial skills required to manage large input supply and crop marketing activities. Efforts to organize cassava supply lines for processing would need to consider the effects of a number of factors on the steady and predictable flow of the materials, e.g., ease of access to fresh marketing channels; ease of access to other processing outlets; influence of variations in farmers' and consumers' preferences on the uptake of new varieties, supply variations including transportation and harvesting difficulties, seasonal effects on drying operations, and the overall seasonality of agricultural production processes..

Through experiential learning, a core team of resource persons from IITA and national organizations has not only increased the scientific knowledge of a large number of men and women change agents but provided a foundation to reduce disconnections between availability/discovery and end-user access to and application of cassava research results. This enables participants to later on empower colleague producer groups, agroprocessors, and entrepreneurs later with the technical knowledge and skills required to embark on a profitable cassava business. Concerted efforts to commercialize cassava are however rare in the countries, except in Nigeria. To tap into the high food and income generating potential of the crop, project beneficiaries need to be aware of identifiable sectors with potential to encourage the industrialization of cassava. These include feed industries, replacement of wheat in bread, pastries and snacks and starch (and its derivatives) industry in the domestic and regional market. Industrial demand for cassava is however still limited in the countries. Mechanisms to ensure guaranteed regular supply of good quality cassava will involve organized and facilitated linkages enabling actors in the cassava value chain to ensure the safety and quality of cassava products.

New challenges will be presented in consolidating a shift towards market-oriented production systems. This is particularly so in an atmosphere of urgent demand by a wide range of UPoCA stakeholder groups to enable cassava producers and the related food industry to diversify their income sources. The kinds of new challenges emerging from the implementation experience of the UPoCA project include the following.

- Generating and promoting economically productive varieties with profitable functional, nutritional and quality characteristics for different end-uses and markets. Cassava is practically all carbohydrate. In recent years, however, IITA breeding programs have developed "yellow-fleshed" cassava varieties containing pro-Vitamin A. This nutritional quality is lacking in many existing improved cassava varieties. The varieties need to be adapted, multiplied, and disseminated in localities of FBO beneficiaries and other government-supported interventions.

- Employing improved techniques to produce cassava for viable markets: This process will involve greater reliance on input and output delivery systems and integration with other sectors of the domestic, regional, and international economies to maximize returns on investments. Along with this will be experiential learning by the FBOs to boost national average yields toward the proven on-farm potentials of at least 25 t/ha. At such yield levels, FBOs will be in a good position to easily justify requests for automated cassava processing equipments.
- Overcoming the interlocking problems of poverty, low productivity, and resource degradation: Addressing these features of the cassava subsector will help reduce unit production costs and lower the real cost of food for consumers whilst still preserving the natural resource base.
- Institutionalising standards for cassava processing and cassava products quality management will pave the way for food safety compliance in health and trade.
- Cassava and livestock integrating to further expand utilization of the crop.

Addressing these kinds of challenges requires a longer-term research for development engagement with stakeholders and beneficiary groups. This will enable the partnerships to fully embed cassava subsectors within the framework of national expectations of an expanded future role for cassava in food, feed and industrial applications in the countries

Project UPoCA, a transition activity by its nature, has laid a solid foundation that needs to be built upon to meet these expectations. The evolving achievements of UPoCA indicate that a longer-term R4D partnership of that nature will enable actors in the cassava value chain to contribute significantly to national economic growth in Africa.

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Table 1: Priority constraints and proposed interventions

Key constraints	Proposed interventions	
	Action	Implementing partners
Production issues		
1. Poor and declining soil fertility leading to low productivity	Training on nature of the problem, corrective measures, sources of information, technical and material inputs; weed management	- National research institutes - Agrochemical dealers - Ministries and development agencies/MDAs; agricultural development projects
2. Inadequate supply of clean planting materials of improved varieties	Establish private and community seed farms; training in rapid multiplication and quality control of stems	- Nat. research institutes - MDAs and agricultural development projects I.1. - Private sector (firms and individuals) - Farmers groups
3. Biotic threats	Training in pest management, stem and plant health; biological control applications; Mass Information Education and Communication (IEC)	- Crop protection services - MDAs and agricultural development projects - Community radio networks - Farmers groups
Post-harvest issues		
4. Poor quality metals in processing machines	Upgrade existing machines; replace mild steel with stainless steel in cutting edges; training in equipment fabrication, repair and maintenance	- National research institutes - Private sector/national machine fabricators - Agro-dealers - Food processors
5. Poor storage quality of fresh roots and processed products	Training in value-added processing techniques; introduce improved packaging facilities	- National research institutes - MDAs and agricultural development projects - Private sector in packaging - Food processors
6. Poor drying of cassava products	Introduce processors to improved dryers; fabricate new rural friendly dryers	- National research institutes - Private sector/national machine fabricators - Agro-dealers - Food processors
Market issues		
7. Lack of cassava market information	Assess market potential of cassava products; establish strategy to link producers to markets IEC	- National research institutes - MDAs and agricultural development projects - Community radio networks
8. Lack/ low of awareness of grades and standards for cassava products	Agro-enterprise training; IEC value added processing and quality needs; field day demonstrations of cassava products and recipes	- National research institutes - National standards bureaux - Equipment fabricators - Agro-dealers - Farmer groups and food processors - Community radio networks

Table 2: Summary of UPoCA achievement by end September 2010

Common indicators	Overall target	Overall achieved by end Sept 2010	% delivery on overall project target
SO 1.1: Number of rural households benefiting directly from interventions			
IR 1: Access to improved production technologies and practices increased			
IR 1.1: No. of rural farmers & processors benefiting directly from interventions	395000	350,018	88.6
IR 1.2: No. of vulnerable households benefiting directly from interventions	184925	28,263	15.3
IR 1.3.1a: Male attendance at short term training	620	979	>100
IR 1.3.1b: Female attendance at short term training	305	833	>100
IR 1.3.2: Type of training	5	24	>100
IR 1.3.3: No. of trainings	42	44	>100
IR 1.3.4: Other trainings	900	428	47.6
IR 1.4: No. of Seed Farms Established	26	390	>100
IR 1.5: Area of Seed Farms Established (ha)	176	710.2	>365.6
SO 1.2: Gross margin /ha for targeted (cassava) commodities			
IR 2: Increased agricultural productivity			
IR 2.1: Gross margin per hectare for targeted commodities ($)	200	0.0	0.0
IR 2.2: No. of technologies made available for transfer	6	16.0	>100
IR 2.3: Crop productivity (t/ha)	20	24.2	>100
IR 2.4: Area (ha) under improved cassava varieties	27000	12,566.2	46.5
IR 3: Improved agric marketing & commercial viability of micro/SME			
IR 3.1: No. agriculture-related firms benefiting directly from interventions	35	58	>100
IR 3.2: No. of partner organizations & active institutional members of those partner org.	36	71.0	>100
IR 3.3: No. of producers organizations, trade & business associations, & CBOs assisted	13	239	>100
IR 3.4: Number of public-private partnerships formed	19	2.0	10.5
IR 3.5: No. of jobs	27000	26,956	99.8
IR 3.6: Sales ($) of agricultural commodities/products/services	17320000	70,579.2	0.4
IR 3.7: No. of fabricators linked	12	21.0	>100
IR 3.8: No. of products introduced and improved	5	24.0	>100
IR 3.9: No. of Information resources developed	5	13.0	>100

Evaluating the effects of UPoCA prior to implementation: taking stock of where we were

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Abstract

Most development researchers and practitioners agree that the sharp rise in international prices for agricultural commodities that emerged in 2003 and peaked in 2008 resulted in a global food crisis. To combat the crisis, IITA and national partners in seven African countries are evaluating the effects of cassava research for development approach on increasing the productivity of production and processing of cassava for home consumption and marketing surplus produce. This paper uses farm household and econometric modeling with baseline and counterfactual data to predict the impact of implementing the project prior to its full implementation. The results show that cassava is at different stages of transformation from a famine reserve, food security crop and rural food staple to a cash crop for urban consumption and manufacture of industrial products. The impact of UPOCA will likely depend on the stage of transformation of the cassava sector in the country. UPoCA will likely have the most impact if interventions are aligned with the stage reached by the country.

Introduction

Most development researchers and practitioners agree that the sharp rise in international prices for agricultural commodities that emerged in 2003 and peaked in 2008 resulted in a global food crisis. Africa was hardest hit because of its high population growth rates, dependency on imports for staple foods, climatic variability and structural adjustment policies (Patel, 2008). The food price crisis is predicted to have negative long-term impacts on food prices and access in sub-Saharan Africa. With climate the global food price crisis is a sign of events to come in the future (Intergovernmental Panel on Climate Change, 2007).

African governments responded in the short-term by banning exports of cereals; removing duties and taxes on cereal staple imports; providing food aid for free, cash for work, food for work and feeding programs; selling strategic grain reserves at subsidized prices; providing seed, fertilizer, fuel and electricity subsidies; and increasing minimum wages. The governments responded in the medium to long-term with agricultural development programs to increase domestic food production and supply; raise incomes and prevent recurrence by providing agricultural input subsidies; expand public sector seed production and distribution; strengthen extension; establish public food reserves; and improve irrigation, roads and telecommunication infrastructure.

There are food policy debates whether these interventions work and have impact on food supply and prices; and whether to target the big three urban staples -- wheat, rice and maize -- or rural staples and famine reserve crops -- cassava and sweet potatoes (Eicher, 1990; de Janvry and Sadoulet, 2008a; 2008b). To inform the policy debates and help governments and smallholder farmers combat the crisis, the International Institute of Tropical Agriculture and national public and private partners are implementing the project "Unleashing the Power of Cassava in Africa in Response to the Food Price Crisis" (UPoCA). The project is evaluating the effects of the research for development approach to combat the food crisis through "next harvest" program interventions to increase the productivity of land and labor in smallholder farming. This will, in turn, permit households to produce more food for their own consumption and market surplus produce through expanding access to output and input markets, disease-free planting materials of improved varieties, crop and post-harvest management technologies complemented by technical assistance. The project is being implemented in seven countries: Democratic Republic of Congo, Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, and Tanzania.

In this paper, we apply farm household and econometric modeling to baseline survey data collected at the start of the project in 2009. We address the question of how farm level outcomes with the UPoCA project will likely be different from the outcomes without the project prior to its implementation. We address this question by using baseline data of sample households in areas in which the project is being implemented and sample households in neighboring non-project areas to estimate economic models. We then use the estimated models to predict outcomes with counter-factual data. We find that binding constraints vary with different stages of transformation from a famine reserve, food security crop and rural food staple to a cash crop for urban consumption and manufacture of industrial products. The impact of UPOCA will likely depend on the stage of transformation of the cassava sector in the country.

Conceptual framework

We model the farm household's decision-making process about staple food production and consumption and sale, the impact of the global food price crisis and farmers' responses using the farm household models and expert opinion.

The farm household maximizes utility of consumption and leisure subject to endowment of land and labor and prices of consumption goods, labor and land. Solving this problem under conditions of market failure such as poor transport infrastructure, high transactions costs, high costs of product assembly and input distribution characterizing much of smallholder farming in Africa yields demand, input demand output supply functions that are complex functions of just about everything in the environment (Sadoulet and de Janvry,1995; Ligon, 2009). A sharp rise in global food prices if transmitted to domestic prices has a positive welfare effect if the household is a net seller of food and a negative effect if it is a net buyer. The effect is proportional to the net sale or purchase of the product. The household's response to rising food prices depends on increasing productivity of inputs and risk reduction in production for home consumption to meet food deficits for net buyers of staple foods and substitutability in production and consumption to mitigate negative impacts. Different categories of households are differentially affected according to their net positions on food markets as sellers or buyers, poverty status and the transmission from international to domestic prices.

Opportunities can be created for smallholder households to reduce the negative impacts of the food crisis and amplify positive ones to increase productivity in cassava production for home consumption and marketing surplus produce through improving their access to disease-free planting materials of improved varieties; science-based crop management practices; processing machinery and equipment; and technical assistance. The research for development approach integrates different research products and development interventions among different public and private organizations engaged throughout the value chains through common platforms for working at higher scales of human organization. The platforms better facilitate compared to the traditional research and extension approaches the integration of different agricultural research components: crop varieties, on-farm agronomy, integrated soil fertility management, pest management, sustainable natural resource management, institutional arrangements for variety release and multiplication and distribution of disease-free cassava planting materials, processing, extension and farmer organizations, private sector agribusiness firms and rural credit systems. The platforms also promote networking, capacity-building and skill development of diverse actors to undertake this kind of work and implement the integration within evolving division of labor especially among farmers, extension agents, non-governmental organizations and private sector firms. This generates synergies in market access and participation, on-farm productivity and sustainable use of natural resources, which drives driving adoption and generates impact at scale on farm level outcomes.

Research hypotheses

Applying the conceptual framework generates three hypotheses tested in this study. The first hypothesis is that the R4D approach will likely have causal effects on household participation in markets.

The second hypothesis is that the R4D approach will likely generate synergies among improved varieties and crop management technologies and encourage adoption by farm households.

The third hypothesis is that the R4D approach will likely help households achieve higher levels of household food security.

Methods

The first hypothesis is tested by first estimating a hurdle model of farm household access and participation in markets using logit and fractional logit models. The models are estimated using data of sample households in villages with past R4D interventions and sample households in villages without previous R4D projects. The estimated equations are then used to estimate the incremental effects of the R4D treatment compared to the counterfactual without the project by switching households in villages without previous R4D interventions from controls to treatment and those in villages with past exposure from treatment to controls.

The hurdle model is used because there is a large mass of farmers with zero sales of cassava and there are skewed sales among those households selling cassava. The double hurdle model is appropriate for analyzing participation decisions in this context because households first choose whether or not to choose to participate in the market and then choose how much to sell given a decision to sell (Wooldridge, 2002). For the second decision of how much to sell to become relevant, there must be a positive response on the first decision. The fractional logit model is used because the dependent variable is measured using the percentage of a farm household's cassava harvest sold and a dependent variable measured in proportions can be appropriately modeled using a fractional logit model (Papke and Wooldridge, 1996; 2008). The two part model exploits the basic rule of probability $E(\%sales \mid x) = \Pr(\%sales > 0 * E(\%sales \mid \%sales > 0)$ and splits market into two parts (Deb et al., 2008). The first part is $\Pr(\%sales=1)$ This is estimated for the full sample with logit regression. The second part is the level of sales conditional on $\%sales>0$. This is estimated as a fractional logit model using a generalized linear model (GLM) with family binomial and log link. The model is valid under the assumption used in the generalized linear models (GLM) literature that the variance-mean ratio is a positive constant $Var(y \mid x) = \sigma^2 eE(y \mid x)$ (Wooldridge, 2002).

The second hypothesis is tested by first estimating a model of adoption of improved varieties and crop management technologies that are being made available to households through the project using multinomial logit regression. The model is estimated using data of sample households in villages with past R4D interventions and sample households in villages without previous R4D projects. The estimated equation is then used to predict the probability of adoption of alternative sets of the number of technology options. The model is used to predict the counterfactual scenario if all sample households had been exposed to past R4D interventions. The likely effect of the R4D is predicted as the difference between the predicted counterfactual scenario and the actual outcomes. The multinomial logit model is used because households can choose whether to adopt or not to adopt technology options and when adopting to adopt the practices independently or as bundles. The choices of the number of technologies adopted are mutually exclusive and exhaustive. The multinomial logit model requires the assumption of independence of irrelevant alternatives (IIA) to hold in the data.

The third hypothesis is tested by first estimating a model of household food security status as a binary indicator of whether the household produces enough staple food to meet its annual requirements using the Heckman's treatment effects model to estimate the corrected selection model. The model is estimated using data of sample households in villages with past R4D interventions and sample households in villages without previous R4D projects. The model is then used to predict the expected food security outcome given treatment and non-treatment and these are used to estimate the likely average treatment effect (ATE) and marginal effects. The Heckman's treatment effects model is used because households can self-select into treatment based on unobservables and the method corrects for omitted variable and selection bias using the inverse Mills ratio.

Data

The data are drawn from baseline surveys conducted at the start of the project from May to September 2009 in the seven countries. The baseline surveys were implemented to establish counterfactuals for ex post impact assessment, collect pre-treatment household and village characteristics and benchmark levels of adoption and outcomes targeted under the research.

The data were collected by interviewing a randomly selected sample of households in areas targeted for implementation of the project and neighbouring non-project areas (Figure 1). The survey used stratified random sampling to select contact households. Districts and lower level administrative units (local government planning areas, extension planning areas, wards, secteur, and chiefdoms) selected for implementing the UPOCA project were randomly selected from provinces and regions targeted under the research. Villages were randomly selected from the districts and households were randomly selected from population lists of the villages. To establish counterfactuals for evaluating the project, comparison households were similarly randomly selected from districts, wards and villages similar in observable characteristics but outside the range of influence of project activities. The final sample consisted of 505 households in DRC, 522 in Ghana, 528 in Malawi, 488 in Mozambique, 630 in Nigeria, 571 in Sierra Leone, and 548 in Tanzania.

Secondary data on annual area planted to cassava, yield and production and open air market prices for cassava products were collected from the national statistical offices. Annual average temperature in degree Celsius and rainfall in millimeters over the period 1951-2005 were assembled for survey villages (Hijmans et al., 2005)

Results and Discussion

This section discusses characteristics of survey households, binding cassava production constraints and historical patterns of adoption of improved varieties and crop management technologies. The section discuses results of estimating the models and predictions of impacts with counterfactual data.

Characteristics of survey households

To identify the impact of the global food price crisis and mechanisms by which UPoCA interventions will likely have impact on farm level outcomes, the baseline survey data were used to construct a typology of farm households. The typology was based on access to land by farm size (de Janvry and Sadoulet, 2008b). Four farm typologies were constructed based on farm size: sub-family farms ranging from 0.1-1 hectares; small family sizes ranging from 1.1-2 hectares; moderate family farms ranging from 2.01-3 hectares; and large farms exceeding 3 hectares. Sub-family farms are below levels that produce optimal efficiency; small family farms can guarantee subsistence levels; moderate farms can achieve subsistence levels with marketable surpluses; and large farms can generate marketable surpluses. The distribution of farm households by farm size is similar across the countries. These show that 11-29 % of sample households are sub-family farms, 21-48 % small family farms, 16-26% moderate family farms and 9-50 % large farms (Tables 1-7). The distribution is shifted to the right for Ghana, indicating selection bias during sampling of farmers for interviewing during the baseline survey towards larger farms.

The results show heterogeneity across different farm typologies. Proportionately more sub-family and small farms crop their cultivated area to staple food crops: maize in Malawi and cassava in the other countries. Only 20% of sample households in Malawi have ever grown cassava. In contrast, virtually all households in the other countries have ever grown cassava. Sub-family and small farms have lower proportions of percent cassava harvest sold and self-sufficiency in food production. By contrast, sub-family and small farms have higher proportions of households growing cassava for own-consumption and buying food. Compared to moderate and large farm families, sub-family and small farms have younger and poorly educated household heads, smaller family sizes and family labor, hiring of casual labors and investments in farm equipment and livestock and more off-farm cash income sources. Proportionately less sub-family and small farms make contact with government and NGO extension agents and participate in farmer organizations. Sub-family and small farms are mostly female headed households. These results suggest that cassava is more important for poor households who are mostly female headed households. The pattern is consistent across the seven countries. This suggests that heterogeneity across countries is limited enough that results can be generalized.

The typology also shows that although all farm categories will be negatively affected by a rise in the price of staple foods. However, the sub-family farms especially de jure female-headed households will be more negatively affected. This is because these households have higher food production deficits and rely on markets and agricultural casual labor sales for food staples. A large majority of the farm households in Malawi depends on production of maize for home consumption and cassava for both home consumption and sale. In Ghana most households have an equal share between maize and cassava for own household food consumption. By contrast, the majority of households in Mozambique, Tanzania, DRC, Sierra Leone and Nigeria produce cassava mainly for domestic consumption. Therefore the majority can be assisted by increasing the productivity of land and labor in production, processing and marketing to offset deficit in food production relative to household consumption and to provide farm-financed social welfare when exposed to shocks.

Compared to farm families in comparison areas, households in UPoCa sites have statistically significant higher proportions whose major objective in growing cassava is for own-food consumption, self-sufficiency in food, higher investments in livestock, and who make contact with government extension agents. This suggests selection bias resulting from targeting of areas with field extension agents and that have previously implemented research for development programs. Ex post impact assessment will need to control for this selection bias.

Cassava production constraints

Figure 2 presents the incidence of cassava production problems reported by survey households. There are higher order system constraints that limit adoption and impact of new technologies more than multiple biotic or edaphic constraints. These include ill-health; weak preferences for cassava; land shortage; theft; lack of disease-free planting materials of improved varieties; poor soil fertility and a lack of fertilizers; the lack of extension services; pest and diseases; poor rainfall distribution; the lack of tools and equipment; unavailability of transportation to move cassava from the fields to processing centers; the lack of processing machines; labor shortage; poor market access; the lack of capital and poor government support. The most frequently reported binding constraints shift with the stage of transformation of cassava from a famine reserve crop and rural staple to a cash crop for urban consumption and livestock feed and industrial crop.

Major production problems in Malawi at the early stage of the transformation process are livestock damage; the lack of interest in growing cassava; land tenure constraints; and theft. Livestock damage, land tenure problems and theft are most important in the early stage of the cassava transformation. This is because farmers have not adjusted their farming systems in which the cropping season lasts for 5 months during which livestock are herded and then allowed to graze freely to that of at least 9 months for cassava to grow and mature. Problems for Tanzania, Mozambique and the DRC in the middle phase are pests and diseases, lack of planting materials, lack of extension, poor rainfall distribution, poor soils and lack of processing machines. Problems for Sierra Leone transiting from to the stage of cash crop for urban consumption stage are lack of processing machines and labor shortages. Problems for Ghana and Nigeria at advanced cash crop stage are poor access to markets and lack of capital and credit and inadequate government support.This suggests that technological, organizational, institutional and policy innovations to resolve the constraints will likely vary with the stage of transformation of the cassava sector.

Diffusion of improved varieties and crop management technologies

Households interviewed during the baseline surveys were asked their awareness and knowledge of improved varieties targeted for multiplication and distribution under UPoCa; whether they have ever used the varieties in their main fields; where they first learned about the variety; when they first used the variety; whether they planted the variety during the survey 2008/2009 cropping season; and why they used or did not use the variety. Households were similarly asked to describe how they carry out the following crop management practices (a) seed/stem selection; (b) planting time (c) weeding (d) plant spacing (e) pest sand disease control. They were asked to recall where they first learned about the practice; when they first used the practice; whether they used the practice during the survey 2008/2009 cropping season; and why they used or did not use the practice. Farmer responses were used to score whether the farmer knew or did not know the recommended practice and to estimate the rate of diffusion among sample households. Diffusion was measured by the change in the percentage of farmers that adopt new innovations over time.

The diffusion of improved varieties and crop management practices over time among sample farmers greatly varies among the 7 countries (Figures 3-9). Diffusion generally follows the S-shaped logistic curve (Griliches, 1957; 1960). In most countries diffusion has still not reached the inflection point. Diffusion follows a stepwise pattern (Byerlee and Hesse de Polanco, 1986). Variety, seed selection, spacing and weeding are simultaneously adopted first, followed by planting time and then by pest and diseases control. In most countries although the earliest adoption of improved varieties occurred in the 1950s, diffusion was very low until the mid-1990s. Variety, seed selection, spacing and weeding technologies have diffused more rapidly in the last 15 years following implementation of cassava planting materials multiplication and distribution programs and processing programs.

Effects on market participation

To test the first hypothesis the first part of the hurdle model was specified as a logit regression using a binary indicator as the dependent variable that equals 1 if the percentage of the household's cassava harvest sold (*cascrs* 01) is greater than zero and 0 otherwise. The regressors include a dummy treatment variable (*Exposed*) that equals 1 for households that live in villages previously exposed to R4D interventions and equals 0 for households that live in villages that have never been exposed to R4D treatment; education of head of household in years of formal schooling (*hhedu*); family labor in number of household members available to work on household land (*farmav*); size of cropped area in hectares planted to crops (*Cropareaha*); importance of cassava in proportion of cropped area planted to cassava (*casprop*); dummy variable for preferences for growing cassava (*dcasobj*); a dummy variable for extension contact (*extvisit*); a dummy variable for household participation in a farmers' organization (*famorg*); a dummy variable for female-headed household (*dfem*); and farm equipment resources in total US dollar value of gross investment (*equipval*) and distance to urban markets in kilometers (*dist*).

The second part of the hurdle model was modeled as a GLM with family binomial and log link using the fraction of the household's cassava harvest sold (*cascrs01*) as the dependent variable. The same regressors were used in the logit and fractional logit models. The model was used to calculate the predicted probability of sales conditional on the household participating in the market. A first counter-factual scenario was set up by pretending that all the households were exposed to past R4D treatment and the model was used to generate the predicted probability for this counter-factual scenario. A second counterfactual scenario was set up by pretending that all the households were not exposed and the model was used to generate the predicted probability. The predicted probabilities were compared and used to calculate the average treatment effect (ATE), the average treatment on the treated (ATT) and the average treatment on the untreated (ATU).

Figure 10 summarizes the model prediction results. The model suggests that the if all households were exposed to R4D interventions the incremental proportion with positive cassava sales would be positive in Malawi and DRC, around zero in Nigeria and negative in Tanzania, Mozambique, Sierra Leone and Ghana. This is because cassava plays different roles as a staple food crop and cash crop in different countries. The ATE, ATT and ATU would be positive for DRC, Malawi, and Tanzania; and negative for Mozambique, Sierra Leone, Ghana, and Nigeria. This suggests that impact is likely to be greatest in countries on the steeply rising part of the curve of transformation of their cassava sector.

Effects on technology adoption: To test the second hypothesis the model was specified as a multinominal logit regression with the number of technologies adopted by the household (mum_adopt) as a function of dummy variable for residency in village with or without past R4D interventions (Exposed) and household, farm and village characteristics and the error term (Feder et al., 1985; Sunding and Zilberman, 2001). Household characteristics include education of head of household in years of formal schooling (hhedu), family labor (farmav) and a binary indicator variable for female-head of household (dfem) and a dummy variable for preferences for growing cassava (dcasobj), a dummy variable for extension contact (extvisit), a dummy variable for household participation in a farmers' organization (famorg). Farm characteristics include the size of cropped area in hectares (corpareaha) , proportion of cropped area planted to cassava (casprop), and investment in farm equipment (equipval) and distance to urban markets in kilometers(dist). The dependent variable mum_adopt takes on the values j=0,1,2E6 indicating the choice made by household to adopt none, one or more than one of the six technology options delivered by the program.

To analyze the difference if all households were exposed to R4D, the model was estimated and used to calculate predicted probabilities for each outcome. The counterfactual scenario was set up and used to predict the probability if all households were exposed. Table 11 summarizes the results. This shows that the likely impact of UPoCA is to reduce the probability of a household taking up 0, 1 and 2 technology options and to increase the probability of 3, 4, 5 and 6 technology options. The effect is greatest for DRC, Mozambique and Sierra Leone. These are the countries on the steeply rising part of the curve of transformation of their cassava sector.

Effects on household food security: To test the third hypothesis, the model was specified as a Heckman's treatment effects model with the household food security status as a binary indicator of whether the household produces enough staple food to meet its annual requirements as the dependent variable. For R4D treatment to have effects on food security, households must choose to be exposed, become aware and knowledgeable and adopt the improved technologies. Therefore the treatment variable was measured as a dummy variable (*treat*) equal to 1 if the household lived in a village with past R4D interventions and adopted an improved cassava variety and 0 otherwise. The regressors included the treatment variable (*treat*), age of household head in years (*hhage*), education of head in years of formal schooling (*hhedu*), family labor in number of household members available to work on household land (*farmav*), size of cropped area in hectares planted to crops (*cropareaha*), importance of cassava in proportion of cropped area planted to cassava (*casprop*),farm equipment resources in total US dollar value of gross investment (*equipval*), binary indicator for female head of household (*dfem*).

To address potential endogeneity and selection bias, the model used data on visits by government extension agents to the household farm (extvisit) and household participation in farmers' organization (famorg) as instruments for thevariable. These instruments were used as exclusion variables because they affect participation but not outcomes other through participation. The model was estimated using the "treatreg" maximum likelihood (ML) command in Stata (Cameron and Trivedi, 2009). Post-estimation methods were to obtain the average treatment effect (ATE) and marginal effects. Figure 11 summarizes the ATE results. The estimated average treatment effects on food security are positive except for Sierra Leone which has an estimated ATE that is not statistically significant from 0. This means that a randomly chosen household might expect to a positive increase in being able to produce enough food to meet its annual requirements from participating in UPoCA interventions. The effects are greatest for DRC and Tanzania. This is because they have a higher incidence of pests and disease problems.

The marginal effects show thatandhave relatively large coefficient estimates (Figure 12). This suggests that UPoCA will likely have greater impacts if the multiplication and distribution of disease-free planting materials of improved varieties, crop management and post-harvest technology management interventions are complemented with technical assistance through government extension services and the development of farmers' associations. The relative magnitudes of the coefficient on extension and farmers' organizations are different in different countries. This shows that UPoCA will likely have the most impact if interventions are aligned with the stage reached by the country.

Conclusion

The sharp rise in international prices for agricultural commodities that emerged in 2003 and peaked in 2008 resulted in a global food crisis. To combat the crisis, IITA and national partners in seven African countries are evaluating the effects of cassava research for development approach on increasing the productivity of production and processing of cassava for home consumption and marketing surplus produce. This paper uses farm household and econometric modeling with baseline and counterfactual data to predict the impact of implementing the project prior to its full implementation.

Using a hurdle model of farm household access and participation in markets using logit and fractional logit models the likely effects of UPoCA were predicted to be ambiguous. Using a multinomial logit regression model of adoption of improved varieties and crop management technologies the effects were predicted to reduce the probability of a household taking up none or a few technology options and to increase the probability of a household adopting most of the technology options. Using the Heckman treatment effects model of food security status the likely effects of UPoCA were predicted to increase the probability of a randomly chosen household to produce enough food to meet its annual requirements.

The results suggests that UPoCA will likely have greater impacts if it complements multiplication and distribution of disease-free planting materials of improved varieties, crop management and post-harvest technology management and technical assistance with revitalizing government extension services through development of farmers' associations. UPoCA will likely have the most impact if interventions are aligned with the stage reached by the country.

The shortcomings of the current study are data availability and quality and assumptions underlying estimation methods. Future studies are required to measure ex post impact using rigorous methods and to compare the results with the ex ante predictions in order to improve research prioritization and learning what works, when, why and for how much.

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Table 1: Social poverty map for the UPoCA target and comparison sites, Malawi, 2009

	Farm size (Ha)						non-UPOCA	UPOCA	All	Significance
	0.01-1	1.01-2	2.01-3	>3	All	Significance				
Households (number)	76	200	124	128	528		153	375	528	
Households (%)	14.4	37.9	23.5	24.2	100.0		29	71	100	
Ever grown cassava: Yes (%)	13.2	15.5	25.8	27.3	20.5	0.010	11.1	24.3	20.5	0.000
Proportion area allocated to crop										
Maize	0.87	0.57	0.42	0.27	0.51	0.000	0.48	0.51	0.5	n.s.
Cassava	0.03	0.04	0.04	0.03	0.04	n.s.	0.17	0.043	0.035	0.004
Proportion harvest sold										
Maize	3.3	4.5	5.0	7.0	5.0	n.s.	5.9	4.69	5.04	n.s.
Cassava	4.4	5.8	10.6	11.4	8.1	0.024	3.5	9.9	8.1	0.002
Major objective growing cassava: Household food only (%)	30.0	23.3	50.0	30.8	31.2	n.s.	42.9	28.4	31.2	n.s.
Major objective growing maize: Household food only (%)	73.2	85.5	88.3	81.8	83.3	n.s.	87.6	81.7	83.3	n.s.
Household produces enough food: Yes (%)	23.7	32.5	38.7	56.3	38.4	0.000	39.2	38.1	38.4	n.s.
Household buys food: Yes (%)	55.3	56.0	51.6	43.0	51.7	n.s.	50.3	52.3	51.7	n.s.
Food coping mechanism: Casual labor (%)	50.0	37.0	25.8	18.8	31.8	0.000	29.4	32.8	31.8	n.s.
Age head (years)	43.1	42.7	44.1	45.6	43.8	n.s.	43.9	43.7	43.8	n.s.
Formal education (years)	4.6	5.4	5.9	6.4	5.7	0.030	5.9	5.5	5.7	n.s.
Household size (number)	4.7	4.9	5.4	5.7	5.2	0.004	4.9	5.3	5.2	n.s.
Household members work on farm (number)	2.5	2.6	2.8	3.0	2.7	0.006	2.6	2.8	2.7	n.s.
Cash income off-farm (%)	38.2	37.0	38.7	39.1	38.1	n.s.	40.5	37.1	38.1	n.s.
Hire casual labor: Yes (%)	28.9	34.5	38.7	39.1	35.8	n.s.	40.5	33.9	35.8	n.s.
Value of farm equipment (US$)	47.1	111.4	106.4	223.5	128.1	0.012	126.5	128.7	128.1	n.s.
Value of livestock (US$)	139.3	340.6	581.6	825.1	485.7	0.005	651.2	418.1	485.7	n.s.
Visit extension: Yes(%)	14.5	22.5	23.4	35.9	24.8	0.004	20.3	26.7	24.8	n.s.
Extension visit: Yes (%)	19.7	29.5	28.2	38.3	29.9	0.042	30.7	29.6	29.9	n.s.
Female-headed (%)	15.8	11.0	13.7	8.6	11.7	n.s.	15.0	10.4	11.7	n.s.

Source: IITA farm survey, 2009

Table 2: Social poverty map for the UPoCA target and comparison sites, Tanzania, 2009

	Farm size (Ha)						non - UPOCA	UPOCA	All	Significance
	0.01-1	1.01-2	2.01-3	>3	All	Significance				
Households (number)	86	138	140	178	542		350	192	542	
Households (%)	15.9	25.5	25.8	32.8	100.0					
Ever grown cassava: Yes (%)	98.8	98.6	98.6	97.2	98.2	n.s.	98.3	98.0	98.2	n.s.
Proportion area planted to crop										
Maize	0.25	0.25	0.31	0.15	0.23	n.s.	0.26	0.17	0.23	0.064
Cassava	0.68	0.45	0.35	0.29	0.41	0.000	0.39	0.45	0.41	0.026
Proportion harvest sold										
Maize	21.1	19.8	22.7	31.4	24.9	0.083	27.4	18.5	24.9	0.041
Cassava	48.4	45.2	47.1	54.6	49.2	0.052	44.0	57.5	49.2	0.000
Major objective growing maize: Household food only (%)	32.6	50.0	61.4	61.2	53.9	0.000	55.7	49.0	53.3	0.078
Major objective growing cassava: Household food only (%)	57.0	62.3	63.6	51.7	58.3	n.s.	64.5	46.9	58.2	0.000
Household produces enough food: Yes (%)	28.2	41.6	51.1	46.2	43.4	0.007	41.9	46.9	43.7	n.s.
Household buys food: Yes (%)	83.5	87.6	81.3	78.2	82.2	n.s.	84.4	77.3	81.9	0.027
Food coping mechanism: Casual labor (%)	27.9	34.8	32.9	21.9	29.0	0.054	30.1	26.0	28.6	n.s.
Age head (years)	48.3	48.4	49.3	48.7	48.7	n.s.	47.8	50.0	48.6	0.090
Formal education (years)	5.9	5.7	5.4	5.8	5.7	n.s.	5.6	5.8	5.7	n.s.
Household size (number)	5.2	5.3	6.0	6.5	5.9	0.001	5.9	5.9	5.9	n.s.
Household members work on farm (number)	2.3	2.5	2.9	3.0	2.7	0.000	2.6	3.0	2.7	0.001
Cash income off-farm (%)	50.0	50.0	40.7	51.1	48.0	n.s.	48.0	48.5	48.2	n.s.
Hire casual: Yes (%)	43.0	38.2	37.1	49.2	42.3	n.s.	36.3	53.8	42.6	0.000
Value of farm equipment (US$)	9,357.1	22,619.7	29,345.9	30,175.8	24,734.2	0.012	21,494.2	31,436.5	25,050.2	0.033
Value of livestock (US$)	166.4	115.3	162.7	269.9	186.4	0.096	148.3	250.4	184.8	0.043
Visit extension: Yes (%)	20.0	17.5	24.5	35.1	25.4	0.002	20.2	35.6	25.7	0.000
Extension visit: Yes (%)	27.1	29.2	27.5	32.9	29.6	n.s.	23.8	40.7	29.9	0.000
Farmers' organization: Yes (%)	29.4	28.5	23.7	25.9	26.5	n.s.	21.6	36.1	26.8	0.000
Female-headed (%)	18.6	13.0	3.6	2.3	8.0	0.000	6.9	9.7	7.9	n.s.

Source: IITA farm survey, 2009

Table 3: Social poverty map for the UPoCA target and comparison sites, Mozambique, 2009

	Farm size (Ha)						non-UPOCA	UPOCA	All	Significance
	0.01-1	1.01-2	2.01-3	>3	All	Significance				
Households (number)	127	236	80	45	488		194	294	488	
Households (%)	26.0	48.4	16.4	9.2	100.0		39.8	60.2	100	
Ever grown cassava: Yes (%)	100.0	100.0	100.0	100.0	100.0	n.a.	100	100.0	100	n.a.
Proportion area planted to crop										
Cassava	0.45	0.36	0.34	0.30	0.38	0.000	0.37	0.38	0.38	n.s.
Maize	0.09	0.17	0.17	0.21	0.16	0.000	0.16	0.16	0.16	n.s.
Percent harvest sold										
Cassava	13.2	14.1	17.9	23.5	15.4	0.023	10.6	18.5	15.4	0.000
Maize	5.9	12.7	15.5	23.3	12.4	0.000	10.9	13.3	12.4	n.s.
Major objective growing cassava: Household food mainly (%)	80.3	87.3	86.3	80.0	84.6	n.s.	90.7	80.6	84.6	0.001
Major objective growing maize: Household food mainly (%)	31.5	53.4	56.3	66.7	49.4	0.000	50.5	48.6	49.4	n.s.
Household produces enough food: Yes (%)	34.9	51.9	63.8	80.0	52.1	0.000	43.2	57.9	52.1	0.001
Household buys food: Yes (%)	71.4	75.7	65.7	65.9	72.1	n.s.	74.6	70.4	72.1	n.s.
Food coping mechanism: Casual labor (%)										n.s.
Age head (years)	41.4	41.4	44.0	45.1	42.2	n.s.	40.8	43.1	42.2	n.s.
Formal education head (years)	2.9	3.2	3.4	4.1	3.2	0.029	3.2	3.2	3.2	n.s.
Household size (number)	4.4	4.8	5.1	5.2	4.8	0.033	4.7	4.8	4.8	n.s.
Household members work on farm (number)	1.9	2.3	2.4	2.7	2.3	0.000	2.3	2.3	2.3	n.s.
Cash income off-farm (%)	20.5	23.7	17.5	13.3	20.9	n.s.	22.2	20.1	20.9	n.s.
Hire casual: Yes (%)	12.6	18.6	42.5	46.7	23.6	0.000	19.6	26.2	23.6	n.s.
Value of farm equipment (US$)	30.8	47.9	57.8	116.1	51.4	0.000	48.4	53.3	51.4	n.s.
Value of livestock (US$)	28.1	60.2	56.2	189.7	63.1	0.001	50.1	71.7	63.1	n.s.
Visit extension: Yes(%)	10.2	13.3	12.5	22.2	13.2	n.s.	17.7	10.2	13.2	0.013
Extension visit: Yes (%)	7.9	10.3	16.3	20.0	11.5	0.073	16.1	8.5	11.5	0.009
Farmers' organization: Yes (%)	15.0	13.9	16.3	31.8	16.2	0.030	19.3	14.2	16.2	0.088
Female-headed (%)	18.9	5.9	0.0	0.0	7.8	0.000	6.7	8.5	7.8	n.s.

Table 4: Social poverty map for the UPoCA target and comparison sites, DRC, 2009

	Farm size (Ha)						Treatment	Non-treatment		
	0.01-1	1.01-2	2.01-3	>3	All	Significance			All	Significance
Households (number)	144	104	99	158	505		275	230	505	
Households (%)	28.5	20.6	19.6	31.3	100.0		54.5	45.5	100	
Proportion cropped to cassava	0.68	0.89	0.43	0.39	0.58	n.s.	0.51	0.68	0.58	n.s.
Percent cassava harvest sold	46.1	49.5	44.7	54.5	49.2	0.003	49.40	48.90	49.20	n.s.
Major objective growing cassava: Household food (%)	60.5	49.5	35.1	29.1	43.1	0.000	52.90	30.50	43.40	0.000
Household produces enough food: Yes (%)	37.5	42.3	43.4	67.7	49.1	0.000	52.20	43.50	48.40	0.029
Household buys food: Yes (%)	63.2	69.2	64.6	51.3	61.0	0.018	62.20	60.00	61.20	n.s.
Household head age (years)	45.7	50.0	46.6	46.3	47.0	0.050	47.60	46.90	47.30	n.s.
Household head formal education (years)	5.5	7.2	8.0	8.4	7.2	0.000	6.98	7.50	7.21	n.s.
Household size (number)	5.8	7.5	7.4	8.5	7.3	0.000	7.26	7.27	7.27	n.s.
Household members work on farm (number)	2.6	3.2	3.3	4.1	3.3	0.000	3.2	3.5	3.3	n.s.
Hire casual workers: Yes(%)	41.0	72.1	57.6	63.9	57.8	0.000	56.4	59.1	57.6	n.s.
Value of farm equipment (US$)	45.0	194.4	65.0	233.1	138.5	0.012	120.63	1467.39	135.01	n.s.
Value of livestock (US$)	69.8	485.5	138.1	463.5	292.0	n.s.	466.25	141.72	284.99	0.042
Visit extension: Yes (%)	20.1	17.9	14.9	47.0	100.0	0.000	64.0	36.0	100	0.014
Extension visit: Yes (%)	20.9	20.0	11.8	47.3	100.0	0.000	67.9	32.1	100	0.001
Other information source:NGO, CBOs: Yes (%)	25.8	18.9	20.0	35.3	100.0	n.s.	60.9	39.1	100	0.044
Farmers' organization	14.4	32.4	33.0	32.7	27.4	0.001	29.0	24.9	27.2	n.s.
Female-headed (%)	70.7	12.2	4.9	12.2	100.0	0.000	51.2	48.8	100	n.s.

Table 5: Social poverty map for the UPoCA target and comparison sites, Sierra Leone, 2009

	Farm size (Ha)						non-UPOCA	UPOCA	All	Significance
	0.01-1	1.01-2	2.01-3	>3	All	Significance				
Households (number)	61	165	152	203	581		95	490	585	
Households (%)	10.5	28.4	26.2	34.9	100.0		16.2	83.8	100	
Ever grown cassava: Yes (%)	90.0	93.8	92.0	96.4	93.8	n.s	97.7	93.4	94.1	n.s.
Proportion area planted to crop										
Cassava	0.64	0.48	0.44	0.32	0.43	0.000	0.41	0.43	0.42	n.s.
Rice	0.28	0.36	0.35	0.34	0.34	n.s	0.30	0.34	0.34	n.s.
Percent harvest sold										
Cassava	64.0	63.4	62.5	64.3	63.5	n.s	64.2	63.5	63.6	n.s.
Rice	26.7	32.7	35.2	42.3	37.2	0.000	38.8	37.0	37.3	n.s.
Major objective growing cassava: Household food mainly (%)	42.6	53.9	49.3	53.7	51.5	n.s.	48.4	50.6	50.3	n.s.
Major objective growing rice: Household food mainly (%)	34.4	66.1	77.0	74.9	68.7	0.000	60.0	68.8	67.4	0.062
Household produces enough food: Yes (%)	1.9	7.4	8.9	19.0	11.2	0.000	13.8	10.8	11.2	n.s.
Household buys food: Yes (%)	96.1	97.1	93.6	97.6	96.5	n.s.	97.5	96.5	96.7	n.s.
Food coping mechanism: Casual labor (%)	23.0	43.6	52.0	26.6	37.7	0.000	31.6	39.4	38.1	0.093
Age head (years)	47.5	44.5	43.1	45.9	45.1	n.s.	44.6	45.3	45.2	n.s.
Formal education head (years)	2.0	1.8	1.5	1.6	1.7	n.s.	1.8	1.7	1.7	n.s.
Household size (number)	8.4	9.6	10.9	12.7	10.9	0.000	10.2	11.1	10.9	n.s.
Household members work on farm (number)	4.4	5.2	6.4	7.2	6.1	0.000	5.2	6.3	6.1	0.059
Cash income off-farm (%)	36.1	44.2	47.4	38.4	42.2	n.s.	45.3	42.4	42.9	n.s.
Hire casual: Yes (%)	76.9	87.8	91.9	91.6	89.1	0.015	82.1	90.1	88.9	0.035
Value of farm equipment (US$)	53.2	34.1	59.8	78.2	58.2	0.027	36.3	62.8	58.5	n.s.
Value of livestock (US$)	31.7	108.5	298.2	142.9	162.1	n.s.	113.7	168.3	159.4	n.s.
Visit extension: Yes(%)	50.0	66.2	61.9	65.5	63.2	n.s.	75.6	60.4	62.9	0.006
Extension visit: Yes (%)	53.7	68.2	65.6	72.1	67.3	n.s.	82.5	64.1	67	0.001
Farmers' organization: Yes (%)	68.5	77.9	78.0	80.2	77.7	n.s.	91.3	74.9	77.5	0.000
Female-headed (%)	9.8	17.6	8.4	10.7	12.0	0.065	14.6	11.1	11.7	n.s.

Table 6: Social poverty map for the UPoCA target and comparison sites, Ghana, 2009

	Farm size (Ha)						non-UPOCA	UPOCA	All	Significance
	0.01-1	1.01-2	2.01-3	>3	All	Significance				
Households (number)	66	108	83	251	508		141	381	522	
Households (%)	13.0	21.3	16.3	49.4	100.0		27	73	100	
Ever grown cassava: Yes (%)	95.5	97.2	96.4	98.8	97.6	n.s.	100	94.7	96.2	0.002
Proportion area planted to crop										
Cassava	0.34	0.32	0.24	0.18	0.24	0.000	0.23	0.24	0.24	n.s.
Maize	0.17	0.18	0.14	0.12	0.14	0.004	0.13	0.14	0.14	n.s.
Plantain	0.13	0.14	0.09	0.10	0.11	0.008	0.11	0.11	0.11	n.s.
Cocoyam	0.09	0.09	0.06	0.06	0.07	0.018	0.07	0.07	0.07	n.s.
Proportion harvest sold										
Cassava	62.3	61.8	60.4	58.9	60.2	n.s.	62.6	59.4	60.2	n.s.
Maize	59.2	67.5	63.3	65.9	65.1	n.s.	63.1	66.0	65.2	n.s.
Plantain	48.3	46.6	40.3	51.2	48.4	n.s.	47.7	48.6	48.4	n.s.
Cocoyam	38.0	30.2	38.6	46.6	42.4	n.s.	42.1	43.0	42.7	n.s.
Major objective growing cassava: Household food only (%)	33.3	34.3	33.7	35.5	34.6	n.s.	32.6	34.7	34.2	n.s.
Major objective growing maize: Household food only (%)	33.3	34.3	33.7	35.5	34.6	n.s.	32.6	34.7	34.2	n.s.
Household produces enough food: Yes (%)	74.2	79.6	75.9	82.4	79.7	n.s.	83.7	76.8	78.7	0.056
Household buys food: Yes (%)	71.2	47.2	56.1	45.7	51.1	0.002	51.1	50.4	50.6	n.s.
Food coping mechanism: Casual labor (%)	4.5	7.4	3.6	4.8	5.1	n.s.	7.1	4.7	5.4	n.s.
Age head (years)	48.3	49.6	47.8	49.7	49.8	n.s.	49.8	49.2	49.3	n.s.
Formal education (years)	7.3	8.5	8.1	8.8	8.4	n.s.	8.8	8.2	8.4	n.s.
Household size (number)	7.2	6.3	6.8	7.7	7.2	0.005	7.2	7.1	7.2	n.s.
Household members work on farm (number)	2.3	2.4	2.5	3.1	2.8	0.000	3.1	2.7	2.8	0.030
Cash income off-farm	50.0	54.6	56.6	52.2	53.1	n.s.	54.6	52.0	52.7	n.s.
Hire casual: Yes (%)	72.7	91.7	89.2	90.4	88.2	0.001	91.5	87.1	88.3	n.s.
Value of farm equipment (US$)	38.3	40.5	31.8	55.2	46.1	0.059	52.7	42.5	45.3	n.s.
Value of livestock (US$)	81.5	188.1	165.6	301.5	226.6	n.s.	225.2	220.3	221.6	n.s.
Visit extension: Yes(%)	24.2	16.7	24.1	33.6	27.2	0.008	18.4	29.5	26.5	0.007
Extension visit: Yes (%)	22.7	26.9	28.9	37.2	31.8	0.060	26.2	33.2	31.3	0.079
Farmers' organization: Yes (%)	10.9	6.5	17.1	21.5	16.2	0.003	11.6	17.3	15.8	0.072
Female-headed (%)	7.6	8.3	3.6	1.2	3.9	0.005	2.8	4.5	4.0	n.s.

Table 7: Social poverty map for the UPoCA target and comparison sites, Nigeria, 2009

	Farm size (Ha)						non-UPOCA	UPOCA	All	Significance
	0.01-1	1.01-2	2.01-3	>3	All	Significance				
Households (number)	71	162	155	242	630		210	420	630	
Households (%)	11.3	25.7	24.6	38.4	100.0					
Ever grown cassava: Yes (%)	100.0	100.0	100.0	100.0	100.0	n.a.	100	100.0	100	n.a.
Proportion area planted to crop										
Cassava	0.57	0.47	0.39	0.35	0.42	0.000	0.41	0.42	0.42	n.s.
Yams	0.09	0.17	0.18	0.15	0.15	0.000	0.14	0.16	0.15	n.s.
Maize	0.06	0.06	0.07	0.08	0.07	0.001	0.07	0.07	0.07	n.s.
Proportion harvest sold										
Cassava	75.4	70.3	72.5	78.6	74.5	0.000	76.7	73.8	74.6	0.045
Yams	50.2	49.0	45.7	58.3	52.4	0.000	53.4	52.0	52.4	n.s.
Maize	60.4	60.7	57.1	65.5	62.0	0.033	60.6	62.8	62.0	n.s.
Major objective growing cassava: Household food only (%)	57.7	76.5	61.9	11.6	45.9	0.000	43.9	46.9	45.9	n.s.
Major objective growing yams: Household food only (%)	35.2	34.0	44.5	37.6	38.1	n.s.	34.3	40.0	38.1	n.s.
Major objective growing maize: Household food only (%)	39.4	38.3	29.7	37.2	35.9	n.s.	37.6	35	35.9	n.s.
Household produces enough food: Yes (%)	48.6	40.4	37.7	73.8	53.4	0.000	50.7	54.8	53.4	n.s.
Household buys food: Yes (%)	65.7	70.9	72.5	41.2	59.2	0.000	61.4	58.1	59.2	n.s.
Food coping mechanism: Casual labor (%)	7.0	16.0	19.4	3.3	11.0	0.000	11.9	10.5	11.0	n.s.
Age head (years)	52.2	49.7	49.5	51.6	50.7	n.s.	50.7	51.6	50.7	n.s.
Formal education (years)	9.4	7.2	7.4	8.5	8.0	0.041	8.3	7.8	8.0	n.s.
Household size (number)	8.0	8.0	9.4	11.3	9.6	0.000	8.9	10.0	9.6	0.049
Household members work on farm (number)	2.9	3.5	4.0	4.9	4.1	0.000	3.9	4.1	4.1	n.s.
Cash income off-farm	64.8	47.5	50.3	47.9	50.3	0.072	44.8	53.1	50.3	0.052
Hire casual: Yes (%)	91.3	93.3	95.8	92.8	93.5	n.s.	91.3	94.6	93.5	n.s.
Value of farm equipment (US$)	259.5	334.3	466.9	1,885.6	952.9	n.s.	300.4	1,279.9	952.9	n.s.
Value of livestock (US$)	284.3	321.1	371.9	1,347.9	723.9	0.048	326.4	922.6	723.9	n.s.
Visit extension: Yes(%)	68.2	55.7	61.0	59.6	59.9	n.s.	56.0	61.8	59.9	n.s.
Extension visit: Yes (%)	72.1	66.7	68.0	64.6	66.8	n.s.	63.5	68.5	66.8	n.s.
Farmers' organization: Yes (%)	54.9	39.5	43.2	46.3	44.8	n.s.	35.7	49.3	44.8	0.001
Female-headed (%)	28.2	13.0	7.7	5.4	10.4	0.000	11.9	9.8	10.5	n.s.

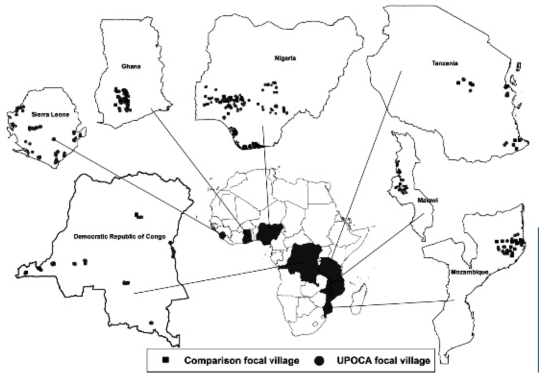

Figure 1: Baseline survey villages

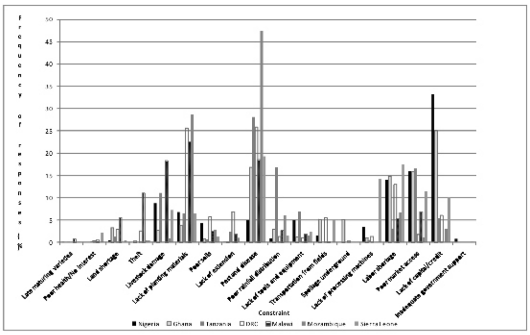

Figure 2: Major cassava production problems in UPoCA survey sites, 2009

Source: Authors' estimates

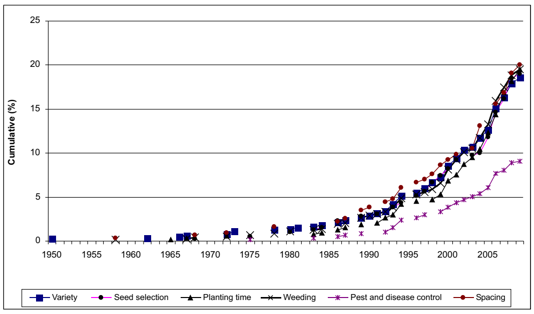

Figure 3: Diffusion of improved varieties and crop management practices over time among sample farmers, Malawi, 2008/09 survey
Source: Authors' estimates

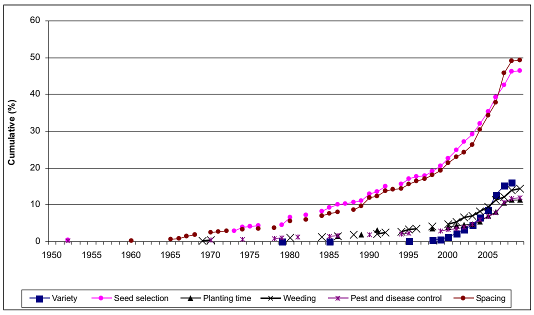

Figure 4: Diffusion of improved varieties and crop management practices over time among sample farmers, Tanzania, 2008/09 survey
Source: Authors' estimates

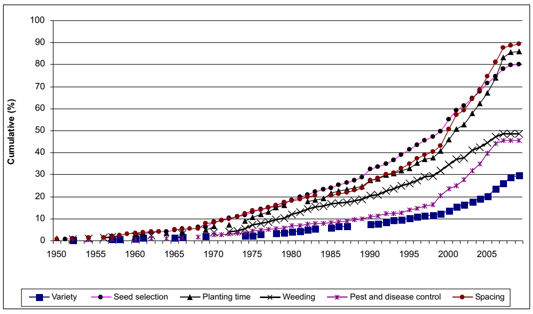

Figure 5: Diffusion of improved varieties and crop management practices over time among sample farmers, Mozambique, 2008/09 survey
Source: Authors' estimates

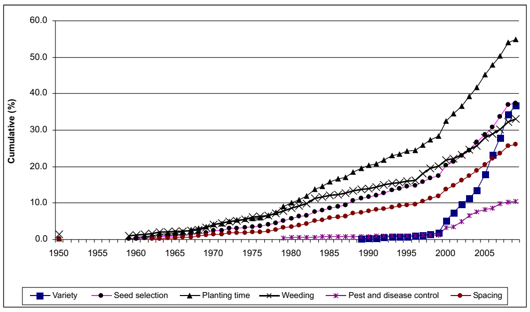

Figure 6: Diffusion of improved varieties and crop management practices over time among sample farmers, DRC, 2008/09 survey
Source: Authors' estimates

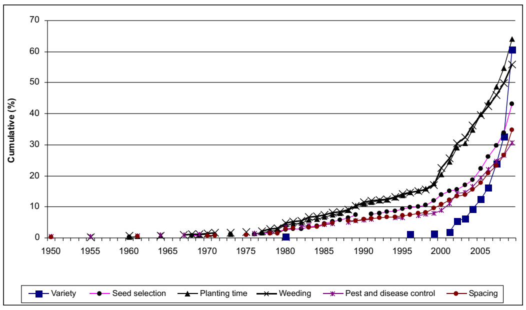

Figure 7: Diffusion of improved varieties and crop management practices over time among sample farmers, Sierra Leone, 2008/09 survey
Source: Authors' estimates

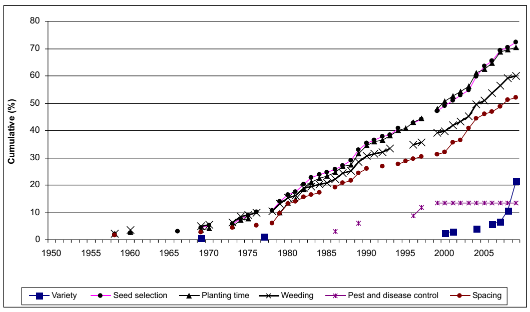

Figure 8: Diffusion of improved varieties and crop management practices over time among sample farmers, Ghana, 2008/09 survey
Source: Authors' estimates

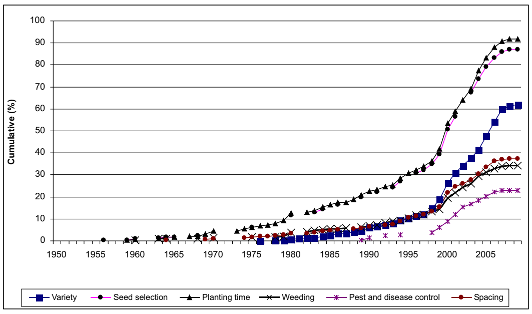

Figure 9: Diffusion of improved varieties and crop management practices over time among sample farmers, Nigeria, 2008/09 survey
Source: Authors' estimates

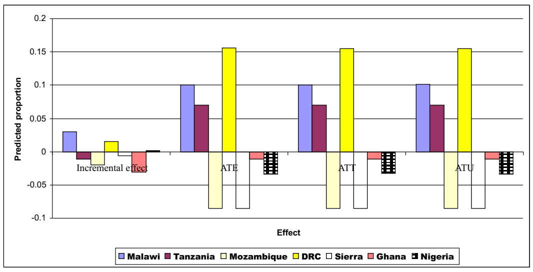

Figure 10: Results of logit and fractional logit regression model prediction with counterfactual data
Source: Authors' estimates

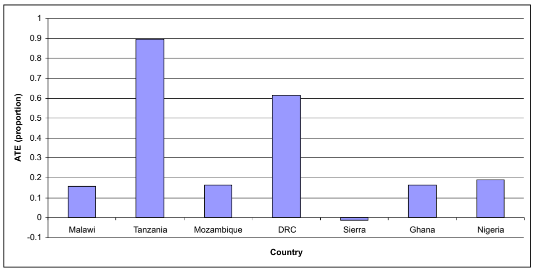

Figure 11: Results of Heckman treatment effects model estimation: Average treatment effect
Source: Authors' estimates

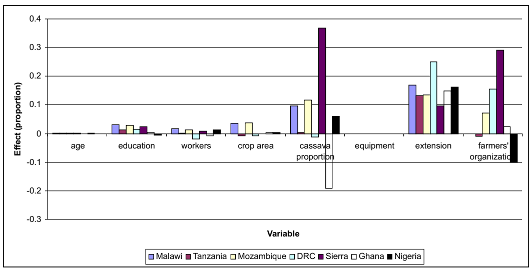

Figure 12: Results of Heckman treatment effects model estimation: Marginal effects
Source: Authors' estimates

Distribution and potential impact of cassava variety spread by UPoCA

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Abstract

Through a combination of conventional and new approaches, root and tuber improvement programs have developed improved cassava varieties that combine multiple pest and disease resistances with superior postharvest qualities, and improve the yield potential by more than 50%. This new generation of cassava germplasm reflects the vision of an expanded future role for cassava in food, feed, and industrial applications. However, unsustainable community access to healthy planting materials of these varieties is a key constraint to higher on-farm productivity of cassava in Africa. The USAID/IITA multi-country project “Unleashing the Power of Cassava in Africa in response to the Food Price Crisis Project” (UPoCA) initiated by end 2008, has significantly increased community self supply schemes of cassava stem planting materials. Fifty-eight (58) improved varieties were planted in 2009 by small holder farmers associated with 55 partner organizations and 11 agricultural related firms. The partners established 306 community cassava stem multiplication sites on 448ha and planted approximately 9,649ha cassava farms with these varieties. The multiplication sites and production farms help to speed up horizontal spread of the varieties to benefit populations within 79,500 km^2 and 107,500 km^2 buffer zones of original introductions in Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, DR Congo and Tanzania in 2010 and 2011 respectively. Based on the current level of variety dissemination, the project is expected to achieve more than its 2-year target of 27,000 ha of new farms under improved cassava varieties. This will enable individual and producer groups to reduce their dependency on research institutes, national extension services and other external suppliers for varieties that had been released in the past years. Area-wide distribution of improved varieties will be backed by appropriate farmer training in appropriate cassava production techniques to raise national average on-farm yields by at least 30% more than baseline figures.

Keywords: Cassava, UPoCA, seed system, yield gap, variety spread

Introduction

The 2-year multi-country project "Unleashing the Power of Cassava in Response to Food Price Crisis" (UPoCA), isfunded by United States Agency for International Development (USAID) and implemented by the International Institute of Tropical Agriculture (IITA) in Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, Democratic Republic of Congo and Tanzania. One major objective of the project is rapid mass propagation of healthy planting materials of improved varieties of cassava. Through a combination of conventional and new approaches, IITA and National Agricultural Research Systems (NARS) have developed a wide range of high yielding and multiple pest/disease resistant cassava varieties. UPoCA project expects that the introduction and dissemination of these high yielding varieties and their subsequent adoption will increase cassava yield by 30% more than baseline figures.

Problems with distributing cassava stem planting material, along with ineffective extension systems, mean that farmers continue to grow local, low yielding varieties leading to wider gap between potential and actual farmer yields. In 18 months of its implementation, UPoCA project empowered farmer-based organizations to provide adequate supplies of healthy stem planting material of improved cassava varieties that will facilitate expansion of on-farm cassava productivity. This paper presents the approach and extent of improved variety distribution.

Challenges in the cassava seed sector

Prior to the UPoCA project national agricultural research systems had released a number of improved cassava varieties in each of the seven project countries (Table 1). However, cassava stems have a low multiplication ratio of 1:10 (stem multiplication farm) or 1:5 (storage root farm) and this limit rapid spread of improved varieties from seed farms established to multiply and maintain released lines. Additional challenges to farmer access to these varieties include information and knowledge transfer on variety characteristics, productivity potential, sources of planting materials, and cost of stem planting materials. Cassava stems are also bulky to transport and transportation costs limits farmers ability to source stems from localities where elite varieties are multiplied.

Other challenges of adequate stem supply include difficulty in maintaining stems across season, over a dry period because cassava stems do not store for more than 4 weeks after harvest. Even when farmers obtain improved varieties, lack of knowledge of good agronomic practice pertaining to plant population, land and soil management, and weed control often lead to poor stem and storage root harvests. There is also the problem of loss of identity of the varieties. Some farmers purchase varieties that are mixed or wrongly labeled. At times errors in the multiplication farm lead to mixtures. Farmers also rename exotic varieties at adoption, in order to remember their names rather than the breeders' given code name. These make it difficult to ascertain to what extent any improved variety has spread through the informal farmer to farmer dissemination approach.

Of particular importance for Tanzania, Malawi, and DR Congo is the problem of cassava brown streak virus. This problem meant that varieties could not be given to farmers without going through a virus free certification exercise.

Multiplication and dissemination strategy

In the 2-year duration of the UPoCA project a combination of approaches was used to acquire, multiply and disseminate cassava stem planting materials (Figure 1). The project partnered with the government Departments of Agriculture and Extension, non governmental organization (NGOs), Community Based Organizations (CBOs), farmer associations and private sector partners e.g., cassava-based industries (Table 2) to mobilize farmers, acquire, multiply and distribute selected varieties (Table 1) to farmers. It was essential to minimize costs due to transportation by establishing community stem multiplication sites within the operational zones of project partner groups. Many of the partners were selected largely on the basis of the geographical spread of their operational zones in each country.

In 2009, the primary multipliers received, mostly under contractual arrangement, bundles of healthy stems of improved cassava varieties to establish seed farms for production of stem planting materials. All primary seed farms were georeferenced and varieties flow documented. Timing of the process was season driven and the first year multiplication was made to tail into the planting season of the second year. In each country the establishment and management of seed farm were supervised by UPoCA project staff to ensure good plant population and maintenance of phytosanitary standards. Partner organizations took care of monitoring of these farms, and provision of other inputs to ensure that agreed volume and quality of roots was sold to them by these farmers. Seed farms were tasked to produce about 10000-15000 plants per hectare. The project owned 60-90% of the stem while the sub-contractor 100% of the roots and remaining stems. In the following season (2010), stems from these farms were harvested for wide scale distribution to other farmers and farm clusters especially those liked to cassava-based industries. The seed farms also served as demonstration sites for host community.

The public sector was especially important in facilitating a conducive policy environment, provision of extension personnel that undertook training of the-trainer programs organized by UPoCA and followed up farmers in their respective zones.

In each of the countries emphasis (as suggested by Akoroda 1997) was placed on clear geographical/spatial multiplication sites to reduce cost of secondary distribution in major production areas. The general steps in secondary deployment of stems to farmers included: cutting of stem (25cm above ground); cutting to stake length (20 cm); sorting of stakes; packing stakes in either polythene bags or simple tying with rope, and labeling of packs with variety name; loading on trucks for transportation to distribution venues; off loading of truck at venues; registration of participants at the distribution venues (documenting farmer name, address, telephone, and other contact details); training on multiplication of cassava stems, tips for cassava storage root production and agribusiness; and formal distribution of packs of stems to farmer participants. A farmer (representing a household of at least 4 persons) received minimum of 100-1000 stakes, enough to plant 1-10% of a hectare respectively.

Area-wide distribution of improved varieties was backed by farmer training in appropriate cassava production techniques, with a strong focus on planting techniques that would raise national average on-farm yields. This involved best practices to prepare cuttings for good root production, plant establishment and higher yields. Training resource persons and participants used experience gained from the numerous farmer training to develop a 1-page user-friendly protocol for estimating root yields, plant population, and root rot incidence on 12 month old farms. In DRC, yield assessment exercise was on 130 farms in seven “Territories” and five provinces. In Sierra Leone, yield data was collected from 240 farmers' fields in 12 districts. In Nigeria, yield data was collected from 80 farms in 7 states.

Results

To expand on-farm-productivity of cassava across the 7 countries, UPoCA project introduced and facilitated area-wide spread of 58 elite cassava varieties from 380 community stem multiplication fields on 643ha to at least 11,540 smallholder farms. The farms were planted by smallholder farmers associated with 55 partner organizations and 11 agricultural related firms. GIS projections (Figure 2), based on spread at 5km per year from each introduction site, indicate that these varieties would spread to populations within buffer zones of 63,300 km^2 and 107,500 km^2 in 2010 and 2011 respectively.

By the end of 2010, using the yield assessment protocol, average root yields recorded by project partners on direct beneficiary sole-cropped cassava farms were 18.9t/ha, 22.9t/ha, 22t/ha and 13.8t/ha in DR Congo, Ghana, Nigeria and Sierra Leone, respectively. In DRC sites the average number of storage root per plant was 4.4, 3.5 and 4 2.7 roots/plant for farms with improved varieties only, farms with a mixture of improved and local varieties, and farms with landraces. Root yields varied from region to region with highest yields recorded at Kisangani hinterland (47.87t/ha) in the rain forest belt of Orientale province and in Seke Banza (28.98t/ha) in coastal forest of Bas-Congo. In Sierra Leone, average plant density of 12,986 crop stands per ha (range: 2,800 to 35,520 crop plants) and root rot incidence was 2.3% and varied widely from none to 25.4% roots lost to the diseases.

In Ghana, UPoCA project assisted new cocoa farmers working with the Sustainable Tree Crops Programme (STCP) managed by IITA to intercrop newly planted cocoa farms with high branching cassava varieties which would provide shade to the cocoa seedlings. UPoCA-Ghana provided STCP with a total of 9,166 bundles of improved varieties *Essam Bankye (516 bundles), Afisiafi (5,348 bundles)* and Bankyehemaa (3,302 bundles) for use in this emerging intercropping technology.

Conclusion

In the traditional accelerated system for multiplication and delivery of cassava stems, farmers will start to receive materials from the fourth year after release. In UPoCA project, stem multiplication and delivery was fast-tracked with the involvement of diverse key partners and stakeholders. Area under improved cassava varieties focused on community self supply of planting material as the first key link in an integrated approach to ensure sustainable raw material (storage roots) supply to agro-processors. By the end September 2009, UPoCA had links with several farming households and Farmer Based Organizations (FBOs). Emphasis in these first contacts was more on increasing access to planting material of improved varieties and than on improved crop management practices for higher productivity. The numerous seed and root production farms will continue to serve as sources of rapid horizontal spread of the new/improved varieties. This would enable individual and producer groups to assure self supply of healthy planting materials of the varieties and act as an essential trigger to reduce unit cost of production.

Cassava root yield increases reported from direct beneficiary farms highlight the expectation that propagation of improved varieties, backed by farmer training in integrated cassava crop management, will lead to on-farm yields of at least 30% greater than with existing traditional varieties by 2011. With intensive agronomic monitoring, high variations in plant population and yield can be reduced enabling farmers to increase on-farm productivity of the improved varieties far more than previously reported national averages. For example, yield from direct beneficiary farms in Sierra Leone and DR Congo were significantly above the respective 2007 national average yields of 5t/ha and 8t/ha.

Feedback from partners shows overwhelming demand for improved varieties by farmers. More farmers know varieties by their released names and their characteristics. In Nigeria, for example, lower price of roots is reported, about $60/t. Though this is favourable to cassava-based industries, it does not appear so for small holders farmers. These initial successes have attracted a lot of positive publicity and governments and international organizations are designing projects based on UPoCA's model to meet smallholder farmers need for clean planting materials of improved varieties, as well as the know-how to grow and manage the crop and boost their incomes.

Acknowledgment

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Table 1. NARS variety releases promoted by UPoCA

Year of release	Country	Variety name
2004	DR Congo	I 95/0211, I 95/0528, I 96/0160, MV 99/0395, MV 99/0038, MM 96/0287, MM 96/7204
2008	DR Congo	Mbankana (I96/0067), 94/0330, 01/1661, 01/1229, Obama je taime (TME 419), Liyayi, Namale and Mayombe
2003	Ghana	TMS 91/02327, TMS 91/02324, 92/0067, and TMS 92/0427
2005	Ghana	TMS 97/4962 (Abglifa), TMS 97/4414 (Bankyehemaa), TMS 97/3982 (Esam banky e), and TMS 97/4489 (Doku duade)
1999	Malawi	TMS 60142, TMS 91934, MK91/478
2002	Malawi	CH92/077 (Sauti) and CH92/112 (Yizaso)
2008	Malawi	LCN8010 and 83350
Pre 2005	Nigeria	TMS 30572
2005	Nigeria	TMS 97/2205, TMS 98/0505, TMS 98/0510, TMS 98/0581 and TME 419.
2006	Nigeria	TMS 92/0326, TMS 92/0057, TMS 96/1632, TMS 98/0002, and NR 87184
2008	Nigeria	TMS 96/1089A, NR 930199
2002	Sierra Leone	SLICASS 1, SLICASS 2, SLICASS 3, SLICASS 4, and SLICASS 5
2003	Sierra Leone	80/40, 80/32, 83/15, 87 /29
2006	Sierra Leone	TMS 92/0057 (SLICASS 6)
2006	Tanzania (Lake Zone)	MM96/4684, MM96/8450, MM96/4619, MM96/5725, MM96/8233, MM96/3075B, TMS I91/00063, TMS I92/0057, TMS I92/0067, TME 14
2006	Tanzania (Zanzibar)	KBH 2002/482, KBH 2002/494, KBH 2002/517

Table 2. UPoCA partners in farmer mobilization, stem acquisition, multiplication and distribution

Country	Partner	Start date	End date	Signature date
Malawi	DOWA DADO	February, 2009	December, 2010	24 March, 2009
Malawi	ELDS	February, 2009	Decembe r, 2010	24 March, 2009
Malawi	KASUNGU DADO	February, 2009	31 December, 2010	24 March, 2009
Malawi	MZIMBA DADO	February, 2009	31 December, 2010	24 March, 2009
Malawi	NTCHISI DADO	February, 2009	31 December, 2010	24 March, 2009
Malawi	TLC	February, 2009	31 December, 2010	24 March, 2009
Malawi	Natures Gift Farm	February, 2009	December, 2009	20 April, 2009
Malawi	Press Agriculture Ltd	February, 2009	December, 2009	30 March, 2009
Sierra Leone	FINIC	March, 2009	30 November, 2010	25 March, 2009
Sierra Leon e	OFTN	February, 2009	31 December, 2010	25 March, 2009
Sierra Leone	SLARI	15 March, 2009	30 November, 2010	25 March, 2009
Sierra Leone	CRS	24 March, 2009	31 December, 2009	30 March, 2009
Ghana	FRI	March, 2009	31 December, 2010	1 June, 2009
Ghana	KNUST	March, 2009	September, 2010	16 April, 2009
Ghana	MOFA	March, 2009	September, 2010	16 April, 2009
Ghana	RTIMP	March, 2009	September, 2010	16 April, 2009
Nigeria	NRCRI	1 April, 2009	31 October, 2010	3 April 2009
Nigeria	PSALTRY	March, 2009	30 September, 2009	6 April 2009
Nigeria	HEAP	1 May, 2009	31 December, 2009	28 April 2009
Nigeria	OLUBUNMI	April, 2009	31 March, 2010	27 April 2009
Nigeria	MICO	April, 2009	31 March, 2010	27 April 2009
Nigeria	GITASA Nigeria Ltd.	April, 2009	31 March, 2010	23 April 2 009
Nigeria	NCGA	April, 2009	31 March, 2010	23 April 2009
DRC	CADIM	March, 2009	31 December, 2010	2 April 2009
DRC	CARITAS	March, 2009	31 December, 2010	3 April 2009
DRC	CRDE	March, 2009	31 December, 2010	11 May 2009
DRC	CRAFOD	March, 2009	31 December , 2010	2 April 2009
DRC	DIOBASS Fizi	March, 2009	31 December, 2010	3 April 2009
DRC	DIOBASS Uvira	March, 2009	31 December, 2010	3 April 2009
DRC	FDM	March, 2009	31 December, 2010	22 April 2009
DRC	GATIFA	March, 2009	31 December, 2010	3 April 2009
DRC	GROPAM	March, 2009	31 December, 2010	22 April 2009
DRC	IAP	March, 2009	31 December, 2010	22 April 2009
DRC	PRODIT	March, 2009	31 December, 2010	27 April 2009
Tanzania	DALDO Bagamoyo	March, 2009	31 December, 2010	9 April 2009
Tanzania	DALDO Kisarawe	March, 2009	31 December, 2010	9 April 2009
Tanzania	DC-Dodoma	October, 2009	31 December, 2010	9 April 2009
Mozambique	IIAM			
Mozambique	Departments of Agriculture and Extension			

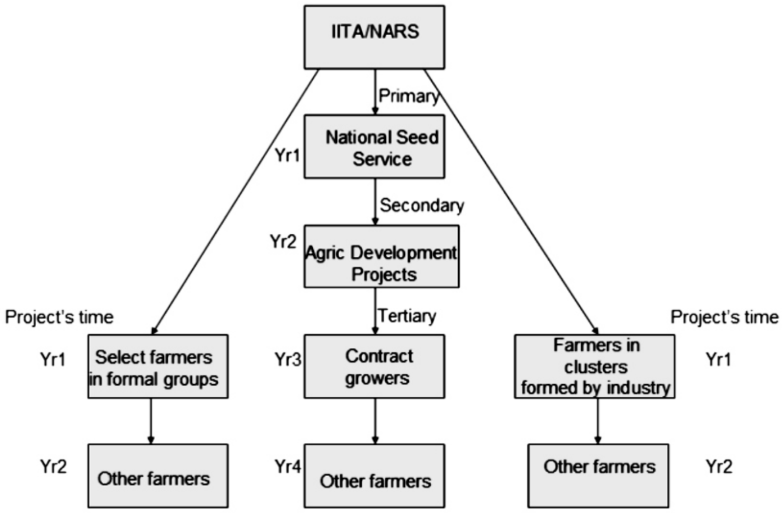

Figure 1. Accelerated cassava stem delivery
model of UPoCA and traditional model

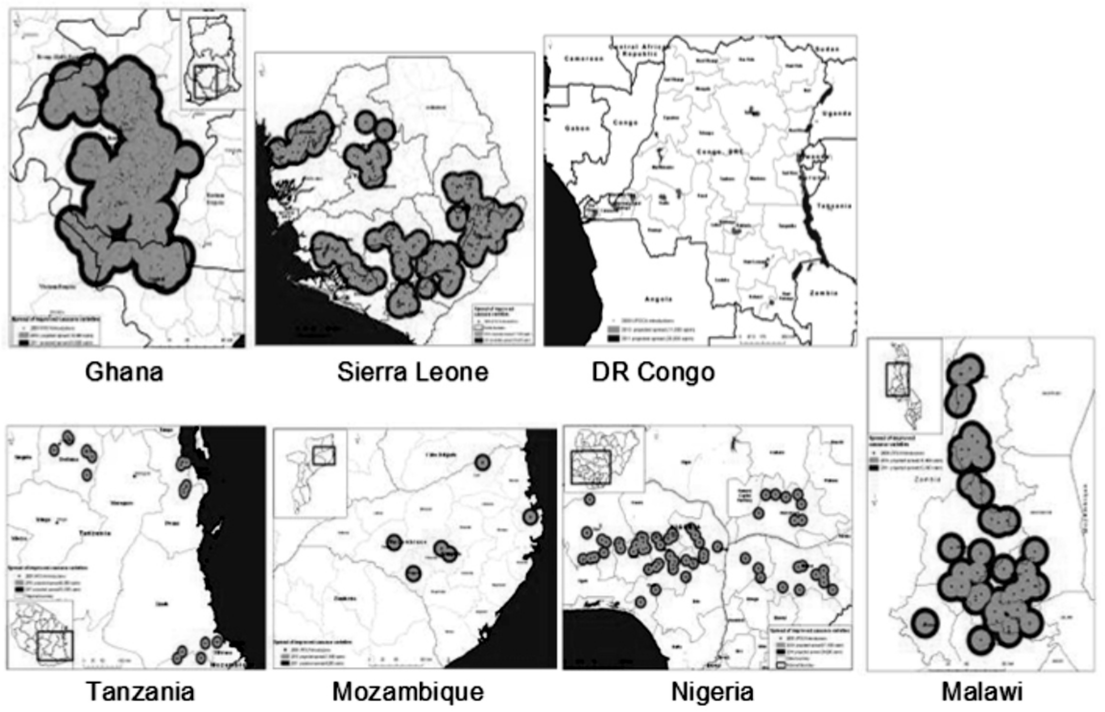

Figure 2. Variety spread for expanded productivity in UPoCA countries

Using Steam to dry Food: Introducing the UPoCA Dryer

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Abstract

The production of cassava flour involves drying grated and pressed cassava into pellets that are milled into flour. The drying process is one of the major bottlenecks to expanding the economic value of the crop. The industry looks for fast drying systems with high flour production capacity to meet market demands. Traditional sun-drying is limited by rainfall, and conventional drying systems are based on motorized machinery unsuitable for farm gate use. The UPoCA dryer has been developed to address these constraints in the production of cassava flours by small to medium processing units. In its standard form, drying system comprises a boiler (325 litres) and two drying cabinets constructed of timber/plywood lined with aluminium sheets. The boiler generates steam that circulates through 7 to 11 shelves of copper coils on top of each is placed a sample tray measuring 1.2m x 0.75m. The coil heats the sample tray and steam from mashed cassava in the tray is removed by convection current of ambient air taken into through the vent holes and dampers. In trials, each cabinet produced 14 to 20 kg dried cassava flour in two hours. With two cabinets operating, the production capacity over an eight to ten-hour working day is about 168 kg and 240 kg for the short, and tall version, respectively. Each version required only three (3) people for regular daily operation. The boiler can operate up to four (4) drying chambers to double the production capacity. The major advantage of this system is that its operation does not require moving parts such as blowers and fans that would require regular maintenance. The system is particularly suited to small scale farming communities in the rural setting, utilising firewood, or charcoal as the fuel source. The application of this device to vegetables and other crops has been tested, with promising results.

Introduction

Cassava comes a close second to the staple foods grown in many African countries, but is commonly perceived as a crop for the poor. However, the poverty alleviation potential of cassava remains largely untapped primarily because of short shelf life of the roots they spoil easily if not quickly processed into products. Expanded growth of cassava industries therefore hinges largely on availability of cost-effective processing centres with sustainable raw material supply chains for the development of value added products (Anon 2008; T. Phillips et al., 2004).

Value added processing to develop a wide range of food and industrial products from cassava can change this low public perception of the crop. Value addition constitutes a huge step in the preparation of farm commodity for the market. Often, the addition provides the impetus for increased cultivation of the crop and thereby helps to improve the economic life of smallholder farmers and food process. For many food crops, value addition involves drying, powdering, and packaging. With the product in powder form, a variety of processing methods for ultimate consumption can be presented e.g. nutritious baby foods from a blend of powdered sweet potato and sesame seed, and a range of products from processed cassava roots. Amongst cassava products are fermented flours, unfermented flours and starch. Fermented cassava flours are used as food and source of starch in industrial adhesives. Unfermented cassava flour known as High Quality Cassava Flour (HQCF) substitutes for wheat flour in bakery and pastry products. Cassava flours are marketed in dry forms with approximately 5% moisture content (Ajao and Adegun, 2009). The drying is a critical aspect of value adding process in the production of cassava flours, especially HQCF which is produced from fresh roots within 24 hours of harvest and has high economic impact value (Abass et al., 1998; Onabolu and Bokanga, 1995).

The process of producing cassava flours consists of the following stages:

- Use of graters to pulverising storage roots of cassava into a mash. In the production of HQCF, the roots are grated son after they are harvested. In the production of fermented flour, the roots need 3not be processed on same day of harvest

- Use of screw or hydraulic presses to dewater the, mash by draining it of excess water. The wet cake is kept for a few days (duration depends of consumer preference) to produce fermented flour. The fermentation stage is avoided in the production of HQCF. In both cases the fully pressed wet cake is broken up into particles for drying
- Use of sun or dryers (e.g., rotary dryers, bin dryers and flash dryers) to dry the particles of the wet cake to desired moisture content level.
- Use of appropriate milling machines, e.g., hammer mill, to produce cassava flours at required particle sizes.

High Quality Cassava Flour has to be produced (from root harvest to drying) within 24hrs of root harvest to avoid fermentation of the product. In all seven UPoCA project countries, small scale agroprocessors adopt sun-drying of particles from pressed wet cakes on raised platforms (Figure 1) or on floors. Whilst the bulk of cassava farms are located in zones with high Length of Growing Periods/LGP to promote high root yields, the same zones have an annual average of less than 6 hrs of sunshine. Sun-dying is therefore mostly reduced to one batch a day and it may take 3 to 5 days (of dry fermentation), depending on prevailing weather, to thoroughly dry the same batch. Long duration drying leads to discoursed cassava flour and reduces chances of producing HQCF. Additionally, the products will be exposed to diverse contaminants during the long periods of drying (Davies, et al., 2008).

Producing cassava flours involves drying, powdering and packaging. Drying technology is a lynchpin in the process. Sun-drying, which predominates in most cassava micro-processing centers, is of limited value where premium is on daily volume and quality of products. Sun-drying is slow, impractical for year-round drying, and compromises quality. The UPoCA dryer has been developed to address these problems faced by rural-based enterprises wishing to produce and market cassava flours and starch.

Among the possible drawbacks of open sun drying method are a) exposure of the cassava sample to biotic and abiotic contaminants in the atmosphere and b) the method is inpractical for year-round drying as it is ineffective in the rainy season.

It is clear from these disadvantages that the preferred drying method would be one for which the drying time is short, and under conditions that would minimise contamination. To address these concerns, the steam drying system was developed by UPoCA project in Sierra Leone to assure year-round drying of processed cassava in flour production, especially in rural areas. This paper presents details of the design, construction, and testing of this UPoCA dryer for cassava products.

Materials and Methods

The initial aim of this work was to produce a system for use in the rural community without electricity or gas supply. The system would be clean, preventing contamination of the cassava sample, and fast enough for processors to regularly turn out clean dried products within a few hours, leading to improvement in economy.

Design and construction: The UPoCA dryer comprises a drying chamber, steam generator and a pressure released valve. Each drying cabinet is constructed of timber and covered with thin aluminum sheets, consists of three (3) vertical panels, a top cover, a base, and a door. The sides and the door is a double-walled chamber of plywood, with air as the insulator; the base is made of thick 2-inch timber.. At least 7 layers of copper coils serve as heating elements (hot plates) inside each cabinet. Copper coils take steam from the boiler and circulated it through the cabinet via one inlet and one outlet. Sample trays of 1mm aluminum sheets sit on each hot plate. Copper tubes and plumbing nipples and unions connect boiler to cabinets. The heat source is steam circulating through copper coils placed inside the cabinet. There can be a maximum of 4 cabinets per boiler which produced the steam.

Steam generator/boiler is constructed of 3mm thick mild steel plates and could hold 325 litres of water. In operation, the boiler is filled to three-quarters of this capacity so steam can be allowed to accumulate and build pressure above the water. Heat conduction is accelerated by conducting steel rods within the boiler. The boiler is connected to the drying chamber by a set of tubes, nipples and union connectors. The connecting pipes are also of copper. A length of 2 m was considered adequate for near minimal heat loss between the boiler and the drying chamber. Steam from the boiler is circulated through the coils, all connected in tandem, with one inlet and one outlet. Condensed water comes out of the output pipe. The cassava sample to be dried is placed on sample racks mounted in the drying chamber. The cabinet with the whole drying system is shown schematically in Figure 2.

For operational safety, a pressure release valve is fitted on the boiler. The valve opens to vent steam and therefore plays a safety role in ensuring that the steam pressure inside the boiler does not increase excessively so as to cause an explosion. The design consists of a weight resting on one of the openings from the generator. A solid cylindrical weight is welded on to the end of a hollow barrel that is inserted into the boiler. When the pressure in the boiler is low, the weight rests on the top of the tube welded into the boiler. With increased steam pressure, the weight is be pushed upwards, thus letting out some steam. This reduces the steam the pressure in the boiler to safe operating level at which point the weight will drop and rest again on the connecting tube. The force lifting the weight upwards to restore equilibrium is calculated in terms of the difference in pressure P inside the boiler and the pressure Po of the atmosphere. Mathematically, the required weight W (=Mg) of the cylinder and barrel is given by the expression (Nonie and Baimba, 2005)

$$(P - P_o) \times A = W$$

giving the inside pressure P as

$$P = P_o + \frac{W}{A} = P_o + \frac{Mg}{A}$$

In the above equations, A is the area of cross section of the connecting tube, M is the mass of the weight, and g is the acceleration of free fall due to gravity. The internal diameter of the connecting tube was measured to be 2.0mm, giving a cross sectional area of 3.14×10^{-6} m^2. A pressure difference enough to raise water to a height equal to the height of the chamber is chosen as a safe operating threshold. With the provision for four (4) cabinets operating from a single boiler, this threshold pressure was calculated to be 3.14×10^5 Pa. Based on this, the mass of the released valve was calculated to be around 95g (or 0.095kg)[2]. In operation an insulating housing is build around three sides, thus helping to reducing firewood or charcoal fuel consumption to bare minimum. There are two principles behind the operation of the chamber. The first is to heat the sample fast without burning it, whilst the second principle involves ejecting the moisture boiled off the sample. Using steam ensures the temperature inside the chamber is kept fairly constant at around 70oC, and the provision of vent holes at the front and back of the chamber, and dampers inserted inside the back of the cabinet and protruding through the top cover work in combination to take away the moisture. The dampers are constructed from PVC pipes around 5cm internal diameter with holes drilled along its length going from the top cover right down to the level of the bottom sample shelf. An important by-product of the system is that the hot water at the exit is actually distilled water, which has commercial value. This was ascertained by electrical conductivity measurements on the out-flowing water. In normal operation the steam dryer requires a two-man operation, one for the addition of fuel and regular monitoring of the boiler, and one for regular checking and turning the contents of the drying cabinet.

To operate the boiler, the tank was filled to about two-thirds its capacity using a graduated dipstick to indicate water levels. The estimated amount of water for this level was around 280 litres. The tank was heated with firewood or charcoal. Whilst waiting for the steam to be produced in the boiler.

Trials were done on grated and pressed cassava mash and on other foods. In each case the drying cabinet was loaded with weighed amounts of grated and pressed cassava. After times of 1 hr, 1.5 hrs, 2 hrs, etc., the dried samples were taken out and weighed. The foods tested were mango for the production of mango juice or mango flavours; sweet potato for producing potato flour; pineapple for the production of pineapple juice or pineapple flavours; chilli pepper for producing powdered pepper; china yam for producing foo-foo or flour; African yam for producing foo-foo or yam flour; okra fruit for producing powdered okra for cooking; and husk parboiled rice.

A glass window in the door provided for easy inspection without the need to open the cabinet frequently during the drying process. The doors were opened for normal inspection and mixing of the sample during drying. In normal operation, warm water flew out of the exit pipe from the dryer. Typical temperature of this water was around 60-70 oC. The lower the temperature, the more desirable the operation. With only two chambers running, it was not unusual to see some steam coming out of the exit. This indicated incomplete heat transfer, in which event it was wise to reduce the amount of fuel.

Results

It normally took between one and one-and-a-half hours to produce steam at the pressure needed to send steam through the coils in the drying chamber.

Trials with grated and pressed cassava: Table 1 gives the results and projected capacities of the tall twin and quad systems. From this table, there is the general trend that the drying time increases as the amount of the sample in the tray increases. Thus it takes longer to dry a larger sample. Whilst this is to be expected, it is interesting to note that the overall daily output of dried product is optimal with 2 kg of sample in a tray. Larger mass produces to a thicker sample, leading to moisture absorption in the sample itself known as self absorption. Some moisture evaporated from the bottom layer of the sample is absorbed in the sample thus extending the drying time. The projected daily outputs for a ten-hour working day are also given in Table 1.

Trials with other foods: Table 2 gives the results and projected capacities of the tall twin and quad systems. Samples chosen for the trials were tubers other than cassava, fruits, and some vegetables. The fruits chosen for the tests were mango, and pineapple. Dried samples of these are often used as drink or food additive for flavouring. On the whole, the effectiveness of the steam dryer is proven for these samples, just as in the case of cassava varying times were of the order of 2 hours or less.

Production costs and projected benefits: The standard quad system consisting of one boiler and four drying cabinets would cost around US$ 7,200. Such a system would have a daily production capacity of 280 kg, giving weekly output over six days of 1680 kg. With HQCF having a retail market price of US$1.00 per kg, a standard quad system would have monthly estimated financial returns in excess of US$6,000.00. This sort of returns would allow the small scale farmer to recover the cost of the drying system within a maximum of 3 (three) months, all other operational costs being taken into account. An added financial benefit can be obtained from the sale of the distilled water that flows out of the system.

Discussion

The steam dryer is rural and end-user friendly, especially in rainforest communities with available firewood. cost of the fuel for daily running stands as low as US$3 per day. On the whole, firewood is considered the fuel of choice, as it does not only take shorter to boil the water, but the overall cost of running the system is considerably low. The main drawback to the use of firewood comes from the environmental issue of deforestation. Fast growing fuel wood tree species can be cultivated to avoid deforestation of natural stands. Outside firewood, the system is easily adaptable to use other fuel sources e.g. charcoal, palm kernel shells, coconut husk and, where affordable, electricity or gas, used either singly or in any form of hybrid combination.. The using of charcoal as fuel was found to be slower than the firewood, due in the main, to the thickness of the 3 mm steel plate used for constructing the boiler. Lighter plate (e.g. 1.5 mm) could yield better result. This, however, has the drawback producing a boiler with limited life due to the intense heat required for drying.

The advantage of the steam dryer arises from the fact that a typical sample tray is heated from the bottom (by the coil the sample sits on), from the coil immediately on top, and from the general thermal equilibrium within the cabinet the latter effectively acting as a uniform temperature enclosure referred to as a black body (Zemansky, et al., 1981).

The dryer has no moving or replacement parts and therefore not prone to operational problems caused by friction. Except for regular cleaning the dryer is practically maintenance free. With the use of rust proof metals the dryer can operate for years without corrosion, friction, Cleaning and maintenance-free. The dryer is ideal for year-round production of fermented, HQCF and starch in conditions that avert product contamination. The system is also applicable to a variety of foods root tubers, vegetables and fruits. Whilst the food quality of the dried product lies outside the remit of this paper, it can be reported that the dried product shows no change in colour. The food is dried at temperatures of 60 to 65oC, temperatures that are low enough to preserve the integrity of most foods.

Manning the system is also easy, as it requires no more than two people for daily monitoring of the fire and loading the cabinets. With convection being the major avenue to get rid of the moisture from the contents of the chamber, theory suggests that the materials would dry a little faster the lower the ambient temperature. It is therefore possible that the oven would dry faster in the dry season when the ambient temperature is power than in the dry/hot season. This, however, has not been tested in this work as the systems are still under trials.

The process to fabricate the dryer brings together the skills of the welder, the fridge mechanic, the aluminum window designer, and the carpenter, all under the direction of an experienced mechanical designer. Thus the materials and specialities available for the construction of the drying system are readily available. The twin system requires a total time of about two weeks, with all the above personnel working in tandem.

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Figure 1: Sun drying of cassava flours.

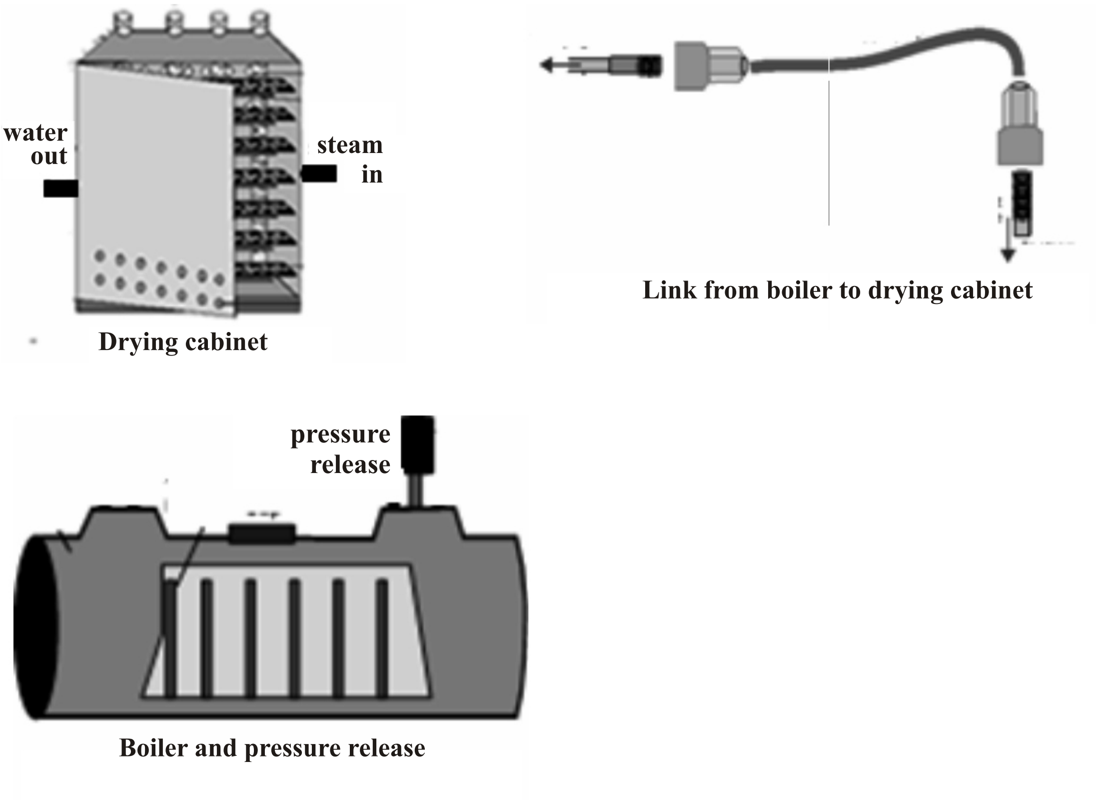

Figure 2: Assembly line of the UPoCA dryer.

Table 1: Results of measurements on grated and pressed cassava

Drying performance	Average weight per tray for 7 loading trays				
Wet weight of HQCF per tray (kg)	1	1.5	2	2.5	3
Time to dry (hours)	1.5	1.5	2.0	3.0	4.0
Weight after stated time (kg)	0.760	1.110	1.543	1.854	2.168
Calculated water lost (kg)	0.240	0.390	0.467	0.646	0.842
Type of steam dryer system	Average daily/10hrs output (kg)				
Estimated daily output (kg): Standard twin cabinets with 7 shelves	84	126	140	105	105
Projected daily output (kg): Tall twin cabinets with 11 shelves	120	180	200	150	150
Projected daily output (kg): Tall quad cabinets with 11 shelves	240	360	400	300	300

Table 2: Testing the drying on other foods

Item	Mass in tray (kg)	Pre -oven preparation	Drying time (hrs)	Mass after drying	Eventual use
Sweet Potato	1.000	Grated and Pressed	2 hrs	0.578	For milling into flour
China yam	1.928	Boiled and grated	2 hrs	0.576	For milling into flour
African yam	1.601	Boiled and grated	2 hrs	0.485	For milling into flour
Pineapple	0.884	Cut into pieces and pressed	3 hrs	0.121	To mill for powder and flavouring
Mango	1.177	Sliced into thin pieces	3 hrs	0.230	To mill for powder and flavouring
Chilli Pepper	0.414	None	2 hrs 45 mins	0.096	To mill into chilli powder
Okra fruit	0.975	Sliced into pieces	2 hrs	0.111	To mill into okra powder for cooking
Husk parboiled rice	2.500	Boil the husk rice for about 10 minutes	2 hrs 45 mins	2.160	Preparation of low calorie rice

Safeguarding good health of consumers: the opportunities and challenges of attaining quality compliance for processed cassava products in Africa

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Abstract
In Sub-Saharan Africa, cassava is mainly grown by smallholder farmers who also process the storage roots into traditional food products. However, improper processing techniques combined with climate variability aggravate risks of health hazards caused by residual toxic cyanogens and mycotoxin contamination of the food products. The introduction of improved processing technologies for the production of a diverse range of cassava-based food and industrial products has enhanced the crop's acceptance as a growing urban food item and industrial raw material. Standards for cassava and cassava products are required by regulatory institutions to assist food processors in producing good quality and safe products for consumption and industrial applications. This paper reports the on-going collaboration among national bureaus of standards, regional organizations, national and international research institutions such as IITA, and other value chain actors for developing specifications for cassava and cassava products and providing certification services to the producers. The paper highlights challenges of achieving conformity in national and regional standards in terms of factory hygiene, product quality and safety. The continuing efforts by IITA and partners, under the CFC-ESA and UPoCA projects, in assisting stakeholders alleviate these challenges are presented. Propositions are made for further supports from research, development and sub-regional organizations to address the current challenges of promoting standardization and quality compliance in cassava trade, commerce and industry in Sub-Saharan Africa.

Keywords: Cassava, processing, standards, compliance, UPoCA, CFC

Introduction
In Sub-Saharan Africa, cassava is mainly grown by smallholder farmers due to its high calorie yield per hectare of land, tolerance to drought and diseases, and its adaptability for piecemeal harvesting. Its chemical composition, functional and pasting properties are desirable for industrial applications in the native state and after modification. Processing is critical for its utilization because of its rapid deterioration after harvest and the presence of cyanogenic compounds. Smallholder producers dominate the processing of cassava storage roots into traditional food products.

Improper processing techniques could aggravate the risks of health hazards through high residual toxic cyanogens in cassava foods and contamination with mycotoxins and pathogenic microorganisms such as *E coli, Pseudomonas aureginosa, etc* (Ayodele et al 2010). The intake of high cyanogens from diets of insufficiently processed cassava roots without a protein rich supplementary food that supply the sulphur amino acids needed for cyanide detoxification lead to many types of disease conditions such as konzo and tropical ataxy neuropathy (TAN). The disease condition was first reported in Nigeria by Moore (1934) while konzo incidence was first reported in the Democratic Republic of Congo (DRC) by Trolli (1938). Afterward, several incidences of konzo have been reported in Mozambique, Tanzania, Central Africa Republic, Cameroon, etc. The most recent reported incidences occurred in Cameroon and in Tanzania. In 2007/2008, sixty-six percent (66%) of the 403 people affected in the eastern part of Cameroon were females and 55% were children. In 2002/2003, three hundred and eighty five (385) people were affected in southern Tanzania and four in 2008/2009. In addition, four cases of acute poisoning were reported in the Lake zone area of Tanzania in 2010. The causative socio-economic factors for the disease epidemics are similar across the countries. The epidemics occur sporadically, mainly in poor cassava dependent communities, where households and processors engage in improper cassava processing practices. The mistaken negative image so created for cassava hampers its acceptance as an urban food and industrial raw material, and lowers its market value.

Sustained and informed partnerships among cassava value chain actors is required to implement a combination of interventions that will contribute to increase the quality and safety of cassava products in ways that safeguard health of consumers, reverse the negative image of cassava, promote its trade, and increase the crops' contribution to economic advancement of rural producers. These interventions include (i) introducing science-based processing methods such as the use of appropriate machinery, (ii) developing specifications for cassava and cassava products, (iii) improving the capacity of processors to adopt quality management procedures and achieve quality compliance; and (iv) increasing the competences of the national bureaus of standards. A number of projects and initiatives have contributed to the implementation of some of these interventions. These projects include the small-scale cassava processing project in East and Southern Africa funded by the Common Fund for Commodities (CFC-project), 'Unleashing the power of cassava in Africa' (UPoCA) funded by the USAID, and the initiative on 'Harmonization of potato and cassava standards in East and Central Africa led by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). This paper reports the on-going partnerships of stakeholders, projects and development agencies in the implementation of the proposed interventions, achievements so far and constraints encountered for safeguarding the health of cassava consumers.

Improved processing techniques

In the past two decades, many research-for-development institutions across Africa have developed and introduced processing interventions and diverse range of cassava-based food and industrial products which have significantly increased public attention to cassava value chains. This has been possible through inter-institutional projects and programs such as Cassava4Bread and postharvest projects; the Pre-emptive Measure Against Cassava Mosaic Disease in Nigeria; root and tubers improvement programs of Nigeria, Ghana and Cameroon supported by the International Fund for Agricultural Development (IFAD); Presidential initiatives on cassava in Nigeria and Ghana; small scale cassava processing and value chain development projects in West, East and Southern Africa supported by the Common Fund for Commodities (CFC); Cassava: Adding Value for Africa (CAVA) supported by the Bill and Melinda Gates Foundation, and recently USAID sponsored Unleashing the power of cassava in Africa. Figure 1 indicates countries that have participated in these kinds of inter-institutional projects and programs involving IITA in partnership with universities, ministries, agencies local governments CIAT, FAO, NRI, and the regional networks SARRNET, EARRNET. Through this partnerships, a wide range of cassava producers, processors, marketers, end-user industries, equipment fabricators have been trained and market linkages among all the actors were enhanced.

These projects and programs have contributed to the emergence of a new generation of cassava processors that have adopted improved processing techniques through the use of machinery and dedicated processing areas or buildings as against the traditional homestead or river-side processing practices. However, as the improved processing practices spread across Africa, significant differences exist between West Africa, mainly Nigeria, and the rest of Africa in the type and scale of cassava processing technologies that emerged. By 2009, higher capacity processing plants for high quality cassava flour (HQCF), starch, glucose syrup, etc emerged in Nigeria. These plants process up to 10-200 tonnes fresh cassava/day compared with 1-2 tonnes fresh cassava/day capacity of processors making gari and fufu in Nigeria before 2000. This was possible because of the increased use of mechanical dryers, higher capacity graters, hydraulic presses, peelers, etc (Abass et al 2009). In East, Central and Southern Africa however, processing mode mainly shifted from homestead mode to mechanized processing capacity to near 0.5 tonne /day and only at demonstration sites.

Despite the use of mechanical processing technologies, quality for cassava products such as HQCF remains a concern for wheat flour millers in Nigeria where it is the desire of the government for wheat millers to produce composite flour from wheat and non-wheat local raw materials. Quality consistency discourages bread bakers and biscuit factories in Madagascar, Tanzania and Uganda from paying higher prices for the new raw material. A microbial quality compliance test done by the bureau of standards in Tanzania (TBS) showed that some cassava flour sold in some supermarkets in the capital city of Dar es Salaam did not comply with standards in terms of microbial quality (Table 1). Although it could not be ascertained which method of processing were used or under what conditions of sanitation the flour samples were produced, it was clear that microbial contamination of cassava products sold in the market is a problem. Similar tests carried out by Manjula et al., (2009) showed that cassava chips and flour sold in Brazzaville, Congo and Tanzania markets contained traces of Aflatoxin and fumonisin, although beyond permissible levels.

Specifications for cassava and cassava products

Commercialization of crops can be enhanced by availability of new innovations in technologies and practices, effective infrastructure, access to markets and an enabling trade policy. Standards or specifications are essential for defining quality and safety of food and non-food items; useful tools for assisting manufacturers to improve quality and safety of products; and yardsticks for the assessment of quality and certification of products (Martin 1979). Standards serve as policy instruments for promoting trade, enhancing commodity prices and promoting investment at both farm and industry levels to achieve positive impacts on food, marketable surpluses and livelihoods.

In the last six years, progress has been made by national food regulatory institutions in the development of specifications for cassava and cassava products. Some R4D multi-country and multi-institution cassava projects designed to increase the productivity, marketability and value of cassava and cassava products have been supporting the development of cassava products specifications in many countries in Africa. There are efforts in East and Central Africa to have harmonized standards for promoting regional trade in cassava. From 2004, a range of partners including the bureaus of standards, research institutions, universities, private sector, regional and international organizations such as IITA and CIP were supported by ASARECA to harmonize seven quality standards of cassava and potato and their intermediate products. The harmonized standards were adopted in 2010 as East African Standards.

As shown in Table 2 and Figure 2, specifications for various cassava products are available for Benin, DR Congo, Ghana, Madagascar, Malawi, Mozambique, Nigeria, Sierra Leone, Tanzania, Uganda, Zambia, Ethiopia, Sudan and Eritrea. However, many countries are yet to develop or approve draft standards for cassava products. Certification records from bureaus of standards in Malawi, Tanzania and Sierra Leone's suggest that certification of cassava and cassava products within the Food, Beverage and Tobacco sectors has not yet developed compared to other subsectors in the Food, Beverage and Tobacco sector (Table 4) The recent existence of quality specifications for the cassava products should assist the bureaus in improving the certification process in the near future. The certification process can be boosted with the use of simple quality management guidelines for use by processors.

Quality management guidelines

National bureaus of standards, national agricultural research and extension services (NARS), and IITA have been engaged in projects' activities that prioritize the development of quality management guidelines and manuals for use by processors. So far, a quality management manual has been developed for high quality cassava flour and gari (Dziedzoave et al, 2006). Quality management guidelines give important details such as the description of the processing steps, how to set-up the processing plants; quality specifications for the final products; implementing a HACCP System; implementing GMP; implementing GHP; management of the quality system; methods of analysis, procedures for determining quality during production, product use and distribution methods.

Training

Although availability of guidelines can assist processors in achieving quality compliance, training of the processors on quality management is critical to ensure proper understanding and application of recommended guidelines. Understanding the factors contributing to nonconformity to quality specification helps in the implementation of capacity development programs for processors. Ten process control; factory and personal hygiene challenges affect the attainment of quality and safety conformity by processing enterprises using mechanized processing methods. These are:

Process control

1) Both low and high in cyanide cassava varieties are processed into flour, makaka,

starch, gari, etc using various methods of processing. The use of mild processing technique such as chipping and immediate drying could therefore pose quality risks when the low cyanide varieties are not available. Quality may be compromised when reject cassava roots from farms where the wholesome roots have been selected for the fresh roots market are include in batches destined for processing.

2) Majority of processors use water from rivers without pre-treatment. This practice poses danger of contamination of the processed product.
3) Most of the processing machines, e.g., graters and slicers, are made of mild steel while few are made of stainless steel. Use of mild steel for food-contact surface areas often leads to significant contamination of products with high levels of iron.

Hygiene

4) Sun-drying is effective from June-October and Jan-Feb in Tanzania; from June-September in Mozambique; and from June-October and Jan-Feb in Malawi. Drying on unhygienic surfaces and for up to four weeks especially in Mozambique provides ample time for multiplication of spoilage microorganisms.
5) Public service hammer mills are the most frequently used for milling cassava into flour, especially in localities where grains and pulses are milled into staple food ingredients. The mills are used for milling many crops and have no regular schedules for cleaning. Contamination of cassava flour with other crops and microorganisms is therefore possible.
6) Cassava products are packaged in 1, 5, and 50kg polypropylene bags without polypropylene lining to prevent moisture absorption.
7) Most processing plants do not have good drainage systems or facilities for handling wastes. Sometimes liquid waste is allowed to drain into nearby valleys.
8) Processors do not have necessary cleaning and sanitation tools. The absence of net screens on the doors or windows of the processing buildings makes products vulnerable to insects and rodent attack or contamination.
9) There are no hand-washing facilities in the processing buildings and there are no hygiene rules for visitors and staff nor staff assigned for ensuring sanitation and hygiene.
10) Occasional weevil infestation problems during storage are encountered and fumigation is not done to prevent the spread of weevils. Regular inspection and fumigation of processing buildings could have ensured early detection and elimination of insects and pests.

Based on the need to address these challenges, IITA, national bureaus of standards, FAO, and other value chain promoters are involved in the training of processors on quality management as part of various value chain projects in Ghana, Nigeria, Malawi, Tanzania and Mozambique. Training is effective in making processors understand how to minimize contamination of products with toxins, metals, pesticide residues and other disease-causing microorganisms in order to safeguard consumers' health. Nonetheless, the national bureaus of standards have the statutory responsibility of working with the processors directly in order to achieve this objective. However, the national bureaus have some challenges in several aspect of the process. The challenges are in regard of low staff capacity, inadequate infrastructure, inefficient or lack of policy framework for supporting the cassava sub-sector. In some countries, there are overlaps of functions between the bureaus and the line ministries, lack of laboratory instruments and analytical procedures hinder critical analyses of processed products and some consumers tend to disregard quality thereby making quality enforcement tricky. The inability to undertake critical laboratory analyses of processed products sometimes cause credibility problems for the bureaus when trading partners, such as the European Union, set new quality limits that are different from the national limits and such bureaus are unable to test for conformity of products designated for export.

Conclusion and Recommendations

Various research-for-development institutions, national standards bureaus, and donors funded projects have helped in the introduction of new processing technologies for cassava, development of appropriate quality management systems, training and sensitization of farmers, processors, marketers, etc on the need to produce high quality and safe foods. However, major constraints against standardization and quality compliance for cassava exist. While most processors have inadequate knowledge of how to attain quality and safety of cassava products, many of them lack the critical infrastructure such as water and appropriate processing machines. Some food regulatory institutions such as national standards bureaus and food and drug control agencies are unable to carry out their primary functions of guiding all actors in the cassava value chain, especially the processors, to achieve product compliance.

Research institutions have a role to play in ensuring an improved cassava sector by generating scientific data required for developing product specifications and methods to test these. Development of simple and quick test methods for the most critical quality and safety parameters of cassava will enhance the ability of the standards bureaus to carry out regular conformity assessments of cassava products meant for local consumption or export. Research institutions also need to continue developing necessary quality management manuals and collaborate with relevant food regulatory agencies and training of their technical staff in addition to training of processors. The bureaus need to engage in training of staff to better manage their weak mandate areas such as certification. From policy perspectives, strong and sustainable policies, provision of resources for purchase of equipment required by regulatory agencies, and staff training by the agencies will go a long way to increase quality and safety of cassava products in Africa. In concert, results of these activities will increase safety of cassava products, promote competitiveness among cassava processors, increase regional trade, reduce the current technical barriers militating against export of cassava from Africa and will increase market access by smallholder producers.

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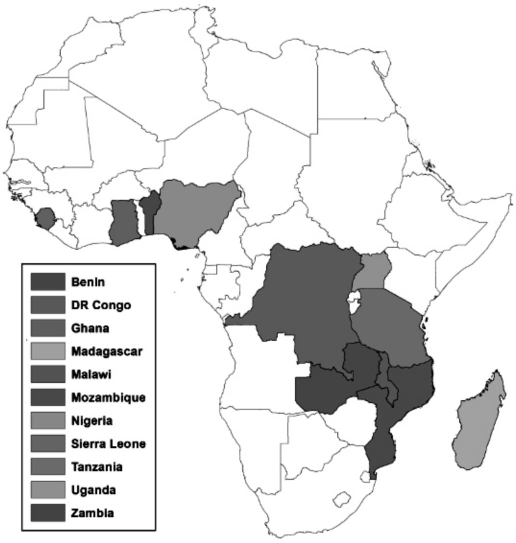

Figure 1: Processing and value addition project countries where IITA and partners were directly involved in development and testing of processing technologies, knowledge transfer or training of equipment makers and market linkages.

Figure 2: Countries where cassava related projects contributed to the development of specifications for cassava and cassava products.

Table 1: Microbial compliance test based on the East African Standards

Microbial quality indices	TBS test results; 2010	Specifications*
Total plate count, cfu/g	6.7×10^4	-
Total coliforms, cfu/g	1.1×10^3	-
E. coli, cfu/g	9.3×10^1	Shall be absent
Yeast and mould, cfu/g	2.6×10^3	10^3
Salmonella, cfu/g	Not detected	Shall be absent
Vibrio cholerea, cfu/ g	Not detected	-

Table 2: Some selected national and regional specifications for cassava and cassava products

Specifications	Nigeria (NIS)	Zambia (DSZ)	Malawi (MS)	Madagascar (NM)	Sierra Leone (DSLS)	EAC* (EAS)
Fresh (Sweet) Cassava/ Cassava Roots Specification	459:2004			101-01: 2006	24: 2010	738:2010
Cassava Crisps Specification						748:2010
Composite Flour - Specification	294:2004		704:2004	101-03: 2006		741:2010
Cassava Flour/Edible cassava flour Specification	344:2004	701:2007	349:2002	101-04: 2006	10: 2010	740:2010
Dried Cassava Chips Specification	343:2004	700:2007				739:2010
Cassava Starch (Industrial/ Food Grades) Specification	386:2004		703:2005	101-02: 2006		742:2010
Assay for Total Cyanogens						744:2010
Gari Specification	181:2004				08: 2010	

*Harmonization of Cassava and Potato Quality standards led by ASARECA-Burundi, Rwanda, Kenya, Uganda, Tanzania.

Table 3: Number of enterprises in the Malawi, Tanzania & Sierra Leone's Food, Beverage and Tobacco sector certified to make various products.

	Tanzania	Malawi	Sierra Leone
Sub-sectors	*1982-2009*	2000-2010	*2001- 2010*
Dairy products,	22	6	0
Canning and preserving of fruits and vegetables, canning of fish & similar foods	17	1	0
Animal products & vegetable oils	25	4	1
Grain milling & baking	8	6	0
Sugar & confectionery	24	2	1
Animal feed	1	8	0
Beverages (distilled alcohol, blended spirits; wines, beer, soft drinks & carbonated water)	114	1	16
Tobacco	1	1	0
Legumes' products	0	1	0
Roots and Tuber products	0	0	0
TOTAL	***212***	***30***	*18*

Inter-project linkages to create cassava enterprises for expanded markets and utilization

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Abstract

The historical view of cassava as "a poor man crop" in Africa has long limited efforts to fully exploit its commercial potential as raw material in the production of food, feed and industrial products. This situation is now changing, led by special projects which promote cassava-based agric businesses for rural development. In mid 1990s, IITA with its partners focused on cassava crop improvement research for development activities within two sub-regional networks EARRNET in East Africa and SARRNET in Southern Africa. A few years prior to and in the wake of the 2008 food price crises, research for development attention focused on multi-country projects using best bet production, processing and marketing approaches, and innovations to ensure sustainable cassava value chains and markets. These included the USAID funded UPoCA and Livelihood projects, CFC funded Cassava Value Chain Projects, BMGF funded GLCI and C: AVA projects. These projects and the special initiatives of some African governments, worth over US$ 80 million, are in line with the NEPAD Comprehensive African Agriculture Development Program (CAADP) which outlines the main agricultural development pillars for Africa and are supported by the NEPAD Pan African Cassava Initiative (NPACI). Whilst the implementation approaches tend to focus on smallholder rural beneficiaries with primary concerns on food security and income generation, private sector participation is slowly being incorporated to underpin sustainable development. Major challenges to overcome include inter-project linkages to facilitate sharing of experiences and lessons to assure complementarities between multi-country, multi-institution and multi-donor projects. This paper, discusses the role of the projects in catalyzing cassava enterprise development in sub-Saharan Africa, identifies options for closer linkages between the different cassava investments and proposes how to mainstream lessons learned into overall development policy and practice of various African institutions and governments.

Keywords: Cassava, SARRNET, UPoCA, GLCI, C: AVA, CFC, complementarities,

Introduction

Over the past four to five decades, Africa's food security situation has hardly shown any substantial improvement due to a variety of natural, environmental, institutional and social causes (Hazell and Wood, 2008). Amongst the consequences of these facors, poverty and hunger remain the greatest barriers to improving quality of life. One of the most effective ways to alleviate poverty and hunger is through area-wide application of agricultural research for development results. For example, based on available research results Thirtle et al (2003) suggest that generally a 1% increase in crop yield will reduce the number of people living under $1 by 2 million in SSA.

After many famine reports of acute food shortage across the continent it was critical that a collective approach was taken to address this issue. It is against this background that cassava has been viewed as Africa's food security crop (NEPAD, 2004). Cassava meets the needs of African farmers who work under harsh environmental conditions. The crop is drought tolerant to harsh environmental conditions and this quality enable it to serve as a food reserve in cases when other crops, especially cereals, fail (Nweke et al. 2002), and has numerous end-user pathways (Balagopalan, 1996). Due to these agronomic and socio-economic features, cassava can be for Africa what rice and wheat represent to Asia and Latin America. Through the intervention of the International Institute of Tropical Agriculture (IITA) with its partners, several African countries have been experiencing growth in cassava-based food products. The crop is a primary or secondary staple food for people in Angola, Benin, the Democratic Republic of Congo (DRC), Ghana, Malawi, Mozambique, Nigeria Uganda and Tanzania - to mention just a few (Table 1). It supplies daily calories for more than 200 million people in sub-Saharan Africa where Nigeria is the world leading producer with more than 44.5 metric tons per annum. Though the Democratic Republic of Congo is the second in production on the continent, its demand is higher than its production suggesting necessity of importing from neighbours countries. On the consumption side, the Congo Republic has the highest consumption per capita (ca. 288kg/capita/year) translating in source of calorie of 861Kcal/capita/day. With increasing demand for cassava by growing populations, changes in food preferences and increase in industrial needs, the sub-sector operators are confronted with the challenge of expanding on-farm productivity, improving access to good quality products and accessing markets.

A few years prior to and in the wake of the 2008 food price crises a number of development efforts have been concentrated on opportunities for value added cassava enterprises, especially for smallholder and rural-based beneficiaries (Mahungu, et al, 2010). These efforts soon evolved into multi-country projects focusing on the need to help establish viable cassava enterprises across Africa. These projects include the USAID funded Unleashing the power of cassava in Africa (UPoCA), Improving Rural Livelihood in Southern Africa through Root and Tubers Crops, Common Fund for Commodities (CFC) funded Cassava Value Chain Projects, Great Lake Cassava Initiative (GLCI) and Cassava Added Value (C:AVA) projects funded by Bill and Melimnda Gates Foundation (BMGF). These projects and the special initiatives of some African governments, worth over US$ 80 million, are in line with the New Partnership Africa Development (NEPAD) Comprehensive African Agriculture Development Program (CAADP) which outlines the main agricultural development pillars for Africa and are supported by the NEPAD Pan African Cassava Initiative (NPACI).

This paper reviews available information on a number of these kinds of projects and discusses their roles to catalyze cassava enterprise development in sub-Saharan Africa, identifies options for closer linkages between the different cassava investments and proposes how to mainstream lessons learned into overall development policy and practice of various African institutions and governments.

Characteristics of cassava enterprises initiatives.

In Africa cassava has long been used as a famine reserve and food security crop produced mainly through smallholder subsistence farming systems. Low input use, rudimentary technology, large post-harvest losses and minimal processing characterize these farmers. Kormawa, et al. (2001) reported that small-scale cassava producers (cultivating <2 ha) constitute about 95%, while those with more than 5 ha constitute about 5%. For example in Malawi, according to Mataya et al. (2001), 89% of cassava was used for home consumption and only 11% represented marketed surplus. The fresh market takes up about 80% whereas the remainder is absorbed in the manufacturing and confectionary industries. Cassava flour has demonstrated the ability to substitute wheat flour in the production of confectionary products. This shows therefore how cassava plays and will continue to play an important role as staple food at household level where it is grown.

The overall strategy for development of cassava enterprises in Africa discloses two principal elements, namely, reinforcing cassava's role as a food security crop in existing rural production set up and consumption systems and developing cassava's market and income generation potential in areas where markets exist (De Vries 2001). The cassava improvement strategy should thus underscore the fact that the target is uniquely smallholder systems and that a research strategy to expand cassava markets and develop the crop's commercial potential should at the same time reinforce cassava's role as a food security crop. Increased productivity linked to more efficient processing methods will increase farmers' incomes at the same time as improving the security of the subsistence farming community.

Some countries such Nigeria, Benin and Sierra Leone where CFC project was implemented have shown remarkable success in cassava processing and utilization at both domestic and commercial scales, although to varying degrees. The introduction of machines for most unit operations of processing has greatly eased the labor-intensiveness of the trade, releasing time for women into other income-generating activities and allowing them to attend to family responsibilities. In all three countries, cassava is processed into some common products: gari, lafun, and starch. Each country also has some exclusive cassava-based products being traded: gari and cassava bread are traded mainly in Sierra Leone. Gari, starch, chips, and high quality cassava flour (HQCF) are common, mainly in Nigeria, and gari and starch in Bénin. This is good lesson to all initiatives to identify and target cassava based products for available markets. Direct involvements by Governments in the promotion of the cassava subsector through policy directives have enhanced development such as Nigeria and Ghana. The Nigerian Government's Cassava Initiative that started in 2003 was highly successful in promoting new entrants and investment into cassava micro-processing as well as encouraging both small and large-scale processing industries. Most micro- and small-scale processors are involved in producing traditional foods or intermediate products, such as chips, HQCF, or starch. Medium-scale factories, processing cassava into HQCF, starch, and high-grade fufu for export, have also been established by local entrepreneurs near cassava farming communities (Sanni, et al. 2009). This could be a model for other initiatives to emulate and sharing will be important in strengthening linkages.

In recent years, a number of the cassava initiatives (e.g., UPoCA, CFC Cassava project) target a range of diversified stakeholders groups including low income populations, women and youth's groups, farmers' groups, research institutions, and agro processors to name the most visible ones. Most of them are concerned with potential increase of production through increased uptake of improved cassava varieties, particularly the high-yielding varieties or uptake of new technologies. In addition, cassava initiatives projects (e.g., C:AVA; CFC cassava project) specifically target agro-processing with objective of adding value to the product. This is usually done with an assurance of a direct link to market. Furthermore some projects (e.g., GLCI) are specifically designed to address challenges related to food and nutrition security, as well as poverty reduction through income generation and job creation in the countries where they are implemented. Formulation of a cassava development policy, funding and equipment provision also rank among the main objectives of some of these initiatives like CFC and NPACI.

Despite the presence of good initiatives, there are some challenges within the cassava industry which the various initiatives are yet to fully address. For example, at the production level, farmers need to produce more competitively. Gaining economies of scale is one of the most important factors towards being more competitive. This can be achieved via collective marketing / trading / action that enable farmers to gain from reduced input costs and increased output prices. Many observers view the lack of cooperation among farmers in Africa, as one of the key factors in their inability to engage effectively in the present dynamic liberalized marketplace. Also, despite the widely known fact that post-harvest loss of fresh storage roots is a major issue of common concern in cassava sub-sectors, research for development (R4D) initiatives putting specific focus on the constraints effecting post-harvest storage of fresh cassava roots are rare. One of the most critical areas where support is required to make initiatives successful is therefore to generate and increase end-users' access to improved post harvest technologies. This would be followed by strengthening of financial capacity of the players involved in the value chain while capacity building could be ranked third.

Efforts of IITA and its partners through regional linkages

IITA is an Africa-based international R4D organization. Its mission is to enhance food security, income and well-being of resource poor people in the humid and sub-humid tropics of sub-Saharan Africa by conducting research and related activities to increase agricultural production, improve food systems, and sustainably manage natural resources, in partnership with national, regional and international stakeholders. Cassava is one of the institute's mandate crops.

IITA has played a leading role in the development of improved cassava varieties which are disease and pest resistant, low in cyanide content, drought resistant, early maturing, and high yielding. The improved varieties have been introduced throughout Africa's cassava belt. Varieties with resistance to the major diseases give sustained yields of about 50% more than the local varieties (Dixon et al 2007). IITA started expanding its activities on root crops in East and Southern Region Africa region through the East and Southern Africa Root crop Research Network (ESARRN) since 1986/87. The network made an outstanding contribution to the development of strong root crop research programs of the member countries. To better serve the increasing number of members' countries, it was decided to split ESARRN into two NARS-oriented networks: the Eastern Africa Root Crops Research Network (EARRNET) and the Southern Africa Root Crops Research Network (SARRNET).

IITA through EARRNET and SARRNET has introduced tens of thousands of cassava clones to the region from the continental breeding program in Nigeria, and have subsequently played a leading role both in identifying which are most suitable for each of the major agro-ecological zones, and in transferring elite germplasm to all countries. Major successes have been achieved. Success, using biological control approaches, has been so significant that neither cassava mealybug nor cassava green mite are now considered amongst the major constraints to Africa's cassava production (Neuenschwander, P. 2001; Yaninek, et al., 1993). IITA has played a key role in coordinating the regional effort to tackle the CMD problem, played a role of regional coordination response to the cassava mosaic pandemic by raising awareness about the importance, using control approaches combining the deployment of resistant varieties with phytosanitation measures (Legg and James. 2005). Using this knowledge, thousands of cassava stakeholders at various levels (farmers, extension staff, agriculture workers, researchers and plant quarantine officials) have been trained in cassava problems and their management. In addition, a resistant variety development, multiplication and dissemination program has been coordinated across the continent, and has improved the cassava production in the region. USAID, OFDA among others donors strongly supported this mitigation program of the CMD pandemic effects in East Africa region from 1998 to 2007 (Ntawuruhunga and Okidi, 2010).

In Southern Africa, SARRNET worked with the NARS of the Southern Africa Development Community (SADC) region through two five consecutive phases (1994-1998 and 1999-2003) where activities focussed on research, information, technology exchange, training and institutional capacity strengthening. Research themes focused on: germplasm development, introduction and evaluation, surveying and studying production systems, managing pest and diseases, establishing rapid multiplication and distribution stems of health planting materials, development and distribution of post harvest and technologies. Phase 2 adopted a shift toward market demand-driven while building on achievements of phase 1 with inclusion of private sector to play a role in initiating cassava commercialisation (IITA/ SARRMET, 2004). Both networks, introduced, adapted and promoted post harvest technologies that have moved cassava in the food system which has created a lot of interest in the private sector but there is still a lot to be done to make cassava competitive.

New initiatives promoting cassava enterprises

In the last 5 years or so, cassava related initiatives have mushroomed in countries where this commodity is reported as playing a key role in food security. This is the case in East Africa, central Africa and West Africa where local and international NGO's have been promoting cassava production with an ultimate goal of food security using technologies that have been developed by IITA and NARS. In essence food security emerges as a final goal of the majority of cassava related initiatives; meaning the impact.

The new initiatives aiming to boost cassava enterprises are in line with the NEPAD Comprehensive African Agriculture Development Program (CAADP) which outlines the main agricultural development pillars for Africa and are supported by the NEPAD Pan African Cassava Initiative (NPACI). Generally, the projects are working to improve cassava production and increase its yield from dissemination and adoption by farmers, reduce postharvest losses and increase value added and to enhance food security, increase income generating capacity and improve well being of producers. The NEPAD Pan African Cassava Initiative (NPACI) was created as a means to tap on the enormous potential of cassava for food security and income generation in Africa. NPACI is a strategic institutional arrangement that is aiming at linking national agricultural research and extension systems to regional initiatives on cassava in order to ensure food security and income generation in Africa. These new initiatives include the following:

Commodity Funds for Community (CFC) Small-scale Cassava Processing and Vertical Integration of the cassava sub-sector in Southern and Eastern Africa: The objective of this project funded by CFC is to develop the income generating potential of cassava by capitalising on the existing, but unexploited, and profitable market opportunities for cassava derivative products in the cassava growing communities in the project countries. This is planned to be achieved through a broader application of the market-oriented and more profitable cassava production methods, dissemination of appropriate, more efficient and higher-scale processing techniques for High Quality Cassava Flour (HQCF) production, and vigorous market expansion approaches. The project focuses on a supply chain development for HQCF through a two-step village-level processing of cassava and the diversification of HQCF use in the project countries. This was being implemented in Madagascar, Tanzania and Zambia. A similar project funded by the same donor is implemented in West Africa with almost the same approach but gari is the main product.

Great Lakes Cassava Initiative (GLCI) is a project funded by BMGF to Catholic Relief Services (CRS) and implemented jointly with the IITA, the NARS programs from Burundi, Democratic Republic of the Congo, Kenya, Rwanda, Tanzania and Uganda and other stakeholders. This innovative pilot program using technology-based education and data communication helping cassava farmers to increase food availability and incomes is aiming to strengthen the capacity of partners to prepare for and respond to the present cassava mosaic disease (CMD) and emerging cassava brown streak disease (CBSD) pandemics that threaten food security and incomes of cassava dependent farm families in the six Great Lake countries. GLCI aims to help 1.15 million farmers identify key cassava diseases, grow disease-resistant varieties and ultimately replant healthy fields in the participating countries.

The Cassava: Adding Value for Africa (C: AVA) supported also by a grant from BMGF to the University of Greenwich is a project that is developing value chains for High Quality Cassava flour (HQCF) in Ghana, Tanzania, Uganda, Nigeria and Malawi to improve the livelihoods and incomes of smallholder households as direct beneficiaries including women and disadvantaged groups. The project is promoting the use of HQCF as a multipurpose of cassava based product for which diverse markets exist. The project is focusing on three key intervention points in the value chain: (i) ensuring a consistent supply of raw materials; (ii) developing viable intermediaries acting as secondary processors or bulking agents in value chains; and (iii) driving market demand and building market share (in, for example, bakery industry, components of traditional foods or plywood/paperboard applications). Farmers and farmer/processors are being supported in production and primary processing activities through partnership with NGOs or other extension services. Business development and other specialists are supporting intermediaries to meet the requirements of end users. It is anticipated that incomes of smallholder households will increase significantly over the life of the project. It is anticipated to get additional benefits through employment at the village and intermediary level, reduced raw material costs for end users

Unleashing the Power of Cassava (UPoCA) funded by USAID: UPoCA project operates in Ghana, Malawi, Mozambique, Nigeria, Sierra Leone, Tanzania and Uganda. The project purpose is to provide adequate supply of cassava products at economically affordable prices through availability of improved cassava varieties, production processes and farm gate processing. Specifically the project is doing rapid mass propagation of improved varieties of cassava with on-farm yield potential greater than existing varieties; promotion of farm gate processing to increase shelf life of cassava, mop up seasonal excess production (thereby reducing food losses from the perishability of cassava storage roots) and add value and training of farmers in improved cassava production and processing techniques.

Challenges to overcome in establishing cassava enterprise initiatives

The following are common challenges facing emerging cassava enterprise initiatives

Agronomic challenges: Although improved varieties with potential yield of more than 40 t/ha have been released for cultivation, the average on-farm yields are still less than 12 t/ha. The low yields are attributed to poor agronomic practices, low soil fertility, and poor input delivery mechanisms. Shortage of planting materials is also compounded by farmers' inability to preserve planting materials and this is more pronounced in southern African region where climatic conditions prolong drought period. The lack of well-organized planting material multiplications and distribution system in almost African counties is one of the major constraints to the adoption and spread of improved cassava Availing high quality planting material of the improved varieties to farmers is one of the potential means of ensuring high adoption of the released cassava varieties.

Pest and diseases: Field pests and diseases plague cassava causing high economic losses.For example, production losses due to cassava mosaic disease (CMD) in Nigeria has been more realistically estimated at 6.78-9.69 million tons in 1998 when the total harvest for the country was 33.56 million tons (Echendu et al. 2003). In East Africa and particularly in Uganda CMD effect was estimated to cause a at over 60,000 ha of cassava, equivalent to over 600,000 tones (US$60 million) of fresh cassava (Otim-Nape et al., 1997) while the disease forced farmers to abandon the crop, causing localized famine and revenue losses of more than 1 million in Kenya alone (Legg, 2004).

Processing and storage: In fresh form, cassava roots are bulky and perishable. Processing reduces the bulkiness and extends the shelf life and therefore reduces the transportation cost, as well as adding value to the product. The traditional cassava processing methods are highly labor intensive and expensive. For example, manual processing requires a minimum of 4 person-days to peel and wash, 23 person-days to chip one ton of fresh cassava roots which translates to approximately $65/t of flour (Kormawa & Akoroda, 2003) because appropriate processing technologies, machines and tools are not easily affordable and sometimes unavailable at the farm level. In contrast the cost of processing cassava into flour is approximately US$16/t in other cassava producing countries, such as Colombia under mechanized processing. Additionally the absence of efficient dryers, peeling machines are among principal constraints to cassava processing and common to all initiatives. Perhaps the greatest constraint to cassava processing is drying which takes up to 4 days to complete by sun-drying. Drying is a key process for making virtually all cassava products. Although dryers using kerosene, charcoal and electricity exist, their economic advantages have not been widely demonstrated at farm levels. They are also expensive and not energy-use efficient. Flash dryers are the most appropriate machines for drying cassava in powdered form and these are being promoted by C: AVA project in Malawi. There are a number of locally made flash dryers that can be used by small-to-medium scale enterprises. However flash dryers are relatively new introduction in Africa and their cost is prohibitive to many processors. To make cassava competitive, both for the domestic and export markets, investments in cassava processing machines among others must be a prerequisite.

Diversified cassava utilization and marketing: The greatest constraint to cassava development shared by all initiatives is the inability to diversify the use of the crop as a basic raw material for human and industrial use. Though some progress has been done in Western Africa, for example through CFC project, this aspect is still at its infancy in most of Africa. With changing focus from food to market diversification, e.g., cassava in the livestock feed industry, textile, pharmaceutical, alcohol and beverages among others, there is need to explore these opportunities to diversify cassava markets. This requires private public partnerships, with the private sector investing in market development and procuring needed machinery, while the public sector provides the needed policy environment and physical infrastructure. The market diversification will also require strengthening the presently weak link between industrial processors and producers of cassava products. Different studies (Bokanga, and Tewe, 1998; Buitrago, and Ospina 2002), have shown that the potential market for cassava is in the livestock feed industry. However, the use of cassava for livestock feed is not competitive at the moment. For example in Nigeria only about 5% of the total cassava produced is used as feed indicating that the industry is under developed. It is unlikely that cassava will completely replace maize as the basic energy source in livestock feed. Cassava tubers are cheaper than maize in both rural and urban markets, but additional processing costs to chips and pellets are prohibitive due to high processing costs. But marketing can be then a problem for poor farmers who may not have resources to transport their commodities to the market, especially those living in villages with poor feeder roads.

Transport: Typically, farmers transport cassava to the market on heads as head loads, on bicycles or in lorries. With poor market access, marketing of cassava can be particularly problematic because of its bulky nature, especially if it is not processed. Poor access also makes movement of goods and people difficult. This is more so during the rainy season when many parts of the rural area are inaccessible on the continent. Associated with these are problems of unreliable supply, uneven quality of products, low producer prices, and costly marketing structure, which affects its use for agricultural transformation.

Missing linkage opportunities: Opportunities facing the cassava subsector are that there is renewed interest among various players including government, NGOs and international research centers and donors aimed at boosting cassava production as well as value adding activities. Already there are initiatives being undertaken in the country. Some of the major constraints include the fact that the advantage cassava has over competing products is that it should be cheaper product vis a vis other products such as wheat, bread and maize flour. As such its continued success will mainly pivot on its being a low priced product. This calls for public initiative in spearheading the development of value adding activities to ensure continued growth of the cassava subsector. However, lack of efficient coordination that facilitates linkages among opportunities being undertaken by different institutions at country level will not allow achieving the objectives that will impact significantly the livelihood of targeted communities.

In Malawi, for example, studies conducted by SARRNET (Kambewa and Mahungu, 2007) indicated that the main opportunity for high quality cassava flour (HQCF) is as a partial substitute for wheat flour, such as biscuits manufacturing, bread, and confectionary in both rural and urban areas. Other opportunities are in plywood, textile and packaging industries. UPoCA and C:AVA are two main projects being implemented with aim of adding value to cassava and are mostly using the same strategies to collaborate with partners to address potential markets available in the country. Closer collaborative linkages between the two projects, sometimes with overlapping operational zones, would help be useful for technology generation and sharing. Fir example, the potential avenues for supply of HQCF to users will be community processing groups using sun drying targeting rural markets and possibly potential processors that will be using flash dryers targeting wheat millers and big buyers. The sun drying technology has been introduced and promoted some years back by SARRNET. However, the sun drying technology have some issues that have to be solved and requires a collaboration between projects: estimate economic and finance to estimate margins, capacity building for medium/large scale processors; need to develop markets based on targeted production ; developing skills in business management. Capacity building is another area that requires inter-project linkages to help build a national cadres of technical service providers.

Conclusion

Where collaborative linkages focus on cost-effective search and delivery of solutions to key challenges facing cassava enterprise initiatives, the enterprises stand to make significant economic gains as raw material for different end uses and product markets. This would raise the demand for cassava, provide the necessary incentive to improve production, expand trade and income generating capacity of cassava producers and processors (Sanni, et al. 2009). With committed inputs and service delivery through inter-project linkages cassava enterprises will be best placed to increase the range and quality of consumer acceptable cassava based food, feed and industrial products.. The input and service delivery areas requiring joint action such as can be sources through national cassava development platforms would include:

- The key to successful and sustainable enterprise development is favorable policy. Production of high quality cassava flour is probably one of the most promising enterprises, but this is unlikely to succeed without genuine government commitment to introduce and enforce a policy of mixing cassava flour with wheat. Even where there is this commitment, enforcing it can be a problem. Overall, IITA's influence, through different initiatives explained in this paper, has been considerable in terms of advocacy for improving the conditions for those engaged in cassava production and value addition as a business. However, while projects can do a good job of stimulating cassava enterprises on pilot scales, integrating these lessons into overall development policy and practice remains very deceptive. This is where the different initiates could strive to complement each other to strengthen inter-project linkages to create cassava enterprises for expanded markets and utilization
- Institutional innovations (e.g. producer and marketing groups/clusters) and capacity building of farmers and market actors. Institutional innovations address market failures such as lack of market information, poor physical access to markets, lack of capital for production and trade, etc. By organizing and empowering farmers and other actors, projects can demonstrate impacts and ensure sustainability of cassava enterprises through: (a) increased access to markets and market information, (b) improved business skills and product/service standards for integration into high value domestic/regional/international markets, (c) increased market power to bargain for better input/output prices and greater market share, and (d) increased access to capital/credit.
- New generation of technologies: Technolo-

gies make cassava enterprises more rewarding/attractive than alternative enterprises/investments. These could be production technologies (i.e. varieties for promoting cassava production as a business) and/or postharvest technologies targeting product development/value addition. Both technologies are highly complementary. For example, by creating demand for cassava itself, value addition stimulates cassava production and technology adoption. In areas where mechanized processing has been introduced, evidence has shown that there is also greater uptake of new varieties.

- The sustainability of the initiatives on cassava will depend strongly on the effectiveness of the public-private partnership advocated by these initiatives. Unfortunately, it appears that the majority of the implementing actors are relying essentially on the fact that it is "government project" intervention. It is worthwhile that donors and countries support and provide an initial adequate funding to support all activities considered critical for managing the implementation of an initiative to really achieve its objectives. After that the primary role of the government should be to facilitate/coordinate and promote private sector led strategies to be involved to ensure the sustainability of the initiative. To this end, all stakeholders must commit to the initiative and be involved in the planning, implementation, monitoring and evaluation of the program.. It is very important that the monitoring and evacuation (M&E) component of the initiatives be reviewed, adapted, and institutionalized

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Table 1. Countries with large calorie intake from cassava in SSA

Country	Consumption per capita (Kcal/capita/ day)	Consumption per capita (kg/capita/ year)	Production per capita (kg/capita/ year)	Average production (2006-08) **(x000) (tons)**	Yield **(t/ha)**	Population (million)	Demand 2007 **(x000)** (tons)
Congo R	861	288	258	1,000.0	9	4	950.0
Congo DR	808	279	235	15,004.3	8	64	18,598.2
Ghana	599	201	400	9,646.4	12	24	9,638.8
Liberia	457	152	137	536.7	6	4	550.0
Benin	407	139	266	72,4	14	9	2,282.0
Angola	379	138	505	8,830.0	12	17	8,840.1
Central African Republic	347	136	133	587.3	3	4	595.0
Cote d'Ivoire	315	105	128	2,520.1	7	20	2,341.6
Togo	314	104	118	807.1	6	7	773.5
Guinea	304	102	115	1,095.3	8	10	1,095.3
Madagascar	291	120	119	2,419.6	8	20	2,480.3
Uganda	285	95	151	4,818.0	13	32	4,970.3
Zambia	256	85	89	1,083.0	6	12	1,100.1
Cameroon	253	84	110	2,100.0	6	19	2,098.6
Nigeria	253	89	292	44,571.0	12	152	43,401.7
Niger	252	114	8	116.1	22	15	125.3
Tanzania	235	123	156	6,452.8	10	41	6,589.1
Gabon	228	82	175	238.3	5	1	240.7
Burundi	213	74	66	562.7	9	9	602.2
Comoros	211	70	91	58.0	6	1	60.0
Malawi	136	72	222	3,187.4	18	14	3,239.0
Africa	291	96	714	116,398.7	10	163	118,177.3

(Source: FAO, 2008)

Seed System Innovations in the Great Lakes Cassava Initiative

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Abstract

The Great Lakes Cassava Initiative (GLCI) is a four year cassava project operating across 6 countries and with more than 50 implementing partners. The project brings together national and international research, government, and non-governmental organizations in a single network tasked with producing and delivering disease tolerant cassava planting material to more than 1.1 million farming families in East and Central Africa. The paper will highlight the main lessons learned and challenges encountered as related to planting material production and seed systems in the GLCI project.

During the course of the project, GLCI partners have collectively been gained and lessons learned on cassava seed systems. This paper will discuss five innovative approaches used in GLCI seed production and seed dissemination activities. These include the positive and negatives of decentralized production in attaining scale, the use of and challenges with source site sampling and diagnostic testing, the benefits and limitations of visual in-field quality management protocols to validate fields before dissemination, and the importance of transparent and participatory dissemination processes.

The paper will describe the innovative elements of each approach and indicate what seed system challenge the innovation was designed to address. Furthermore, the paper will discuss on-going challenges for these innovations and provide practical suggestions for practitioners which may be applicable to other vegetatively propagated crops.

Keywords: Decentralized production, source site sampling and diagnostic testing, quality management protocols, transparent and participatory dissemination processes.

Introduction

Catholic Relief Services (CRS) and the International Institute of Tropical Agriculture (IITA) implemented the Great Lakes Cassava Initiative (GLCI) in Burundi, Democratic Republic of Congo (DRC), Kenya, Rwanda, Tanzania, and Uganda. All project activities were done in collaboration with government mandated partners operating under their respective Ministry of Agriculture (Cassava Agricultural Research, Plant Health, National Seed Inspectorates) and with local civil society & community based organizations.

The Great Lakes Cassava Initiative (GLCI) was a unique initiative in that it brought together research and development practitioners together under one project that operated across six countries. With a target to reach more than 1 million farmers directly with improved and disease tolerant cassava planting material and with a budget of nearly 25 million USD, of which 25% was allocated to research, GLCI ambitiously linked research and development at scale but faced the challenge of being executed in countries where cassava brown streak disease was emerging as a distinct disease threat in mid to high altitudes. At project inception, CMD-UG was major cassava seed system constraint which the program was designed to address and secondarily CBSD, which had been identified in Kenya and Uganda and in Lakes Zone Tanzania.

Discussion of the disease constraints, namely the emergence of CBSD, is important to demonstrate the dynamic context against which the seed system innovations were introduced.

While the CMD pandemic affects more than ten countries in East and Central Africa, there are excellent CMD resistant cassava varieties which were developed through breeding efforts and collaboration between IITA and National Breeding programs. CBSD has been endemic to coastal East Africa (Tanzania, Kenya, Mozambique) but since 2003-2006 CBSD has appeared in medium to high altitudes of southern Uganda, western Kenya and the Lake Victoria zone of north-western Tanzania and unlike CMD, all local cultivars and most of the CMD resistant cultivars are susceptible to CBSD.

During the course of GLCI, sequencing for cassava brown streak improved greatly which made disease diagnostics and CBSD identification more accurate. Three years into GLCI, a second species of cassava brown streak viruses (CBSVs) was formally recognized, cassava brown streak Uganda virus (CBSUV). Both CBSUV and the earlier species, known as cassava brown streak virus (CBSV), cause the same symptoms.

Methodology

Results and conclusions discussed in this paper are based on the activities and outputs from the Great Lake Cassava Initiative, a project financed by the Bill& Melinda Gates Foundation with an initial four year time frame of November 2007 through November 2011. In order to achieve project targets and in response to seed system challenges a number of seed system innovations were developed and/or scaled by GLCI.

This paper will briefly present the major seed system innovations which were attempted by GLCI and discuss the rational for each innovation. Data sources will include the GLCI M&E System, GLCI disease surveillance reports, and GLCI laboratory testing reports. Analysis and findings will focus on the use and application of the innovation. CRS staff responsible for the development, execution, or ensuring 'end use' of these seed system innovations during most of the implementation phase of GLCI serve as main authors of this paper.

Results

Small is Beautiful Decentralized Production and Dissemination

Rationale

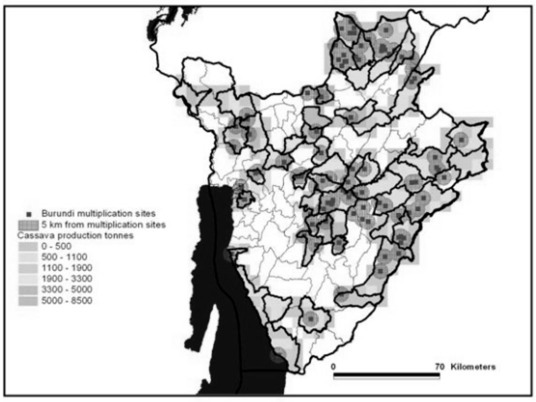
Cassava planting material under GLCI was euphemistically called 'self progagating medicine' because nearly all cassava planting material produced and disseminated at start of GLCI was CMD resistant, and CBSD was not yet a major constraint nor its epidemiology well understood. In order to maximize sharing of material and geo-coverage within the zone of intervention, GLCI promoted for the average package to be 20-25 full stems per farmer receiving planting material.

Easier access to smaller plots of land and lower labor and management challenges with smaller multiplication plots encouraged GLCI to recommend bulking sites be a maximum of 2 ACRE and a minimum of ½ acre. This necessitated greater decentralization which would increase the perceived demonstration effect, i.e. farmers will more readily seek to access and adopt improved disease tolerant varieties when they witness the materials performance, but also resulted in GLCI making concerted effort to spatially allocate fields ten KM apart in intervention zones.

Risk aversion to CBSD and stem loss in transport also favored a 'small is beautiful' approach. Considering the loss of several large multiplication sites which occurred in the early stages of GLCI in Lakes Zones Tanzania it was believed 'too risky' to have large source sites. Smaller more decentralized fields promote the transport of planting material 'in full stems on farmers heads in a single bundle' as opposed to 'cuttings or mini-stems in bags loaded on vehicles', generally the former have a shelf life of several weeks versus several days for the latter.

Project Results

The map below is based on geo-referencing of multiplication plots for GLCI in Burundi and it visually demonstrates the spatial allocation of plots decentralization effect of 'small is beautiful'.



The table below indicates the extent of decentralization in terms of the total number multiplication sites per country within the GLCI project. The average multiplication site in GLCI was just under 5 HA.

Average Size (HA) of GLCI Tertiary Multiplication Sites

Tertiary Sites			
Country	Total # of sites	Total size (ha)	Avg. Size (ha)
Burundi	568	259.11	0.46
DRC	734	435.21	0.59
Kenya	470	187.22	0.4
Rwand a	709	412.95	0.58
Tanzania	632	217.6	0.34
Uganda	376	173.44	0.46
Summary	3,489	1685.53	0.48

Source: GLCI Data Base

The table below shows the average number of stems received per recipient farmer within the GLCI project was 28 while the average disseminated field served about 300 farmers.

Cummulative Dissemination Results Through September 2011

	Fields Disseminated	Beneficiaries Served	Stems Disseminated	Average Stems per Beneficiary	Average Beneficiary per Field
Burundi	270	102,365	3,468,239	34	379
DRC	1,621	614,764	14,076,574	23	379
Kenya	167	28,636	790,404	28	171
Rwanda	517	106,154	5,214,194	49	205
Tanzania	313	15,883	562,860	35	51
Uganda	69	35,264	1,074,140	30	511
Summary	2,957	903,066	25,186,411	28	305

Source: GLCI Data Base

Mitigating against CBSD Source Site Sampling and Laboratory Testing

Rationale

In GLCI, CRS, in collaboration with partner NGOs and national research and extension systems, is multiplying improved cassava varieties resistant to CMD in the six countries. The multiplication and dissemination system is organized in a hierarchical manner, a small number of primary sites feeding a larger number district level secondary sites provide planting material for over 1,000 village level tertiary sites. The big concern for the multiplication system is the spread of viruses that cause CBSD. Two species of cassava brown streak viruses (CBSVs) are now recognized: Cassava brown streak virus (CBSV) and Cassava brown streak Uganda virus (CBSUV). GLCI project established a rigorous quality control system to minimize the risk of spreading CBSVs through the multiplication scheme.

Primary sites and most secondary sites are tested being using virus diagnostic methods (Real time PCR) for the presence of CBSVs. Only sites that have had NO positive virus test results have been used as source sites for secondary or tertiary sites. This approach has been referred to as the 'zero tolerance' approach. The sampling frame of 300 plant leafs per field (tested in ten batched of 30 plants) was determined in order to detect with 95% confidence 1% CBSD incidence.

Project Results

The following tables, drawn from GLCI reports, show the number of fields that were identified and as a result not disseminated due to confirmed CBSD from testing. If not 'caught' these fields would have been disseminated.

Table 1: overview of samples tested in 2010 (number of positive samples in brackets)

Country	Fields received (March 2010)	Fields received (Sept 2010)	Fields received (Oct 2010)	Total fields received (2010)
Burundi	0	0	0	0
DRC	27	32	0	59
Kenya	3	7 (1)	0	10
Rwanda	0	2	0	2
Tanzania	9	5 (1)	7 (5)	21
Uganda	0	0	0	0
Total	39	46	7	92

Source: GLCI 2011 Six Month Report

Table 2: overview of samples tested in 2011 (number of positive samples in brackets)

Country	Fields received (March 2011)	Total fields received (2011)	TC samples
Burundi	0	0	
DRC	26	26	
Kenya	6	6	165 (4)
Rwanda	0	0	
Tanzania	5 (2)	5	
Uganda	0	0	
Total	37	37	

Source: GLCI 2011 Six Month Report

Beyond 'catching' diseased source sites, the testing and its associated human and financial costs, forced project actors to work collaboratively to lower throughput and develop useable decision making frameworks. Some of this thinking is captured in the Cassava Disease Pest Risk Analysis and per the table below[1].

Vegetative phase	Partners, roles and field characterisation	CBSD and virus monitoring	CBSD and virus result	Distribution decisions (receiving environment CBSD categorisations)		
				CBSD-Free Area [~0%]	CBSD-Low Prevalence Area [<5%]	CBSD-High Prevalence Area [>5%]
GLCI Source site (synonym primary or secondary site)	• Mainly NARs, NGOs, Farmer groups • Phytosanitory inspectors • Moderate -to-large fields • On-station and farmers field	• QMP @ 3mths • QMP @ 9mths* • PCR @ 9mths	• QMP pass PCR pass	• Further multiplication as source or tertiary • Distributed to all 3^0 sites within a country	• Further multiplication as source or tertiary • Distributed to all 3^0 sites within CBSD low and high-prevalence areas of same CBSV species status only	• Further multiplication as source or tertiary • Distributed to all 3^0 sites within CBSD high prevalence areas of same CBSV species status only
			• QMP pass PCR fail	• CBSD-Free Area status lost; see Low-Prevalence Area	• No multiplication; material derogated for non - GLCI release intended for local distribution only • Advice provided by GLCI to farmers based on PCR and field survey results gap analysis and probable benefit	• No multiplication; material derogated for non - GLCI release intended for local distribution only • Advice provided by GLCI to farmers based on PCR and field survey results gap analysis and probable benefit
			• QMP fail	• CBSD-Free Area status lost; see Low-Prevalence Area	• No multiplication; material derogated for non - GLCI release intended	• No multiplication; material derogated for non - GLCI release intended

Vegetative phase	Partners, roles and field characterisation	CBSD and virus monitoring	CBSD and virus result	Distribution decisions (receiving environment CBSD categorisations)		
				CBSD-Free Area [~0%]	CBSD-Low Prevalence Area [<5%]	CBSD-High Prevalence Area [>5%]
				• CBSD-Free Area status lost; see Low-Prevalence Area	• No multiplication; material derogated for non - GLCI release intended for local distribution only • Advice provided by GLCI to farmers based on QMP and field survey results gap analysis and probable benefit	• No multiplication; material derogated for non - GLCI release intended for local distribution only • Advice provided by GLCI to farmers based on QMP and field survey results gap analysis and probable benefit

Source: GLCI Third Annual Report, November 2010

[1]PRA for Cassava Disease which was written by staff from plant health and cassava research institutes in Burundi, Rwanda, DRC as well as Uganda, Kenya, and Tanzania under the coordination of the Great Lakes Cassava Initiative (GLCI). This is a living document describing the nature and threat posed by the disease and indicating how risk of introduction and spread can be reduced as well as how and by whom an outbreak should be handled.

QMP in field visual quality management

Rationale

Quality Management Protocol (QMP) was first developed under the Crop Crisis Control project and then used at greater scale under GLCI. While not perfect as it is based on visuals, it provides a simple method that takes less than a couple hours to support field level quality control. The QMP methodology involves visually inspecting 100 plants and taking a sub-sample of ten for root inspection. QMP is used at all levels of multiplication. At source sites it confirms it is used in CBSD areas to screen a field, if it fails CBSD, the field does not have to be lab tested at a large cost of time and money. The big innovation in GLCI was using QMP across tertiary sites, the final level of multiplication from which planting material is disseminated to farmer.

QMP is used foremost to ascertain quality, primarily in terms of disease (CMD and CBSD) incidence, secondarily to determine varietal purity, and thirdly to estimate the amount of planting material which shall be ready for harvest. To pass QMP, fields must have disease levels below specified targets, which vary depending on if the field is a source site or community based bulking site and the prevalence of CBSD in the receiving environment. Fields that pass QMP may be used for dissemination, whilst those that fail are not be disseminated.

Project Results

The scale of QMP within GLCI is indicated in the table below. By 2010, nearly 2/3 of all fields were QMP'd and for 2011 we project that more than 90% of all fields will be QMP'd.

Scale of QMP 2009-2011

	Fields QMPd	Fields Disseminated	Percentage QMPd
2009	203	701	29%
2010	1169	1564	75%
2011	597*	656*	91%

*on-going QMP and Field Dissemination

Source: GLCI Data Base

By mid October 2011, the GLCI project will be able to present more detailed QMP data such as total fields per country, % passed, and CMD and CBSD incidence per leaf and stem visuals. As of September 2011 this information is not currently available.

Documented and Participatory Dissemination

Rationale

GLCI developed reporting frameworks and processes to ensure that every single farmer that received planting material was documented and all field disseminated were registered in the GLCI data based, QMP'd, and completed field dissemination plans. Dissemination plans focused on promoting a transparent discussion with local authorities on the amount of planting material to be disseminated, the target villages and criteria for beneficiary selection. GLCI had a specific aim to help marginal groups so the dissemination planning and the documentation of dissemination was intended to promote improved targeting and service to vulnerable farmers.

Project Results

The documentation processes of GLCI indicated that nearly one million farmers were direct recipients of GLCI as of September 2011 and nearly 1/3 were female and more than ½ were considered vulnerable.

Cummulative Dissemination Results Through September 2011

	Total fields disseminated	Total beneficiaries served	Average stem per beneficiary	% Female	% vulnerable	Average beneficary per field
Burundi	270	102,365	34	25%	28%	379
DRC	1,621	614,764	23	36%	62%	379
Kenya	167	28,636	28	51%	74%	171
Rwanda	517	106,154	49	9%	30%	205
Tanzania	313	15,883	35	32%	48%	51
Uganda	69	35,264	30	38%	68%	511
Summary	2,957	903,066	28	32%	55%	305

Source: GLCI Data Base

Percentage of disseminated fields with field dissemination plans

Season	Dissemination Plans Completed	Fields Disseminated	Percentage
Jan - July 2009	15	266	6%
Jan -July 2010	145	764	19%
Aug Dec 2010	629	800	79%
Jan July 2011	333	645	52%

Source: GLCI Data Base

The dissemination planning under GLCI was not followed in the first period of dissemination but has become institutionalized as more than 50% of all fields disseminated were following this process by the end of 2010.

Conclusions

Small is beautiful many fields, small fields, small amount of planting material per recipient farmer is an effective strategy when using disease resistant germ-plasm to respond to a disease constraint (CMD-UG) but it is less appropriate from a CBSD perspective because more decentralized fields in endemic CBSD zones would be difficult to isolate from farmer fields.

Testing of source sites under GLCI was highly effective in identifying CBSD threats and eliminating them from the system while establishing a risk management framework under which decisions were taken. However, at a cost of nearly 750 USD per field, it is crucial that costing comes down and sampling frames are re-visited with an eye to embed this capacity in national and regional actors.

Decentralized quality control in the form of visual assessment QMP - is among the most crucial field level actions to support CBSD mitigation. GLCI was effective in scaling this approach and demonstrating that it can be done. However, actual impact and use of QMP under GLCI cannot be estimated due to insufficient data analysis.

Dissemination documentation processes undertaken by GLCI demonstrate a large commitment to promoting transparency and accountability. With the emergence of CBSD, such orientation to promoting traceability within cassava seed systems is critical.

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