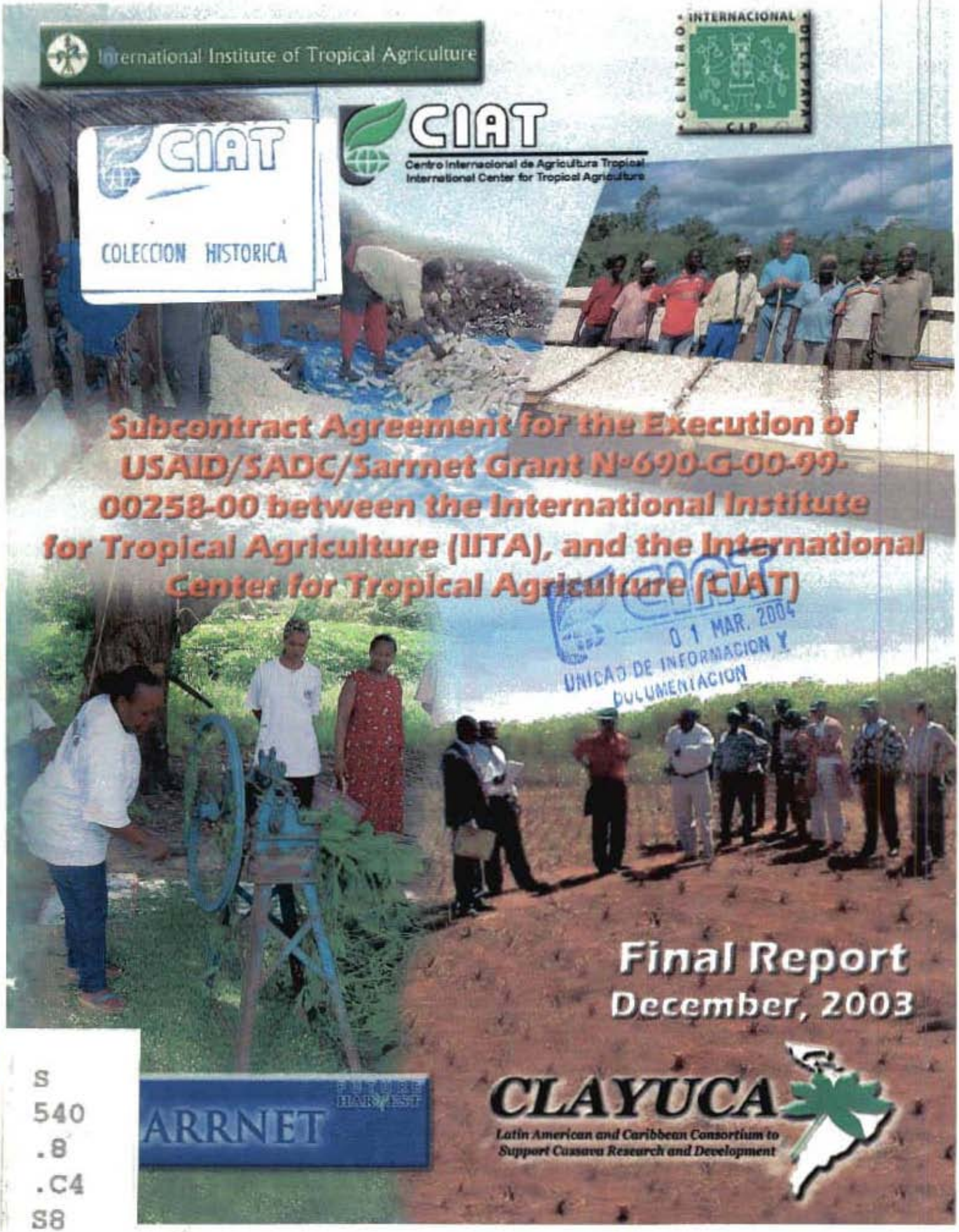
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Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
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Subcontract Agreement for the Execution of USAID/SADC/Sarrnet Grant N°690-G-00-99-00258-00 between the International Institute for Tropical Agriculture (IITA), and the International Center for Tropical Agriculture (CIAT)
CIAT
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Final Report
December, 2003
SARRNET
CLAYUCA
Latin American and Caribbean Consortium to Support Cassava Research and Development

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Final Report

Presented by: the International Center for Tropical Agriculture, CIAT

Presented to: the International Institute for Tropical Agriculture, IITA

December, 2003

CLAYUCA
Latin American and Caribbean Consortium to Support Cassava Research and Development

SARRNET

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Subcontract Agreement for the Execution of USAID/SADC/SARRNET Grant No. 690–G–00–99–00258–00 between the International Institute for Tropical Agriculture, IITA, and the International Center for Tropical Agriculture, CIAT

1.0. Introduction

The Southern African Root Research Network (SARRNET) seeks to increase income and improve the welfare of the rural poor by increasing small farmer cassava and sweet potato productivity through:

- The adoption of improved varieties and practices,
- The strengthening of national root crops research capabilities, and
- Commercialization to increase added value to the crops.

The subcontract agreement between the International Institute of Tropical Agriculture (IITA) and the International Center for Tropical Agriculture (CIAT) is to provide professional and other related services to meet the overall objective of SARRNET, described above. CIAT will provide these services through its own Rural Agroenterprises Development Project and through its membership of the Latin American Consortium for Cassava Research and Development (CLAYUCA). These services will contribute to achieving the specific objectives of the following four theme areas:

Theme I: Establish of a private–public consortium to support research and development of sweet potato and cassava in at least one country.

Theme II: Detailed understanding of the subsector and marketing opportunities to increase awareness among stakeholders of potential opportunities for the crops in the region.

Theme III: Sustainable, appropriate processing technologies adopted by farmers and industrial processors.

Theme IV: Stakeholders trained in new skills to support the market driven strategy at regional level.

2.0. Report on activities undertaken in the subcontract agreement

Following the definition of a work plan for implementation of the IITA/CIAT subcontract agreement, CIAT and CLAYUCA personnel participated in various activities (Table 1). Based on the results obtained in these activities, a description is given in each of the four themes included in the work plan, with explanations about the activities implemented, the results achieved and some conclusions.

Table 1. Summary of major interventions of CIAT & CLAYUCA Consultancy Team. Period November 2000 to March 2003

Action / intervention	CLAYUCA/CIAT personnel involved	# of person-days	Countries visited
Facts finding and planning trip. 1-11 November 2000	Bernardo Ospina and Rupert Best	33	Nigeria, Uganda and Malawi
Contact with current and potential users of cassava and sweet potato in Tanzania, Malawi and Kenya. (February 17 to March 17, 2001).	Bernardo Ospina and Julian Buitrago	30	Tanzania, Malawi and Kenya
Training course in Agroenterprise Development. 2-11 May 2001.	Rupert Best and Carlos Ostertag	13	Uganda
SARRNET Steering Committee Meeting. 14-17 May 2001.	Rupert Best	6	Tanzania
Consultancy mission (October–November, 2001)	Bernardo Ospina	14	Tanzania, Malawi
Consultancy mission (October–November, 2001)	Julián Buitrago	14	Tanzania
Coordination of scientific exchange mission to Latin America	Bernardo Ospina	10	Colombia, Brazil
Information system translation	Jhon J. Hurtado and Rupert Best	4	
II Report preparation	Bernardo Ospina Rupert Best	5 2	
Participation in Steering Committee Meeting, Pretoria, South Africa	Rupert Best Bernardo Ospina	5 5	South Africa
Consultancy mission (April–May 2002)	Bernardo Ospina	15	South Africa, Tanzania, Malawi
Consultancy mission (May 2002)	Julian Buitrago	14	Tanzania, Malawi
Market study review	Rupert Best	7	
Consultancy mission ((March 2003)	Bernardo Ospina	12	Tanzania, Malawi
Final report preparation	Bernardo Ospina Rupert Best	8 3	
	TOTAL	**200**	

3.0. Work plan: What was done? What was accomplished?

Introduction:

CIAT's leading role in cassava research and development in Latin America and the Caribbean region during the last 30 years, allowed the development of a methodology for linking farmers to growth markets, via new processing and product development technology. This methodology aims at coordinating changes in farming systems with changes in the marketing system, within the framework a multi-institutional, interdisciplinary research and development project. This methodology is better known as Integrated Cassava Research and Development Projects (ICRDP).

More recently, CIAT promoted among collaborating countries in the region, the establishment of a novel approach to garner resources and support required for sustaining a long-term research and development effort on cassava. This new mechanism was named CLAYUCA-The Latin American and Caribbean Consortium to Support Cassava Research and Development. The establishment of CLAYUCA as a joint effort mechanism between public and private sectors was justified on the grounds that it allows countries to have more control on the agenda and the benefits obtained. Each sector contributes with its own capacities and strengths and the work is planned and conducted based on common interests and prioritized problems.

The decision to include CIAT's Rural Agroenterprise Development Project and CLAYUCA's expertise to provide consultancy services to IITA/SARRNET through the USAID/SADCS/SARRNET Grant No. 690-6-00-99-00258 was aimed at helping SARRNET to meet its overall objective of increasing income and improve the welfare of the rural poor by increasing small farmers cassava and sweet potato productivity. The consultancy services of CIAT and CLAYUCA were to be delivered according to a work plan divided in four main themes. The following section presents each theme, the activities conducted, the results obtained and the indicators that can be used to assess the achievement of the objectives.

3.1 Theme I. Establishment of a private-public consortium to support cassava research and development of sweet potato and cassava in at least one country

3.1.1 Expected result

Establishment of a private–public consortium to support cassava research and development of cassava and sweet potato, in at least one country.

3.1.2 Activities implemented:

a. Cassava and sweet potato workshop (Malawi)
b. Contacts with Malawian industries
c. Contacts with Tanzanian industries
d. Formulation of the Consortium framework
e. Preparation of materials on root crop processing for business plans development
f. Meeting for launching the Consortium, in at least one country
g. Implementation, monitoring and evaluation

Theme I Establish a private–public consortium to support research and development of cassava and sweet potato in at least one country (2001–2002)

Activity and dates	Participants	Expected output	Indicator (s) for monitoring progress
Participation in cassava / sweet potato workshop (SARRNET/ ARPTU Bunda College) (Workshop was organized late May 2001)	SARRNET Malawi team	Potential partners identified First by–laws drafted Follow-up agenda defined SARRNET recognized as a 'technology clearing house' for cassava and sweet potato production and processing technologies	# Participants Draft document circulated Agenda of the workshop
2. Contacts with Malawian industries identified as having interest in using cassava/sweet potato products	SARRNET Team CIAT / CLAYUCA and local private and public partners	Specific interests identified Action plans developed Information on technology options delivered	Documents available with information about characteristics and needs of potential partners and action plans for proposed actions.
3. Contacts with Tanzanian industries identified as having interest in using cassava/sweet potato products	SARRNET Team CIAT/CLAYUCA and local private and public partners	– Specific interests identified – Action plans developed – Information on technology options delivered	Documents available with information about characteristics and needs of potential partners and action plans for proposed actions.
4. Formulation of the Consortium Framework for at least one country and define a tentative R&D agenda	SARRNET Team CIAT/CLAYUCA and local private and public partners	– Draft document circulated among potential stakeholders – Revised version of document available	Revised version of draft document available Document with first draft of TAFIC bylaws available

Theme I. Establish a private–public consortium to support research and development of sweet potato and cassava in at least one country 2001–2002 (continuation)

Activity and dates	Participants	Expected output	Indicator (s) for monitoring progress
5. Preparation of materials on root crop processing (catalogues, prices, layouts, information) for business plan development (On–going activity)	SARRNET CIAT/CLAYUCA	Technology options identified according to specific requests and interests expressed by potential partners Technology package available for cassava flour for animal feeding, starch and croquettes for human consumption, and silage	List of technologies available according to each potential option Documents available with specifications, prices, capacities, etc
6. Meeting for launching the Consortium, if needed, in at least one country	SARRNET Team CIAT/CLAYUCA and local private and public partners	At east one consortium established and operating	Official documents like Acts, by laws of the consortium, list of activities/ work plan.
7. Implementation, Monitoring and Evaluation (On–going, continuous process)	SARRNET Team CIAT/CLAYUCA	Feedback information on project results available Feedback information delivered to stakeholders Make information available through SARRNET Web page, ROOTS, to stakeholders including SC and partners	Progress reports, annual reports, SARRNET WebPages, ROOTS, special documents prepared.

3.1.3 Results achieved:

a. Cassava and sweet potato workshop in Malawi

The cassava/sweet potato workshop was realized in May 21-23, 2001. SARRNET gained recognition in Malawi as a "technology clearing house" for cassava and sweet potato production and processing technologies.

b. Contacts with Malawian industries

- A total of 14 industries, potential collaborators and clients of SARRNET were identified in Malawi, through direct visits and contacts. Detailed information on these industries was presented in previous reports submitted under the present agreement[1]
- This group includes private sector industries, NGOs, national institutions, projects and farmers
- SARRNET-Malawi has conducted during the last two years collaborative activities with some of these companies and institutions

c. Contacts with Tanzanian industries

- A total of 32 potential collaborators and clients for SARRNET were identified through direct visits and contacts[1]
- This group includes private sector industries, national institutions and programs, NGOs and farmers
- SARRNET-Tanzania is currently conducting collaborative activities with some of these companies and groups

d. Formulation of the Consortium framework for at least one country and definition of a tentative R&D agenda.

- A draft of CLAYUCA's bylaws was circulated among potential members of a Consortium type of mechanism in Tanzania and Malawi. Very little feedback was received from them.
- In Tanzania, a novel proposal was developed by SARRNET and FOODNET, to create an organization named TAFIC (Tanzanian Animal Feed Consortium)
- A draft of bylaws for TAFIC was written and circulated among potential members
- Two promotional meetings for TAFIC were held at SARRNET's offices in Tanzania
- The idea of forming TAFIC in Tanzania was dropped due to lack of commitment among potential stakeholders
- Activities conducted by SARRNET in Tanzania and Malawi has led to the identification of few, yet committed private sector collaborators, who are currently engaged in collaborative activities. This group can be the basis for the organization of some type of Consortium in the future

[1] See CLAYUCA, CIAT, SARRNET, IITA, CIP, 2001 and 2002. Report on the Subcontract Agreement for the execution of USAID/SADC/SARRNET Grant No. 690-G-00-99-00258-00 between the International Institute for Tropical Agriculture, IITA, and the International Center for Tropical Agriculture, CIAT. CIAT, Cali, Colombia.

e. Preparation of materials on root crop processing for business plans development.

- Various documents with information about different technologies and quotations for processing equipment were assembled and delivered to SARRNET personnel in Tanzania and Malawi. These information packages were delivered in the form of written documents, catalogues, electronic files (Word documents and power point presentations), and compact disks
- A document on the use of cassava in poultry nutrition, originally in Spanish, was translated into English and delivered to SARRNET as a printed document and also in electronic form (PDF format)
- A document on the use of cassava in dairy feeding, originally in Thai, was translated into English and delivered to SARRNET as a printed document and also in electronic form (PDF format)
- The first draft of the translation to English of the book "Uso de la Yuca en la Alimentacion Animal", originally published in Spanish, was concluded in October 2003. The draft document was delivered to FOODNET, which has agreed to finance the next step of this work, a scientific editing.

f. Meeting for launching the Consortium, if needed, in at least one country.

- Two meetings were held in Tanzania to try to launch TAFIC as a Consortium-type mechanism
- A Consortium, as a formal mechanism, was not established in neither Tanzania nor Malawi during the duration of the present project

g. Implementation, monitoring and evaluation.

- Conducted as a continuous activity through periodic consultancy visits and permanent e-mail contact with SARRNET technical personnel in Tanzania and Malawi
- Two progress reports and one Final Report were produced during the duration of the project.

3.1.4. Conclusions:

- The formation of a Consortium type of mechanism through which public and private sectors are invited to work together in the definition and implementation of a cassava research and development agenda is not a goal that can be accomplished within a relatively short period of time

- Nonetheless, private sector industries, with genuine interest in the cassava crop, can be attracted and become reliable collaborators, when they are offered concrete technological solutions to the problems that they have prioritized (ex. improved seeds, processing equipments, new products and markets, technical assistance, training)

- The prevailing institutional landscape in Tanzania and Malawi is full of institutions, especially NGOs, that can become important partners in the implementation and dissemination of cassava-based research and development activities

➢ Activities conducted by SARRNET in Malawi and Tanzania during the last two years, using the linking farmers to market approach, have allowed the identification of an important group of private sector companies, public sector institutions, NGOs and farmer groups, with which collaborative activities have been initiated. The promising results that have started to emerge from these activities could be used as the basis to attract more commitment and support from public and private sectors for cassava research and development activities.

3.2. Theme II: Detailed understanding of the sub–sector and marketing opportunities to increase awareness among stakeholders of potential opportunities for the crops in the region.

3.2.1. Expected result

A detailed understanding of the sub-sector and marketing alternatives to increase awareness among stakeholders of potential opportunities for cassava and sweet potato in the region.

3.2.2. Activities implemented

a) Collection of demand information for cassava and sweet potato through industry visits in Malawi and Tanzania
b) Review of the draft and final country sub-sector market studies
c) Participation in the synthesis workshop to summarise the findings of the market studies

3.2.3. Results achieved

a) Collection of demand information for cassava and sweet potato through industry visits in Malawi and Tanzania

During this phase of SARRNET, a concentrated effort was made to identify the actual and potential demand for cassava and sweet potato in three countries: Tanzania, Malawi and Zambia. This was undertaken in two ways: through an industrial market opportunity identification study, which formed part of the process for establishing public-private partnerships (addressed under Theme I), and through a formal sub-sector characterisation of cassava production, marketing and consumption study. The latter study concentrated almost exclusively on the production and marketing of fresh and processed cassava for rural and urban consumption.

Industrial market opportunity identification in Tanzania and Malawi

The assessment of the potential industrial demand for cassava in Malawi and Tanzania was achieved through primary data collection and backed-up by reference to published literature where this was available. Information was obtained through a systematic process of selecting and interviewing a sample of actual and potential users of cassava and sweet potato products. The methodology and information gathered has been

presented in previous reports submitted under the present agreement[2]. The principal findings are summarised as follows. The execution of this data collection exercise was greatly facilitated by the participation of technical personnel from FOODNET and IITA – Uganda, with very good expertise and skills

Tanzania

A total of 32 industries were visited, corresponding to the following sectors: 9 animal feed millers, 16 food processors (biscuit, bakery and flour), 4 brewers, 2 non-food industries (chemicals and textiles) and 1 food inspection industry. The complete list is shown in Table 2.

Cassava flour for direct sale to consumers. Analysis of the information obtained showed that in the short term the market with the greatest potential for growth is high quality cassava flour for direct sale to consumers. This product is already on the market, and although the total volume of sales is presently low, informants manifested an increasing demand for a quality product. Cassava flour is preferred flour for some ethnic groups. At present, cassava flour retail price is US$ 500/t, which compares favourably with a price of US$ 300/t for maize flour. More detailed studies, specific to this product, will need to be undertaken to ascertain the likely total volume that could be demanded in this market.

Cassava flour for the food industry. Increasing supply of cassava flour for direct sale to consumers, through supermarkets and other outlets, could open up the opportunity of breaking into the food manufacturing industry (biscuit, bread and possibly others that use flour based products). Interest was shown by food processors, but presently there is insufficient production of high quality flour at a competitive price to meet their requirements. Wheat flour prices for industrial food use in Tanzania are now US$ 220-260/t. Cassava flour would need to be priced below this to be able to compete. Since the wholesale price of high quality flour for direct sale to consumers is US$ 400/t, and demand is increasing, there is no incentive at present for flour processors to sell to food manufacturers. As in the case of cassava flour for direct sale to consumers, a specific study will have to be undertaken to define more precisely the level of demand in the food industry. This has to be accompanied by collaboration with the industries themselves to ascertain optimum levels of cassava flour in their formulations. Increases in cassava productivity and more efficient processing will be required to improve competitiveness of flour production.

[2] See CLAYUCA, CIAT, SARRNET, IITA, CIP, 2001 and 2002. Report on the Subcontract Agreement for the execution of USAID/SADC/SARRNET Grant No. 690-G-00-99-00258-00 between the International Institute for Tropical Agriculture, IITA, and the International Center for Tropical Agriculture, CIAT. CIAT, Cali, Colombia.

Theme II. Detailed understanding of the sub–sector and marketing opportunities to increase awareness among stakeholders of potential opportunities for the crops in the region.

Activity and dates	Participants	Expected output	Indicator (s) for monitoring progress
1.Review and analysis of information gathered through literature review to make a preliminary identification of market opportunities in Tanzania and Malawi.	SARRNET Team CIAT/CLAYUCA and local private and public partners	Potential market opportunities for each crop identified (done) Preliminary cost structure for each market opportunity elaborated for each country (pending, will be done on the results of the on-going field trials)	List of market options (available) List of cost structure for each option
2. Review and analysis of information gathered through surveys currently being implemented (quantitative data on characterization of market chain for cassava and sweet potato in Tanzania, Malawi and Zambia) (Pending activity)	Consultant teams (Phiri et al.) SARRNET Team CIAT/CLAYUCA CIP	Market chain for cassava flour and sweet potato characterized in Malawi Preliminary data on market chain for cassava products and sweet potato in Tanzania and Malawi available	Preliminary data available for Malawi Preliminary data available for Tanzania

Cassava flour for non-food industries. The contacts established in Tanzania with different industrial sectors interested in cassava and sweet potato included four brewery companies. Although a couple of them expressed interest in conducting trials with cassava flour, during the period covered under this agreement, no testing was conducted with them.

Table 2. List of companies visited in Tanzania.

No	*Company Name*	*Sector*
1	A-Z Animal Feeds	Animal Feed Milling
2	Golden Mills	Animal Feed Milling
3	Igo Animal Feeds	Animal Feed Milling
4	Interchick	Animal Feed Milling
5	Jadide Enterprises	Animal Feed Milling
6	Kibaha Educational Centre	Animal Feed Milling
7	Mkuza Chicks	Animal Feed Milling
8	Riamia Millers	Animal Feed Milling
9	Top Millers	Animal Feed Milling
10	Dar Brew; Kibuko	Brewery
11	Kibo Breweries	Brewery
12	Sergenti Brew	Brewery
13	TBL	Brewery
14	OK Plast	Biscuits
15	Soza Plast	Biscuits
16	Tabisco	Biscuits
17	Bahresa/Azam	Bread/Biscuits
18	Asante Dar Bakery	Bread
19	Asha Bakery	Bread
20	Esam Bakery	Bread
21	Qooch Bakery	Bread
22	Royal Bakery	Bread
23	Saasi Bakery	Bread
24	Supa Loaf	Bread
25	Top Bakery	Bread
26	Yombo Bakery	Bread
27	Henkel Chemicals	Chemicals
28	MCC Products	Flour/Biscuits
29	Power Foods	Flour
30	Solile Products	Flour
31	Tanzania-China Textile	Textile
32	TBS	Food inspection

Cassava chips and flour for the dairy and poultry feed sector. Both the poultry and dairy sectors are growing as the demand for chicken and dairy products increases. This provides opportunities for dry cassava and sweet potato chips to replace partially maize in balanced feed formulations and direct feeding of silage (roots and leaves and vines) or dry products to dairy cattle. Present maize usage in animal feed manufacture (based on the industries visited) is estimated at 150,000 t/year. The current price of maize is US$ 160/t (but can fall as low as USD$ 90/t). This dramatic fall in price can be explained easily if we consider that the maize crop is a commodity highly subject to policy issues.

Some years there is plenty of imported maize available, whereas in other years the imported volumes are lower and local prices tend to increase considerably.

Assuming an average 20% replacement of maize in the rations, there is a potential demand for 30,000 t of cassava chips. Pilot trials undertaken by the project have shown that cassava chips can be produced at US$ 80/t chips, which is competitive although with a very narrow profit margin. Actions needed to capture this potential market demand include the dissemination of chipping and drying technology and further trials to optimise and correct deficiencies in the use of cassava and sweet potato in balanced feed rations. For dairy producers, a motorized combined chopper-chipper for leaves has been introduced but needs to be refined (built through SARRNET-Tanzania and a collaborating machinery producer), and feed trials using root and leaf silage and meal are showing promising results. This technology is appropriate for areas with a long dry season where the availability of forage is a limiting factor in milk production.

Cassava starch. There has been recent interest in the establishment of a cassava starch factory in Tanzania. This interest has come about due to the increasing demand worldwide for native and, in particular, modified starch. dTp Studies Inc.[3] reports annual growth rates in demand of 4.2% for Asia, 3.4% for Latin America and 2.3% for Africa. East and Southern African countries import annually US$ 3.2 million of glucose and dextrin, with Kenya spending 74% of this total. In particular, one industrial enterprise in Tanzania, Mohammed Enterprises Tanzania Limited (METL), one of the largest agro-production and processing companies in the country, has initiated a diversification program from sisal, based on cassava production on a commercial scale for starch processing. The current plan is to develop a cassava starch farm and factory using their own land facilities near Kibaha (50 km from Dar es Salaam). SARRNET has already initiated cassava varietal trials with them. Additionally, CLAYUCA helped to organize a trip to South Brazil for one of their staff to visit cassava starch equipment factories. The geographical location and edapho-climatic conditions along part of the Tanzanian coast could make this an ideal location for supplying starch and starch derived products to Asian and European markets, while also satisfying the demand of neighbouring countries.

Malawi

A total of 12 industries were visited, broken down in the following sectors: 3 animal feed millers, 2 dairy industries, 1 farmers' association, 2 food processors (biscuit and bakery), 1 brewer, and 3 non-food industries (plywood, packaging and textile). The complete list is shown in Table 3. In a complementary study, it was estimated that 14 industries are presently using 6,500 t of cassava flour and chips with a potential demand of 10,200 t per year[4]

[3] DTp Studies Inc. 2000. Global Cassava Market Study: Business opportunities for the use of cassava. IFAD, FAO, CIAT, CIRAD, IITA, NRI.

[4] Anon. A Comparative Analysis of the Marketing of Cassava and Sweet Potato in Southern Africa: The case of Malawi. Main Report (Draft). March 2003

Cassava flour for the food industry. One of the major biscuit manufacturers in Malawi (Universal Industries), is currently employing levels of around 20% cassava flour in their formulation. Use is hindered by poor quality product (colour and insect damage). It is estimated that potential demand by this industry is 500 t/year. The price of *makaka* (local name for dry cassava pieces) is US$ 111-133/t, which compares favourably with the price of wheat flour. In the interviews conducted with Universal Industries in October 2001, they reported a price for cassava flour of US$ 140/t, whereas the price for wheat flour was US$ 440. The industry requires the use of sweet cassava varieties that compete for demand from the fresh market. This suggests that areas of production should be chosen far away from the major urban markets that are demanding fresh cassava. The introduction of improved chipping and drying technology has shown that chips of the desired quality can be produced at a competitive price (approximately US$ 90-100/t), but cost estimates need to be further refined. An important advantage of the use of good quality chips instead of *makaka* chips is that usually these chips need to be scrapped before milling to improve their appearance and quality thus increasing the final cost. Pilot testing of this technology with farmers' groups is underway and will require continued support (technical, business and market development skills) to ensure that the groups are capable of sustaining the production of quality flour for industry. This experience will also provide a focal point for demonstrating and disseminating the technology to other parts of the country, where local demand for high quality flour may be identified.

Table 3. List of companies contacted in Malawi.

	Company Name	*Sector*	**Location**
1	Land O Lakes Inc.	Promotion of Dairy industry/feeds	Lilongwe
2	Press Bakeries	Bakery of loaf	Blantyre
3	Universal Industries	Biscuit Manufacture	Blantyre
4	Transglobe Produce Export. Ltd	Animal feed/commodity trader	Blantyre
5	Chibuku Breweries	Brewery	Blantyre
6	Packaging Industries Limited	Packaging materials	Blantyre
7	International Timbers Limited	Plywood	Blantyre
8	Rab Processors	Animal feed and blended flours producer	Limbe
9	Chitipi Farms	Farmer of root crops	Lilongwe
10	Central Region Milk Producers Association (CREMPA)	EU	Lilongwe
11	Meadows	Animal Feed Miller	Lilongwe
12	NASFAM	Farmer Association	Lilongwe

Cassava flour for non-food industries. Cassava flour has been successfully used in papermaking and plywood manufacture. However, the potential demand for cassava in these industries is very small, in the region of 100-200 t/year. One factory producing plywood (ITL) has stopped using wheat flour and is replacing it with cassava flour for the preparation of the glue. However, total demand is just 50 t per year. The economic impact is very significant considering that prices for wheat flour were around 32 kwachas per kg whereas the cassava flour could be purchased at around 15-20 kwachas per kg (prices of October, 2002).

Cassava chips and flour for the dairy and poultry feed sector. Maize availability for animal feed fluctuates widely in Malawi. During years of drought, maize prices soar and there is a critical need for identifying an alternative energy source. Cassava could become one of these alternatives. Substitution of maize in animal feed would provide the opportunity to save, during good years, excess maize production that can be stored for human consumption in drought years. The present demand for animal feed concentrate in Malawi is estimated at 120,000 t/year[5]. Considering a 20% substitution level of cassava for maize, this represents an estimated present demand for approximately 24,000 t of dry cassava chips. The present prices of makaka do not compete with maize prices (US$ 120/t). In 2002, price of maize was as low as US$ 90/t. Under these conditions, it is very unlikely that cassava chips can be produced at a competitive price to be used by the animal feed companies. Transglobe Produce and Export, an agricultural products exporter company in Malawi, tried to export cassava chips to South Africa in 2002. After a selling price had been agreed upon, (US$ 90/t, FOB Blantyre), the deal was called off because of difficulties in purchasing the cassava chips. The company wanted the product delivered in town, transportation costs are excessively expensive in Malawi (5-6 kwachas /km/t), and the final price of the chips was too high to allow for export. In conclusion, this market for cassava will become a reality in Malawi, only if the maize prices become very high or cassava roots can be produced at a lower price. On the other hand, as reported in the case of Tanzania, the use of cassava and sweet potato in vertically integrated dairy production schemes is also looking extremely promising. The size of the demand in this sector has not been determined

Cassava starch. In 1997 the market size for non-food uses of starch was around 780 t/year[6]. This demand was met by importing maize starch at US$ 650/t from Zimbabwe and South Africa. The sectors reporting the consumption of starch are the packaging industry, carton manufacture, dry cell manufacture, plywood and textiles. This volume of imports would not justify the establishment of a large-scale highly mechanised cassava extraction plant. In local circumstances, it might be worth contemplating a small-scale semi-mechanised and semi-continuous process supplying specific industries, similar to the enterprises contemplated for high quality cassava flour production (see above).

b) Review of the draft and final country sub-sector market studies

The draft country documents of the studies were received in April 2002 and these were reviewed and comments returned to the authors for incorporation of corrections. During the Steering Committee Meeting (Pretoria, 2002), some of the main messages of these studies were presented and discussed.

[5] Universal Industries, personal communication, 2002

[6] Fabian, E. 1998. Cassava in the Malawi economy. Presented at the CFC workshop on local processing and vertical diversification of cassava in Southern and East Africa.

Sub-sector studies of cassava and sweet potato production, marketing and consumption

The sub-sector studies in each country were undertaken in three phases, which included a comprehensive literature review, qualitative assessments (pre-survey) and a quantitative study. These studies are written-up and consolidated in a report for each country. A Summary Synthesis Report[7] brings together and compares the principal findings from each country. With the view of complementing the analysis already undertaken, and of providing a few additional objective comments, the following conclusions are drawn from the information that has been gathered.

Production

It was observed that trends in cassava and sweetpotato production are difficult to assess. Data provided by FAO data often contradicts local sources, anecdotal evidence and information generated by research studies. For example, in Tanzania, estimates for the area under cassava are similar, at around 550,000 to 750,000 ha but total production varies by three to fourfold between FAO data and national statistics (6.1 million t versus 1.5 million t). Crop cuts undertaken under the auspices of SARRNET have given three times the yield of cassava and sweetpotato compared to official statistics (Kolijn, personal communication). Care therefore needs to be taken in analyzing the information from any particular source.

In Zambia, the FAO figures, which are considered to be an underestimate, show that cassava area has increased by 50% over the period 1991-2001 and now totals 165,000 ha. Sweetpotato area, on the other hand, has reduced from 3,800 ha to 3,600 ha. The growth in cassava production has been in response to the deficit in maize production, which fell by 30% over the period, occasioned by the repeated droughts experienced in the country and a diversification policy adopted by the government. The combined share in area of millet, sorghum, cassava and sweetpotato increased from 21% in 1990/91 to 37% in 1990/00. Cassava production has expanded from the traditional growing area in the North to cover the entire country.

Similarly in Malawi, over a ten-year period, 1989/90 to 1999/00, recurrent droughts have also caused major declines of maize and rice, and dramatic increases of both cassava and sweetpotato. In 1997/98, total annual production of cassava was over 1.4 million t, rising from under 200,000 t in 1987/88. The equivalent figures for sweetpotato are over 800,000 t and under 200,000 t.

Overall, Tanzania has more favourable climatic conditions and, compared to Malawi and Zambia, is almost food self-sufficient. Maize production fluctuates according to the season but has maintained levels of between 2.3 and 2.7 million t over the period 1998 - 2001. Production of cassava (6 million t) has remained stagnant and

[7] SARRNET. 2003. A comparative analysis of the marketing of cassava and sweet potato in Southern Africa: The case of Malawi, Tanzania and Zambia.

sweetpotato (0.4 million t) has a slight upward tendency. Cassava production is concentrated in two major producing areas: the Lake Victoria region and the Southern Region of Ruvuma. However, there has been an increase in production of both cassava and sweetpotato in the Central and Northern coastal regions supplying the urban Dar es Salaam market. Conversely, there has been an observed decline in peri-urban production around Dar es Salaam, as the land is used for higher value crops, such as citrus, pineapples, coconut etc.

This information underlines the vital urban and rural food security role played by cassava and sweetpotato in situations of drought, as in the case of Zambia and Malawi.

Consumption and other forms of utilisation

Beyond this fundamental role of cassava and sweetpotato as a food security crop, the present studies confirm the importance of both cassava and sweetpotato in the diets of both rural and urban inhabitants in Tanzania, Malawi and Zambia, especially for lower income groups. Maize and rice are the preferred staples, but cassava and sweetpotato are important and appreciated secondary food sources that play an important role in the diet of rural and urban populations.

Cassava is consumed in both fresh and processed form, while sweetpotato is consumed exclusively in the fresh form. The processing of cassava into dried chips and flour is undertaken at the household level. Both fresh and dried products are prepared into different forms for consumption and consumed with a wide range of different foods at different times of the day. Cassava therefore is more versatile and is perceived as a food staple.

In Dar es Salaam, fresh cassava and sweetpotato are the preferred form of consumption, with cassava flour being of secondary importance as a food source. In Zambia, cassava chips and flour are the principal form of purchase of cassava in Lusaka and Kitwe, with an estimated 90% traded in this form. In Malawi, fresh cassava appears to be a growing form of consumption, especially in the urban areas.

In the case of cassava, there are only a few small-scale drying and milling enterprises in each country. There have been attempts at the industrialisation of cassava as a raw material for starch extraction and animal feed in Tanzania but these have not prospered, due to lack of raw material and low cost of alternative products.

Mechanised industrial processing of cassava and sweetpotato for food, feed or other purposes is non-existent in Tanzania, Malawi and Zambia.

Supply chains studied

The study examined in detail the following cassava and sweet potato supply chains.

In Tanzania:

1. **For sweetpotato**
    a. Fresh sweetpotato supply to Dar es Salaam from the coastal region.
    b. Fresh sweetpotato supply to Dar es Salaam from the central region.
    c. Fresh sweetpotato supply to district and regional capitals from central region
    d. Local supply of cassava and sweetpotato (from village to village) in the central region.

2. **For cassava**
    a. Fresh cassava supply to Dar es Salaam from the coastal region.
    b. Fresh cassava supply to Dar es Salaam from the central region.
    c. Fresh cassava supply to district and regional capitals from the central region
    d. Local supply of fresh cassava (from village to village) in the central region.

In Zambia:

1. **For sweetpotato:**
    a. Fresh sweetpotato supply to Kitwe (copper belt) from Solwezi
    b. Fresh sweetpotato supply to Lusaka from Solwezi
    c. Local supply of fresh sweetpotato in Solwezi
2. **For dried cassava chips**
    a. Dried cassava chips and flour supply to Kitwe (copper belt) from Mansa
    b. Dried cassava chips and flour supply to Lusaka from Mansa
    c. Local supply of cassava chips in Mansa

In Malawi:

1. **For sweetpotato:**
    a. Fresh sweetpotato from Zomba district to Zomba and Malosa/Namwera markets
    b. Fresh sweetpotato from Lilomgwe district to Chimbiya, Mitundu, Kawalea and Lilongwe markets
    c. Fresh sweetpotato from Mzimba district to Nkhata Bay, Mzuzu and Mzimba Boma markets

2. **For cassava:**
    a. Fresh cassava from Mulanje district to Zomba and Malosa/Namwera markets
    b. Fresh cassava from Dedza district to Chimbiya, Mitundu, Kawalea and Lilongwe markets
    c. Fresh cassava from Nkhata Bay district to Chimbiya, Mitundu, Kawalea and Lilongwe markets

The information was aggregated and presented in a way that it is difficult to establish the competitiveness of each of these chains, and compare between them. Should any future project seek to make interventions to improve the competitiveness of any of these supply chains, the data generated could be further analyzed and disaggregated by each specific set of actors in the chains of interest.

Market demand

Cities: Fresh cassava and sweetpotato. Traders both in Tanzania and Zambia reported no constraints to demand for fresh roots. Consumers only noted lack of availability of sweetpotato during certain times of the year. In Tanzania, farmers report increased sales of cassava and sweet potato in both producing regions studied. This suggests that the demand is increasing. In Malawi, a quantitative estimate of the daily volumes of fresh cassava and sweetpotato entering Lilongwe city was made in the 2000-2001 season. In excess of 40 t/day of cassava and 30 t/day of sweetpotato were recorded. A similar study undertaken in the following 2001-2002 season for cassava showed higher volumes that might suggest an increase in demand for the fresh product.

Cities: Dried chip and flour market in Kitwe (Copperbelt) and Lusaka. The number of traders of cassava chips and flour has increased, and farmers report increased sales over past 10 years. Traders reported increased volumes. This suggests that the demand for dried chips and flour is increasing. In Malawi, 89% of households reported processing cassava into some form or other, including dry chips or *makaka*. However, trade in dry cassava is mainly concentrated in the North and South of the country.

Intermediate towns. There is considerable trading of sweetpotato over short distances in the central region of Tanzania, indicating local demand by persons that do not grow the crop.

Export: Sweetpotato and cassava. The studies did no explicitly address export of sweetpotato and cassava. However, it is known that in the case of sweetpotato there is informal cross border trade, with regional trade opportunities from Zambia to Botswana, Namibia and the Democratic Republic of Congo. For cassava, there is informal cross border trade of chips to the Democratic Republic of Congo from Zambia

Consumer habits and preferences

Fresh sweetpotato. Sweetpotato is still predominantly a food of the low-income consumer group, but is appreciated by higher income earning groups. For example, sweetpotato is available in supermarkets in Dar es Salaam, where consumers prefer sweetpotato from the central region. Sweet potato from the coast tastes salty. The price of fresh sweetpotato is double or triple price of fresh cassava, with a marked seasonality, and larger price fluctuations than fresh cassava. Sweet potato is mainly consumed as breakfast replacing bread and other wheat-based products. It is considered less versatility compared with cassava, with limited processing and product/recipe applications. Additionally, in some stores of a supermarket chain recently opened in Malawi and Tanzania, it is common to find frozen sweet potato slices, coming from South Africa.

Fresh cassava. Cassava is also still predominantly a food of the low-income consumer group and is the cheapest carbohydrate source available. It is versatile, with wide variety of different forms of preparation, being used both as a staple, complementing *ugali*, rice etc, and as delicacy for certain traditional festivals (e.g. Ramadan). In Dar es Salaam, it is increasingly being sold by food vendors/hawkers on the street as a snack roasted, along with roasted green maize.

Dried cassava chips and flour. Mining industry workers in the Zambian copper belt come from cassava producing areas, where they are accustomed to using dry cassava chips as the basis of food preparation. High maize prices in Zambia have meant a shift from the use of maize to dry cassava in the production of *nzima*. This also occurs in Malawi in years when there is a shortage of maize. In Zambia there has been growth in the use of dry chips as a snack sold roasted by street vendors in the copper belt, accompanied by groundnuts.

Trading and transport

There has been a substantial increase in the small trader class as a livelihood activity, and supply chains from farmers to consumers in cities involve between 3 to 8 actors. Grading of fresh sweetpotato and cassava is an important value adding activity undertaken by traders. In general farmers do not grade before sale, except in certain cases in Zambia. The major price factors in all countries are the size of roots and volume. Neither fresh sweetpotato nor cassava are bought or sold by weight at any point along the supply chain. Traders of fresh produce buy the crop in field, organize harvesting, bagging and transportation to the markets (e.g. Tanzania). Transport by road is the only means of transferring the produce from rural to urban areas, and transport costs are the highest proportion of all off-farm costs.

Supply of cassava and sweetpotato

In general, area under cassava and sweetpotato is less then 2 ha per farmer. In Tanzania, fresh cassava and sweetpotato farmers produce for both home consumption and sale. Amongst sweetpotato farmers there are a number that are more commercially oriented, employing commercial practices (mono-cropping, single varieties, seed beds

etc.). In all countries, the market orientation of farmers is greater the closer they are to major roads and urban centers. The implication of this is that building roads will improve farmer access to markets.

In Zambia, cassava farmers have accommodated their production practices to produce all the year round. However in all countries, sweetpotato production is seasonal. The studies showed that farmers are producing those varieties most preferred by traders and consumers.

There is no use of purchased inputs, except in very selected cases and by those more commercially oriented farmers (mostly planting material: e.g. sweetpotato vines). Farmers sell their produce in the ground, harvesting is undertaken by the traders that purchase the crop. The price is estimated by field inspection by the trader and based on plant age, variety, health status, etc. The studies could not detect any influence on production practices and relative access to market (except those cases mentioned above).

Sweetpotato has moved from being a largely on-farm home consumption crop to a commercial crop, and as a consequence men have become more involved in production and trade. Beforehand, sweetpotato production was principally the domain of women.

As expected, farm gate prices are higher closer to urban markets. This would preclude the processing of these crops close to urban centers, but provides an opportunity for those areas distant from urban centers with poor market access. In all countries, less than 10% of farmers participate in associations and their access to technical assistance is poor.

c) Participation in the synthesis workshop to summarise the findings of the market studies

A mini workshop was held in Nairobi in November 2002 to finalize the studies and prepare synthesis documents that pulled together information from the comprehensive literature review, qualitative pre-survey assessments and the quantitative sub sector study.

Overall conclusions

1. The studies generated an immense amount of information. The summary document, although it is comprehensive and covers the main components on which information was gathered, is not easy to digest. It could have been more illustrative if it had made greater use of tables and figures to compare information across countries. An example is the comparison of market prices and production cost. In this regard, it was unfortunate that at the meeting held in Nairobi in November 2002, to bring all the information together, the study leader was unable to attend. In retrospect, more time could have been set aside for analyzing the data once it had been tabulated. What this means is that significant further analysis could be undertaken on the data gathered, which could be useful for any further study of sweetpotato or cassava in the respective countries. It would be hoped that the basic data could be made available, should other researchers require it.

2. In all three countries, cassava as a human food (fresh in the case of Tanzania and Malawi, and dry cassava chips and flour in the case of Tanzania) is the predominant market. Demand in the food and feed industries is starting from a low, and almost insignificant, base but appears to have growth potential.

3. The questions that the stakeholders in SARRNET will need to address are:

   a. Cassava and sweetpotato are critical for food security in Malawi and Zambia, and to a lesser extent in Tanzania where its food security importance is more regional. The governments of these countries should (and probably do) appreciate the strategic importance of these crops and maintain an appropriate R&D investment to ensure that farmers have access to the most appropriate genetic materials, especially those that are tolerant to drought and to diseases, and maintain high levels of farmer and consumer acceptance characteristics. Given the household food security role of cassava and sweet potato, health related characteristics, such us vitamin A rich varieties, could be important but will require appropriate participatory and promotion mechanisms to increase the probability of adoption by farmers.

   b. Tanzania, because of its strategic location and appropriate edaphoclimatic conditions, could become an exporter of cassava starch to Asia, Europe and within Africa. The private sector has already observed this opportunity and the government could provide supportive policies to encourage potential investors.

   c. The rapid rate of urbanization in all three countries is likely to increase the demand for fresh cassava and sweetpotato. Germplasm improvement programs will need to be proactive in selecting materials that are appropriate for the fresh market. The studies have provided a good indication of the quality requirements sought after by consumers. It would be advisable that improvement programs incorporate regular consumer testing of new materials in their activities, if they have not already done so.

   d. Should the economies of the three countries grow over the next decade, the incomes of urban inhabitants will increase and the demand for cassava and sweetpotato in their present forms will change. Further research should be carried out to determine the preferences of different socio-economic groups for different product forms (many of which could be copied or adapted from other countries). This information would guide new product development activities where national food technology institutes and universities can enter into partnerships with local food and non-food processing industries.

   e. Urbanization and income growth will also increase the demand for cassava and sweetpotato in the food, feed and non-food industries. The most important of these is likely to be the feed industry where both cassava and sweet potato could find important niches. The production regions, and hence the agronomic and quality characteristics of the germplasm required, will be very different from those for the fresh market. Cassava and sweetpotato R&D programs would do

well to organize themselves so as to be precise in their research for these different markets and different production zones in each country.

f. The market for fresh and processed cassava and sweetpotato is fragmented, with the involvement of many middlemen and traders. There are no grades and standards. Products are sold by volume and not by weight. Information flow between retailers, wholesalers, middlemen and producers is informal. This situation is common to many commodities and changes will require actions that go beyond the scope of SARRNET. However, in locations that have a competitive advantage for producing high quality cassava or sweetpotato for the urban market, pilot projects to better organize farmers to meet the demands of purchasers, and to more formally link them to urban wholesalers, with a view to improving the competitiveness and an equitable distribution of the benefits of the supply chain, would generate useful experiences that if successful could be replicated in other regions or countries. Up to now, SARRNET has not explicitly included farmer organisation for enterprise development in its R&D agenda. If it were to recognise this as important, additional and complementary skills to its existing core staff would be required.

g. The private sector has shown an interest in cassava and sweetpotato and their derived products as a raw material for a range of products. The fostering of this interest will require continued input in terms of providing technical and economic information on production, processing and the physiochemical and functional properties of cassava products for different end uses. Post-harvest processing, product development and marketing components are ideally suited to a regional approach, where the competency and capacity of appropriate national institutions or organisations (those best equipped to provide research and technical assistance services) can be enhanced to play a catalysing and convening role between the private manufacturing sector, the public R&D sectors and cassava and sweetpotato farmers.

3.3. Theme III. Sustainable and appropriate processing technologies adapted and adopted by farmers and industrial processors

3.3.1 Introduction

The work plan designed to accomplish this objective was based on the assumption that: a) a methodological approach, the Integrated Cassava Research and Development Project (ICRDP), was available to be tested and adapted in Tanzania and Malawi, and b) the CLAYUCA approach, as a complementary strategy, was also available. In both approaches, the concept of linking farmers to markets is a key component. The methodology also includes technological and methodological interventions. The technological intervention is based on the transfer of an existing processing technology that is further refined and adapted with farmers' participation.

The organizational intervention implies for actors, especially farmer groups, the introduction of changes in their current practices. For example, instead of selling the cassava roots individually to local traders, usually at very low prices, they could establish an alternative commercialization system in which the cassava roots are sold to a processing plant, located within their village, built and owned by them. The roots are processed to transform them into dry cassava chips that are sold to urban markets, or better prices. Private sector markets use this high quality chips to produce cassava flour for human consumption.

3.3.2 Expected result:

Appropriate technologies for cassava production, processing and utilization, adapted and adopted by cassava farmers and industrial; processors in Tanzania and Malawi.

3.3.3. Activities implemented:

a. Animal feed trials in Tanzania and Malawi
b. Establishment of at least one pilot project using the integrated product development approach in at least one country
c. Translation to English of the book "Uso de la Yuca en la Alimentacion Animal" and formatting for web publication
d. Dissemination of relevant information on cassava postharvest technologies
e. Translation to English of cassava information system

3.3.4. Results achieved:

a. Animal feed trials in Tanzania and Malawi

a.1. Tanzania

The approach followed by SARRNET team in Tanzania, to try to attract more interest by the private sector on the use of cassava as one of the ingredients in the preparation of animal feed compounds, was to establish feed trials, so that reliable data could be generated with which a sound analysis could be made about costs, efficiencies, constraints and other important factors.

The strategy was to present real cases based on data obtained locally, as a motivating factor to try to promote the use of cassava in animal feeding. Initially, two small-scale experiments were conducted in poultry farms near Dar es Salaam with the main objectives of getting SARRNET staff familiarized with the use of the software used for formulation of the feed as well as to gain some practical experience on the conduction of biological experiments. The lay out for two experiments, one for broilers and one for layers was described previously[8]. The initial idea was to evaluate the effect of a partial replacement of the maize with cassava flour levels of 25 and 50%. Performance of the animals was measured against two commercial diets. The scale of the experiment was

[8] CLAYUCA, CIAT, SARRNET, IITA, CIP. 2002. Subcontract Agreement for the execution of USAID/SADC/SARRNET Grant No. 690-G-00-99-00258-00 between the International Institute for Tropical Agriculture, IITA, and the International Center for Tropical Agriculture, CIAT. CIAT, Cali, Colombia. Second report. Period June 2001 to May 2002

small (150 animals) and the conditions were not ideal. Despite these difficulties, some initial data was obtained (Figure 1).

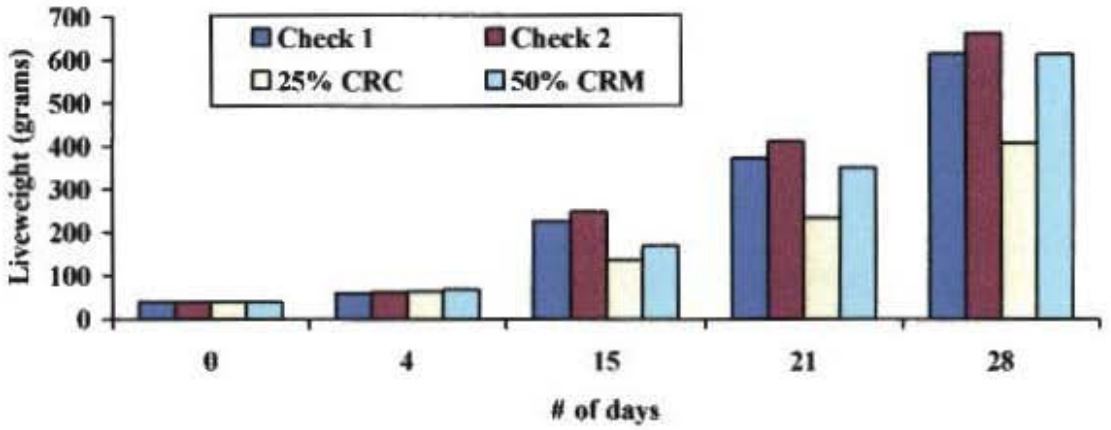


Figure 1. Performance of broilers fed with cassava, Tanzania, 2002

These results were looking promising during the initial stages, considering the high levels of cassava root meal used. Later on, as the experiment proceeded, some mortality, severe in some cases, occurred. This mortality was caused by Salmonella typhanurium that contaminated the fishmeal used. Apparently, the infestation of the fishmeal occurred during the drying process. These microorganisms produce diarrhea, poor performance and death. Drying at high temperatures will destroy the microorganisms. Inclusion of another source of protein (soybean meal) is another solution. Unfortunately, in Tanzania some of these options are difficulty to implement at the present moment. Additionally, at the time these experiments were conducted in Tanzania, maize prices were very low so that the inclusion of cassava flour in poultry diets was not a financially viable option.

Based on these preliminary results, a more scientific work was planned taking advantage of the presence in Tanzania of the student Debby de Groot from Wageningen University, Holland. The student conducted this work to fulfill her thesis requirements for a degree on Tropical Animal Husbandry. A summary of this work is presented in next section.

Theme III. Sustainable and appropriate processing technologies adopted by farmers and industrial processors.

Activity and dates	Participants	Expected output	Indicator (s) for monitoring progress
a. Undertake feed formulation and industrial trials with private sector partners on the use of sweet potato and cassava in animal feeds with emphasis on poultry and cattle in Malawi and Tanzania.	SARRNET Team CIAT/CLAYUCA and local private & public partners	Animal feed trial using cassava (initiated) Economic analysis of results elaborated (pending)	Biological data available Technical data available Economic data available
b. Establishment of at least one pilot plant project using the integrated product development approach in at least one country	SARRNET Team CIAT/CLAYUCA and local private & public partners	One pilot project in operation in Malawi One pilot project in operation in Tanzania	Pilot project operating Farmer's group working under the pilot project concept. Volumes processed
c. Participation in process of translation of the book "The use of cassava in animal feeding" into English and formatting for web publication[9]	B Ospina J. Buitrago	Book on "Use of cassava in animal feeding" translated into English and available for web publishing	Book available on the Web for stakeholders
d. Participation in translation of relevant cassava post harvest handling and processing technology information into English. [10]	B Ospina R. Best J. Buitrago SARRNET team	Information system available in English in various electronic and hardcopy documents	* List of publications and documents available at SARRNET Offices in the form of Web Page publications, CDs, Video, Power Point presentation, * Paper documents. * Finish translation of document "Cassava in poultry feeding" (May, 2002) Finish translation to English of document in Thai language on "Use of Cassava in Dairy Feeding"
e. Participation in translation of cassava post-harvest handling and processing technology information system into English. [11]	R. Best B.Ospina	Information system translated into English and formatted for web publishing	Information system available in web page of SARRNET

[9] This activity is financed by FOODNET
[10] Some documents have already been made available at SARRNET offices
[11] Some documents have already been made available at SARRNET offices

Feasibility study on the use of cassava in animal feed in Tanzania, with special emphasis on poultry feed – A summarized report[12]

Overall objective

The overall objective of this study was to evaluate the feasibility of the use of cassava as an alternative animal ingredient to maize in balanced feeds in Tanzania. Due to the dominant role of the use of animal feed for poultry production in Tanzania, the work emphasized broilers and layers. Feeds based on a combination of cassava and soybeans, as an alternative ingredient to fishmeal, were also evaluated.

Specific objectives:

1. To analyze and document the root and leaves production/utilization/system for different products/end users (costing, yields, quality, labor implications)
2. To evaluate the performance of broilers and layers, fed with alternative feeds prepared with cassava products, using feed formulation software.
3. To analyze the acceptance of farmers and feed millers of cassava as animal feed
4. To make recommendations for future research and development activities for poultry and dairy sectors in Tanzania

Feed trials

Data on the current animal feed practices in Tanzania was obtained through review of the literature available and a specific survey designed to obtain information from key stakeholders in the animal feed and livestock sector. A total of 11 different companies were interviewed including feed millers (4), poultry farmers (4), and dairy farmers (3). Table 4 presents a synthesis of the information given by key stakeholders interviewed. Information obtained was used as an input for the formulation of the experiments.

Two experiments were conducted: one with broilers and one with layers. The experiments were limited to the poultry sector because of the low investment and maintenance costs. The following section presents the discussion of the results obtained and some preliminary conclusions.

Discussion

As mentioned before, the survey with poultry sector stakeholders was conducted with the objective of helping to identify opportunities and bottlenecks for a wider use of cassava in the animal feed sector in Tanzania. Even before conducting the interviews, SARRNET had assumed that one important success factor of cassava, as an alternative feed ingredient was its reputation in the animal feed sector. Therefore, the feed trials in this study were not only conducted to obtain information on its nutritional value, which has been demonstrated in numerous previous trials, but also to demonstrate the potential of cassava to the animal feed sector (farmers, feedmillers, consumers of animal products)

[12] De Groot, Debby. Thesis work Tropical Animal Husbandry. 790407-284-030, Wageningen University, Holland, 2003. Draft document. SARRNET. Tanzania. 2003

Table 4. Opinions of feedmillers and poultry farmers in Tanzania – A survey.

Question Topic	Answers given by informants
Animal feed problems	▪ Low quality or raw materials makes animal feed unable to reach nutritional values indicated in the feed formula ▪ Cheating of the suppliers on the quality of raw materials ▪ Fish meal is especially subjected to this problem, water and sand are added to increase its weight ▪ Fluctuating prices of raw materials ▪ Prices of feed is maintained the same for fear of loosing clients ▪ Animal producers also complain about fluctuating prices of raw materials ▪ Shortages of water is a problem during the dry season
Feed formulation	▪ Some feedmillers employ a nutritionist ▪ Other feedmilers rely on expertise within the family ▪ Top commercial firm has access to the advice of a scientist from Nairobi ▪ Poultry farmers usually purchase their feed from a nearby feed miller and have little knowledge of its composition ▪ Poultry farmers are more concerned about nutritional value of the feed than the price of the feed, providing that there is a certain profit ▪ According to feedmillers, poultry farmers will not be concerned if maize is replaced by cassava, especially if it is cheaper
Objections against cassava in animal feed	▪ Feedmillers are afraid of a decrease in feed quality and low availability of cassava in Dar es Salaam ▪ High cost investment, for example the purchase of a cassava roots chipper ▪ Some feedmillers find cassava root meal (CRM) too dusty and would need it pelletised to be able to include it in the animal feed. A pelletizer will be required and most feedmillers are not willing to invest in machinery ▪ One of the feedmilers did use cassava root meal for a period of six months in broiler and pig feed (60% CRM and 10% maize). Broiler performance was the same and pig performance increased greatly. According to the feedmiler, the inclusion of zinc Bartheracine as a growth promoter was the key for the success of the cassava-based diet. Experience was terminated due to shortage of CRM.

Table 4. Opinions of feedmillers and poultry farmers in Tanzania – A survey (Continuation)

Question Topic	Answers given by informants
Objections against cassava in animal feed (Continuation)	▪ Diseases such us brown streak and cassava mosaic and difficulties with the drying process make feedmillers afraid of using CRM ▪ Planting cassava is too laborious ▪ Feedmilers are demanding that cassava should be chipped and preferably, pelletised; cassava farmers will not be able to make any investment. ▪ Farmers need credit and support to create associations ▪ Main reason for not producing cassava chips is that fresh cassava prices are good and much more profitable, especially if the farms are located near Dar es Salaam ▪ Due to high prices of fresh cassava in Dar es Salaam, poultry farmers use maize bran, which is cheaper. ▪ Some poultry farmers consider cassava roots as an inferior product and will need to see evidence of the contrary before they consider a change in their feed formulas
Opinion about cassava	▪ Cassava leaves have a better reputation than cassava roots ▪ Many dairy farmers use cassava leaves as a replacement for grass ▪ Harvesting cassava leaves is easier and cheaper ▪ Quality of cassava leaves is also considered better, the reason being that employees only cut the tall, older grass and ignore the younger grass because it is more difficult to be harvested and consumes more time ▪ Feedmilers and dairy farmers that used cassava observed an increase in animal performance and cost savings. ▪ Farmers grow cassava because they find it more resistant to irregular rainfall than maize
Alternative feed ingredients	▪ Maize bran is the favorite due to cheap price and good quality ▪ Broken wheat is also used ▪ Sometimes feedmillers use wheat that is no longer useful for human consumption ▪ Due to fluctuating prices of fishmeal, sometimes feedmillers use alternatives such us meat ▪ Feedmillers would prefer to use soybean it is too expensive and not always available. Soybeans need to be imported from India or Brazil and it means higher prices (taxes)
Conditions feedmillers want to see fulfilled before using cassava	▪ Low cost price ▪ Similar or higher feed quality ▪ Good public opinion ▪ Availability ▪ A laboratory test or any other proof of the nutritional value of the cassava formula ▪ A successful feed trial ▪ Cassava roots provided as chips or pellets
Advice/support needed from SARRNET	▪ Technology for drying cassava leaves ▪ Most poultry farmers and feedmillers requested a new, superior feed formula, based on raw material available in Dar es Salaam ▪ Supervision or some control on quality of raw material supply

Adoption-potential for cassava in the animal feed sector in Tanzania

- During the interviews with feedmillers it was mentioned that the cheating with raw materials, by its suppliers, inhibited them to reach the nutritional value indicated by their feed formula. They suggested supervision or quality control on the supplies of raw material in order to be sure of its nutritional value. In the case of cassava, the leaf quality varies greatly with the age at harvesting (HCN), harvesting techniques (leaf-stem ratio / digestibility) and processing techniques (HCN, storage-ability, palatability). Cheating by suppliers with bad quality cassava, low in nutrients and rich in tannins, could seriously damage its reputation. For this reason, its production must be supervised or the final ingredient must be tested and classified into a quality-category before being supplied to the feedmillers.

- Most of the (small-scale, low productivity) feedmillers rely on their own and their families' experiences in feed formulation and do not use a nutritionist or a computer. Usually those feedmillers prefer to stick by their traditional formula and are not very perceptive to the idea of using cassava as an alternative ingredient. They could be influenced, however, by a good reputation of cassava amongst other successful, feedmillers. It seems logical to convince the small group of perceptive, top market-oriented animal feedmillers, to experiment with cassava. Feedmillers could be convinced when the potential profit gain wins from the potential risk. The potential profit gain could be demonstrated with ongoing broiler and layer trials. When the results of feedmillers, who adopt cassava based feeds are good, its reputation will increase, and other feedmillers might be tempted to follow the example.

- Most of the broiler and layer farmers, who utilise up to 80% of the domestic commercial feed produced, purchase their animal feed from feedmillers without knowing its (precise) nutritional content. Assuming that broiler performance will not drop as a result and gain a bad reputation, the cassava-based animal feed will have an immediate market once it is accepted and produced by the feedmillers.

- Dairy and pig farmers usually make their own feed formulation, purchase/grow their own ingredients and mix their own feed. Spreading the reputation of cassava as a potential alternative animal feed ingredient to maize might be more time consuming for this group. Dairy and pig farmers appeared to be less willing to experiment with their feed formulation than the feedmillers, and could need more decision-time before adopting cassava

- Some feedmillers find the cassava-based feed too dusty and insist that it needs to be pelletized before using it in their animal feed. In order to make cassava root chips and to pelletize the cassava based animal feed a chipper and pelletizer are required. Feedmillers are not willing to invest in new machinery and sharing a pelletizer or chipper within a group of feedmillers could prove problematic due to transport costs of the feed and communication difficulties on topics such as time schedules and maintenance.

- An alternative could be to provide the feedmillers and/or farmers with the possibility to hire their personal chipper and/or pelletizer. They would have the machinery on their own domain, eliminating extra transport costs or delay in production. The disadvantage of this solution is that the production costs of cassava diets would increase with the rent costs of machinery. This means that when the rent is high, producing cassava diets will only be possible for highly productive feedmills. The fixed costs of the machinery can then be divided over mass production.

- Another problem is the unavailability of cassava for animal feed. In and around Dar es Salaam and other medium to large towns, cassava is produced mainly for human consumption. The price of fresh cassava is around 90 TSh. Further away from towns and markets cassava is available for a much lower price, which can be as low as 15 TSh. Most of the relatively high productive feedmillers in Dar es Salaam own their own vehicle(s) for the transport of feed (ingredients). When this group of feedmillers will make an agreement with cassava farmers, who are too far away from markets to sell their fresh cassava for human consumption, they will be able to produce cassava based diets against much lower production costs.

- Aside from having cassava available to them, feedmillers could sell their excess cassava to the smaller feedmillers and animal farmers, against a small profit but still below the price of fresh cassava. The planting and harvesting of cassava is laborious and animal farmers will need to employ more people, usually men due to tough workload, to look after this task. High labour costs and a relatively low price for cassava could be a reason for animal farmers to buy their cassava from elsewhere, instead of growing cassava themselves. In this scenario, feedmillers and farmers will have access to cheap cassava, and cassava farmers in rural areas away from towns will have new income.

- The cassava farmers who are targeted to become the supplier to feedmillers in Dar es Salaam, should be informed of improved planting and harvesting strategies in order to ensure a uniform quality of leaves and roots amongst all cassava farms.

- The amount of labour needed to run a feedmill will not change with the introduction of cassava. The labour necessary for weighing and mixing does not differ amongst ingredients. However, extra labour is needed to pelletize the cassava-based diets. Feedmillers do not see this as a relevant problem. Gender division will not change. If new employees are needed they will be male due to the heavy work of carrying feed to and from the pelletizer.

- Some dairy farmers are already using cassava leaves as a substitute for grass. Harvesting the leaves is far less laborious and the quality is better. Meetings should be arranged, joining dairy farmers who are using cassava and those who are not. This way, the good reputation of cassava leaves will be spread. Scientists with knowledge on growing cassava, harvesting cassava and positive effects of cassava leaves on dairy performance should attend those meetings, possibly with results of a demonstration trial, in order to help the 'newcomers' with getting started and the

others with optimising their dairy performance/production costs. During the meetings, the use of cassava roots could be introduced. Cassava root chips can be used as an energy source in lactating dairy cow diets at very high levels

- One feedmiller in Dar es Salaam tested a cassava based diet, by replacing 60% of the maize with cassava root chips, on his own pig farm and was pleased to see a significant increase in pig performance. Meetings such as described above should for this reason also be organised amongst pig farmers. They might prove less effective than the meetings amongst dairy farmers, due to the fact that there is usually less attention being paid to the pig-diet. Pigs are not difficult eaters, and they are usually kept on the side. During the interviews it came forward that the children kept pigs, while the parents controlled the dairy and/or poultry section.

- Aside from cassava, there are other possible alternatives to maize that are currently being used by animal farmers and feedmillers when the fluctuating maize price rises too high. Those ingredients, such as maize bran, wheat and rice, are readily available in Tanzania for relatively low prices. It could be interesting to see in a different study if an alternative feed formula can be found, using readily available ingredients, which is cheaper and has an equal or better nutritional value, resulting in an equal or better animal performance against lower feeding costs.

Comparison of cassava and maize for broiler feed manufacturing

A broiler trial was conducted in order to compare cassava products with the existing feed ingredients for feed manufacturing. As mentioned earlier, the broilers were kept in groups of (initially) 30 broilers each per treatment for two different locations. The results from the statistical analysis were most likely biased due to location and group interaction. This is one of the reasons that the experimental design was unsuitable for statistical analysis. Anther reason is that there was no data available per independent broiler groups. Instead, the mean per week was taken for the whole treatment group. This meant that there were only 12 trials (2 locations* 6 weeks) per treatment group, which explains the very high standard deviation. In other words, the results from the multivariate analysis are not reliable due to bias and high standard deviations.

In the last week of the broiler trial (week 6), the broilers stationed at Mikocheni became sick with Gumboro disease and Mafua bacteria. The first mortality cases were for the 50%CRM treatment group, suggesting it to be the most susceptible group. In a previous study by Ajani (2002), the 50%CRM treatment group suffered from a 42% mortality due to typhoid, with the cause most likely being the *Salmonella typhanurium* that contaminated the fishmeal. This was not the case here, where a high mortality was not confined to the cassava groups. The mortality rate ranged from 19% for the 0%CRM to 38% for control 2. The results from Kigamboni, with zero mortality, confirm that replacing maize with CRM up to 50% has no effect on broiler mortality. The statistical analyses of the results gave no significant difference for mortality between treatments.

Aside from the disease outbreak, there might be some interaction between growth rate and the relocation of the chicks in week 3, giving another explanation to the difference in results between broilers in Mikocheni and Kigamboni. The treatment group, where maize was fully replaced by CRM, suffered from diarrhoea in 1 of the 6 weeks in Kigamboni and 6 out of 6 weeks in Mikocheni, which could have resulted in a relatively low digestibility of the feed. The correlation between feed treatment and faeces abnormality was found to be significant with the multivariate analysis. The treatment where half of the maize was replaced with cassava did not suffer from diarrhoea, except for the last 2 weeks at Mikocheni, due to the disease outbreak.

The Feed Coversion Rates (FCR) in Mikocheni, 3.7 (control 1) to 7.7 (50%CRM), were much higher (more unfavourable) then the FCRs in Kigamboni, 3.3 (control 2) to 5.8 (50%CRM), especially for the 50%CRM groups. This was probably due to the different housing systems, allowing differences in the wasted feed fraction to occur. The CLM used in the broiler trial was not of the best quality. It had a low leaf / stem ratio. The 'stems' in the diets were not liked by the broilers and easily selected and discarded due to the significant size of the stem particles. Therefore, the wasted feed fraction could be higher for the cassava-based diets, overestimating the FCR. During the trial it was attempted to make an estimation of the wasted feed in Mikocheni. However, this proved difficult due to the fact that not all wasted feed was retrieved, underestimating the wasted fraction, and faeces was allowed to drop freely in the bag, overestimating the wasted feed fraction. The adjusted FCRs in Mikocheni are rough estimates. The unadjusted FCRs were used for calculation of feed costs, in order to have the price that broiler farmers will pay. One way to decrease feeding costs would be to introduce a strategy that will make it more difficult for the broilers to waste feed.

Growth depression was visibly noted when broilers were fed with cassava, especially in the last two weeks of the trial. The 50%CRM and 25%CRM diets were similar in composition to that of the 0%CRM batch, the only difference being the inclusion of maize or cassava. Since the growth rate of the 0%CRM batch was not impaired, the depression in growth rate of 48% (kigamboni) to 51% (Mikocheni) for 50%CRM and of 30% to 41% for 25%CRM is probably due to the lack of valuable nutrients in cassava, which needed to be added to the diet. According to previous studies, cassava diets need to be supplemented with methionine to get a similar result to that of maize based diets. Due to the fact that the inclusion of methionine would increase the feed cost significantly and that the results of this trial needed to be of value in practise as well as in theory, it was not included in the diet.

Another significant reason for the depression in growth rate could be the negative effect that cassava appears to have on the feed intake. In previous studies it was suggested that the cassava diets in mash form are too dusty to the broiler taste. For this reason the feed should have been pelletized. Since Dar es Salaam had no pelletizer available, it was not possible to pelletize the feed, resulting in a lower feed intake and a depression in growth rate. The differences for growth rates between treatment groups were significant according to statistical analysis.

Even though growth rates were lowest for the cassava treatment groups, the cost of producing 1 kg of broiler meat in Kigamboni was most favourable for the 25%CRM batch (427.51). The two controls were most expensive (603.64 and 618.99). The feeding costs in Mikocheni were high for all treatments, ranging from 708.91 (25%CRM) to 1095.36 (0%CRM) due to outbreak of disease in week 6 and high wasted feed fractions. These results are somewhat misleading because total output (in broiler meat) should also be taken into account. Even though the production costs are decreasing when using the alternative ingredient cassava, the broilers reach a lower weight. Broilers in Tanzania are usually sold at a weight of 1-1.2 kg. To reach this average weight, broilers need to be kept and fed for 6 weeks when feeding them with 50% maize and 50% CRM of the total diet (25%CRM). The 50%CRM batch did not even reach the 1 kg at the end of week 6. The control groups and the 0%CRM batch reached an average weight of 1 kg in week 5 or even in week 4 for control 2 in Mikocheni. This means that in practise, the batches fed with maize-based diets are ready for sale at week 4 or 5. In other words, in reality the total feed costs for the maize-based diets are lower then the results show.

Still, if the price of maize increases in the future and/or when the feedmillers will purchase their cassava from distant cassava farmers at very low costs, the replacement of maize with cassava could be economical. Pelletizing the feed will, as mentioned before, increase feed intake and growth rate.

Comparison of cassava to maize for layer feed manufacturing

The experimental design of the layer trial made it impossible to conduct any statistical analysis, since there was only one trial or source of data per treatment group. With no repetitive results it was not possible to calculate a standard deviation or the significance of the feed factor

In this layer trial the egg production was negatively effected by cassava. The cassava treatment groups had a lower egg production then the control group, of 27% for the 50-no batch and 19% for the 25-no batch. This might be due to the fact that the feed was offered in mash form and not in pelleted form, as done in the previously mentioned layer trial by Smith (2002). Cassava did not have a significant effect on the egg size or egg weight.

Combining soybean with cassava had an even further negative effect on egg production. Soybean is more expensive, lower in nutrients and higher in fibre then fishmeal. Combining soybean with cassava increased the methionine deficiency. The advantage that soybean had over fishmeal is that it is not easily contaminated with sand and water. Also, as mentioned before, fishmeal can be contaminated with Salmonella. However, the advantages of soybean may not be worth the reduction in egg production of 21% for the 50-yes batch and 27% for the 25-yes batch. It is possible that, because some of the soybean bean particles were relatively large, layers selected the soybean beans and that for this reason soybean -cassava combination groups did not receive the nutrients it needed. When the feed is pelleted, the decrease in egg production may not be as significant as it was now.

To compare the production rates from weeks 1 to 6, resulting from the layer trial, with the original production rate at week 0 at Tazara farm might be misleading. The layers for the trial had been selected on their productivity. The layers that were not (yet) laying were excluded from participating in the trial. The original production rate comes from a batch that includes those unproductive layers. Therefore, even though the 50-no and the 25-yes batches have similar production rates (58%) to that of the original rate at Tazara (59%), the actual production might have decreased.

Cassava had an adverse effect on the health of the layers. In all treatment groups a decrease in the average layer weight was noted from 9% (25-no) to 19% (50-yes). This loss in layer weight and the decrease in egg production for the 50-no and 25-no batches were surprising. The 25-no feed was not only the cheapest but also very well balanced in its nutritional value. Theoretically, the 25-no batch should have had the highest performance. The best explanation that can be given is the mash form in which the feed was offered, which allowed selective feeding. A different trial should be set up, re-demonstrating the same formulas, in pelletized form.

Cassava had a positive influence on the egg quality. Cassava eggs had relatively dark yolk colours. The yolk colour was darkest when cassava roots fully replaced maize. This is surprising due to the fact that the dark yolk colour comes from the natural pigmentation of the cassava leaves, which is included in all cassava diets in equal amounts. There should be no difference between yolk colours amongst the different treatment groups. Another method to increase the yolk colour would be to include, the more expensive, yellow maize in the diet, instead of white maize. Soybean also had a positive effect on egg quality, reducing the occurrence of meat and blood spots in the egg white. In the sensory analysis cassava eggs were much preferred above the control eggs on appearance and taste. The control eggs scored 68% of the time for worst looking and 45% of the time for worst tasting.

Cassava roots can replace 50% of the maize (25-no) in the diets, with similar feed cost per egg produced to the control (28,4 and 26,1 TSh respectively). Final output/egg production is lower and the average weight of the layer is impaired, but this picture will probably change when the feed is pelletized. When the maize price rises and / or when the cassava can be purchased at lower costs, the 25-no diet will quickly become cheaper then the maize-based diet. The inclusion of soybean is not profitable. The feed cost per egg is on average 203% higher then the cost of the control feed.

Recommendations for future experiments

In a next study, the experimental design should allow an accurate statistical analysis of the results. This may not add to the positive reputation of cassava in the animal feed industry in Tanzania, but it is important to conduct a proper statistical analysis to obtain estimates of the significance of differences between treatment groups.

The method of conducting the trials at existing farms should be repeated. The results of such trials are more representative of the result obtained by the animal farmers themselves, than when the results are obtained on research compound. Also, the reputation of cassava could spread more rapidly.

In this study, one of the objectives was to demonstrate the potential of cassava by conducting trials. Unfortunately, the growth rates and egg production were lower for the cassava treatments than for the controls. The reasons for this were previously mentioned. However, it became clear that people could be influenced by the outcome of demonstration trials. The owner of Rulu farm, for example, decided to change her feed to the control feed due to the increase in layer performance. For the demonstration trials to be as effective for the adoption of cassava, the demonstration trials should be repeated with pelletized cassava diets, preferably supplemented with methionine. As mentioned before, pelletized cassava diets are expected to result in a higher poultry performance.

Observations by Julián Buitrago (CLAYUCA consultant) on the results obtained in the feeding trials

- The feeding trials with high levels of cassava root meal conducted under Tanzanian conditions showed erratic results in broilers and layers, both in performance as well as in mortality. Overall performance of broilers and layers was quite poor in all trials, including commercial controls (final weight at 6 weeks is slightly higher than 1.0 kg, compared with 2.0 kg in commercial broiler production). Mortality was quite high in diets with high levels of fishmeal.

- In contrast, high levels (50%) of cassava meal have demonstrated excellent performance when mixed with other high quality feed ingredients in other regions. Broiler diets with 50% cassava root meal and 6% cassava leaf meal resulted in excellent weight gain and feed conversion when mixed with fullfat soybeans (whole seeds) processed by roasting or extrusion. This type of diets did not produce the same results in the Tanzanian demonstrations. Some of the limiting factors may include:

- The type of fishmeal used in Tanzania is of poor nutritional quality (high ash, high fat, low protein) and with a high microbial contamination. The open processing of fishmeal does not provide the minimal sanitary conditions and opens the entrance to Salmonella, E. Coli and Clostridium. These microorganisms may originate diseases, which will affect performance and produce high mortality. The diets with high cassava are more susceptible to microbial contamination since they will contain higher levels of fishmeal. The high level of fat in fishmeal will also facilitate oxidation and rancidity of the diet, which has a negative effect in animal feeds

- Cottonseed cake (CSC) is not a recommended ingredient for poultry diets. Levels higher than 8 % may produce toxicity because the gossypol content will be dangerous. Poor growth and high mortality may be produced with high CSC in broilers and layers.

- High cassava meal diets should be pelletized in order to obtain best results. Otherwise there is a trend for feed picking which will affect the nutrient balance and will result in poor flock uniformity. Unfortunately there is not a pelletizer available in Tanzania, which is a very important tool when high levels of cassava meal are going to be used in poultry diets.

- Soybeans are an excellent protein and energy ingredient for poultry, especially when mixed with cassava root and cassava leaf meals. Levels up to 60% cassava meal and 30% full fat soybeans may be used with a very high performance and a very low mortality. However the processing of soybeans should be controlled very carefully both in the temperature and the retention time during processing. Under or overprocessing will have a negative effect. Extrusion or roasting has to be carefully controlled in order to obtain the best results. Soybeans is a very complete ingredient with a high level of energy (3,700 kcal /kg) and a high level of protein (38%) in comparison to other common feed ingredients:

- Raw soybeans contain some antinutrients (antitrypsin), which disturb the digestion of proteins. Fortunately a precise heat process can eliminate these antinutrients. Underprocessing does not eliminate the antinutrients and overprocessing destroys part of the feed proteins.

a.2. Malawi

In Malawi, a different approach was followed to establish an animal feeding demonstration trial. Initial contacts with some representatives of the poultry sector were not successful; one of the largest poultry producers expressed his current satisfaction with maize-based feeds and technical assistance from South Africa and refused to conduct any trial incorporating cassava in their formulas. The sector in which there was a positive response was the dairy sector, and more specifically on the possibility of using cassava leaves as a protein supplement for milking cows.

Dairy farmers in Malawi face constraints due to short supply of raw materials. When there is a food deficit in the country, some of the raw materials (maize bran, rice bran) are used to supply the food deficit in rural areas and the availability of raw materials for feeding cows is affected.

After several contacts and meetings with Land O'Lakes (LOL) and the Central Region Milk Producers Association (CREMPA), it was decided to organize a workshop for dairy farmers to demonstrate methods of intensive production of cassava foliage and also the technique to produce good quality silage with cassava leaves. As a follow up of this activity, some trials with milking cows were designed. These trials were to act as a demonstration effect. LOL promotes the production and utilization of milk in Malawi through technical assistance, introduction of artificial insemination techniques, extension services and training. LOL is very keen to technology interventions and has had good results in the past. For example, using improved feed (molasses), milk yields have increased from 3 to 5 liters per day. Formulations were based on the use of molasses,

maize, cement and other raw materials. Experiences with cassava were new for them and decided very enthusiastically to participate in the trials. The Figure 2 presents some of the results obtained. Values represent the average daily milk production of 3 cows that were fed with cassava leaves silage and 3 cows fed with maize/grass silage. Both groups were milked during 80 consecutive days. It can be observed that milk production of cows fed with the cassava silage was, if not superior at least equal, than the production of the cows fed with maize/grass. This could be a very important opportunity to promote a more intensive use of cassava, roots and leaves, in the dairy sector of Malawi. These results, although very encouraging, have to be taken with some caution because they were obtained in Katete Farms, one of the largest milk producers in Malawi, under real life conditions, but the scale of the trial was small. What is important is the indication these results are giving about the great potential of cassava to become a raw material for the dairy sector. Further studies, with more scientific basis need to be conducted in the future.

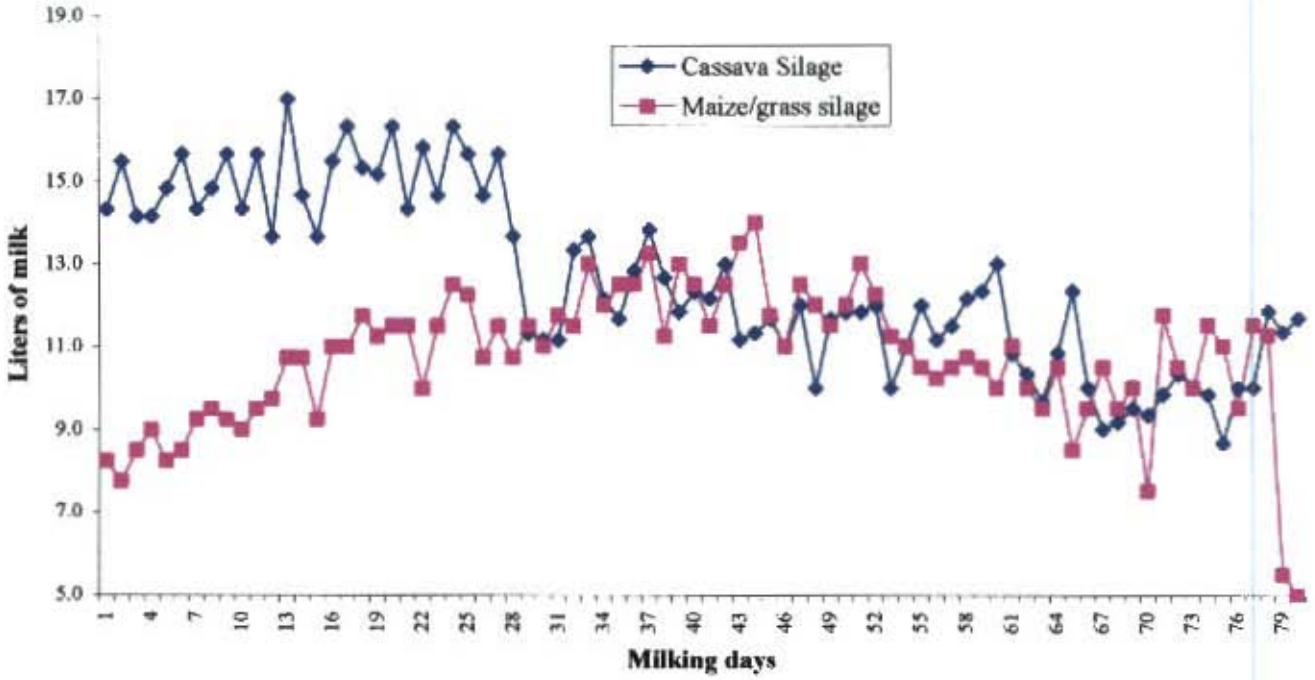


Figure 2. Performance of milking cows in Malawi fed with cassava silage.

b. Establishment of at least one pilot project using the integrated product development approach

b.1. One pilot project operating in Tanzania.

In 2002, the SARRNET team in Tanzania initiated a pilot project in the village Bungu located 140 km south of Dar es Salaam. This region was selected as a potential area for transferring improved cassava processing and marketing technologies, based on

the difficulties that farmers were facing to sell the cassava roots in the Dar es Salaam market. Cassava traders prefer to buy cassava roots from farmers located nearer the capital, mainly due to poor road communication between the capital and the far distant villages like Bungu. This village was chosen as the pilot project area considering its high cassava production, high yields (20 MT/ha), low pest and disease pressure and the growing importance of the crop as a major cash income for farmers since coconut and cashew nut production are declining in the region.

Prices paid by cassava traders in villages near Dar es Salaam are as high as US$ 30/ton (March, 2003), whereas in regions like the Bungo village, the prices paid to cassava farmers are around US$ 15 / ton. Farmers around Bungo village traditionally eat the cassava roots in fresh form or processed in the form of a product called Makopa (medium to large size chips dried for 8 to 10 days). This long processing period produces some fermentation of the cassava chips and very often the final product contains a lot of dust, fungi and soil particles.

One of the strengths of SARRNET was precisely the availability of chipping and drying technology for cassava chips. These technologies includes: a) a simple chipper motorized with a 3.5 horse power petrol engine, with capacity to produce 400 to 500 kg of fine cassava chips per hour, and with a total cost of around US$ 400 per unit; b) a drying method usually based on raised drying trays that allow reduction of the moisture in the chips to safe levels within one day of exposure to the sun. These two components represented the technological intervention that was presented to the farmers in the Bungo village. The idea of setting up a pilot project based on this innovation was presented to the farmers during a public demonstration conducted in the village with the help of local agricultural, extension staff and farmers leaders.

During the demonstration, SARRNET officers brought to the village the chipping unit and some drying trays. Both men and women tested the equipment and became very interested in the clean and white cassava chips produced. They later took home the dried chips and have them tested in their traditional foods. Additionally, SARRNET officers took the high quality cassava chips into Dar es Salaam and established contacts with potential markets that became very interested in the product.

After the successful demonstration, building upon the interest shown by farmers, the SARRNET team and collaborating institutions in Tanzania decided to establish a small-scale processing plant, as the pilot project site, with the Mpondi Farmer and Business Group, a very well organized group of farmers engaged in cassava production and very eager to get involved in cassava processing in commercial scale. The deal proposed to farmers was that SARRNET would provide the drying trays and the chipping unit whereas the farmers will be responsible for building the processing shed. The eight members of the Mpondi group contributed with their own cassava roots and provided the labour required for the processing activities. Very soon the pilot plant was operating and the group was in business with urban markets.

The farmers group received direct, learning-by-doing training on the processing technology. Some of the farmers were also taken to the capital to visit major markets and get acquainted with potential buyers. By May 2002, the group was fully operating the cassava processing pilot plant with an output capacity of around 400 kg of high quality cassava chips per day.

A significant economic impact has been achieved with this simple, small-scale, affordable technological intervention. Farmers are now able to sell their cassava roots at better prices to the processing unit, which is located near their cassava plots. Before SARRNET intervention, they were having difficulties selling the cassava roots since the only available market were few traders visiting the region. The prices they received were very low. With the new market, the prices they receive are higher and additionally, the processing activities at the pilot plant are creating employment opportunities, especially for older people and women that take care of peeling the roots prior to chipping and drying. Also, other villages and local traders have started to buy their high quality chips instead of the traditional Makopa. Another very important advantage is that farmers are now able to sell older cassava roots coming from plots that have more than one year of growing cycle. The traders do not buy the roots coming from these old cassava fields. In the processing plant, the old, oversized roots are easily transformed into cassava chips and find a market. In general, cassava farmers in the vicinity of the processing unit are now interested in increasing the size of their cassava plots.

For SARRNET, the success obtained in the establishment of the first cassava pilot project in a Tanzanian village has been very helpful in promoting a better integration among local institutions. The Root and Tubers Crop Research team at Kibaha and the technical personnel from the Rufiji District, for example, are now promoting very enthusiastically the expansion of these results in other cassava growing areas and regions of Tanzania. Technical personnel from the Tanzanian Food and Nutrition Center (TFNC), private sector entrepreneurs and farmer groups have also become very active collaborators.

The impact obtained by SARRNET with the application of the pilot project concept as a strategy to link farmers to markets can be analyzed from two angles. First, is the rapid diffusion of the innovation among farmers within the village. Early innovators were allowed to use the technology, adapt it, make their own adjustments, and very soon other groups took up the initiative and engaged also in setting up similar processing units. In few months, there were 5 processing plants located in a radius of not more than 40 kilometers around Bungo Village. Secondly, there has also been impact at national level. By March-April 2003, the SARRNET team in Tanzania, together with collaborating institutions were invited to visit other regions, in South Tanzania, to discuss with regional and district level authorities the possibilities of implementing similar work. The discussions moved forward to the extent that plans are underway to establish new pilot projects in this region, based on the same concept and methodology used in the Bungo village. It is expected that by the end of 2003, with financial support coming from the local authorities and districts, these new pilot projects will be functioning. A clear example of the quick adoption and diffusion of an innovation technology when it its

meaningful to the main beneficiaries, the cassava farmers. Annex I presents additional information and some pictures that illustrate the activities conducted at the Bungo Village Pilot Project.

b.2. One pilot project operating in Malawi

In Malawi, a similar approach was followed to set up a pilot project through which the concept of the "linking farmers to markets strategy" could be tested. The area selected for the pilot project was Phalombe, one of the 27 districts of Malawi, located 137 km east of Blantyre, the most commercial city of the country. In the region, the major source of income for farmers is the sale of agricultural products such us maize, pigeon pea and sunflower. Traders who establish temporary purchasing places dominate commercialization of agricultural products. The agricultural products are transported later to the city of Blantyre for use in human consumption and industrial markets.

Through a strategic alliance with the Christian Service Committee (CSC), an international NGO with operations in Malawi, the SARRNET team in Malawi initiated the pilot project in the Phalombe region. Farmers from eight villages were invited to participate. The initial contact with farmers was made through a sensitization meeting held at Kolowiko village, attended by over 200 farmers, mostly women. The objective of this meeting was to sensitize framers about the importance of cassava as a cash crop, for food security and also as a strategy for opening and strengthening new markets for their agricultural products. The concept of using improved processing technology to produced improved quality products with which to open new markets was discussed with the farmers. SARRNET staff brought over four motorized cassava chipper units and some drying trays. This initial meeting also allowed farmers to place a strong demand for improved cassava varieties and good quality planting materials. Later on, taking advantage of the existence of cassava planting material nurseries in two research stations (Chitedze and Kasinthula), SARRNET and CSC provided planting material of two recommended varieties. 100 farmers received enough planting material to plant an average of 0.2 ha per family. In addition, 15 demonstration plots were planted using one improved clone.

The results obtained with the pilot project approach were not as encouraging as those obtained in Tanzania. Although the acceptance of the technology by the farmers was very good and the chips obtained were of improved quality compared with the traditional ones, the factor that proved to be the most limiting one was the very long distance between the pilot project site and the main road that communicates with the urban markets. The private sector companies contacted during the surveys were interested in purchasing the cassava chips but they refused to collect them at the village. The high cost of taking the chips from the village to the main road and later to the urban markets made the whole operation very difficult. Although some few tons of cassava roots were chipped and sold, in general, the pilot project strategy required some adjustments. For example, the dried chips can be stored in a place located on the main road, paying lower transportation costs; once a sufficient volume is completed, a buyer could be sought that would be willing to collect the chips at this place. Of course, this will mean additional

bargaining abilities and power by the farmers. The final price that farmers will receive for the chips has to account for the transportation costs between the pilot project site and the main road storage place. As part of the pilot project work conducted in Malawi, some cassava production trials were implemented. Results obtained are presented in Annex 2.

c. Participation in the process of translation of the book "El uso de la yuca en la alimentacion animal", from Spanish to English and formatting for web publication.

This activity has been conducted over the last two years. This book, one of the most important bibliographic references existing in Latin America for this topic was originally published by CIAT in 1990 and has 444 pages in its original Spanish version. During the last decade, the book sold well all over the Continent and is now totally sold out at CIAT's publication unit. The idea to translate it into English language was originally proposed to CIAT and CLAYUCA by FOODNET, the IITA network operating in East African countries.

To accomplish this objective, CLAYUCA hired a translator who was in charge of producing a first, non-edited translation. Later, Dr. Julian Buitrago made a revision and his corrections were incorporated in the draft text. At this stage, in October 2003, the draft text was delivered to Foodnet (Dr. Shaun Ferris) for a final, scientific editing work. The idea is to format the final document into a web-page style so that it can be easily and quickly disseminated.

In the future, CIAT and CLAYUCA intend to publish a second edition of this book, in English language, adding two or three chapters and changing the style of the book into a more user-friendly format.

d. Participation in the translation of relevant information on cassava postharvest technologies into English language

This activity has been conducted systematically through the duration of the present agreement. Two main documents were translated into English language and were delivered to SARRNET, as paper copies and also in electronic form (PDF documents). The first document translated was ***"Cassava in Poultry Feeding"***, originally published by CLAYUCA in Spanish, with financial support from the Colombian Poultry Growers Federation-FENAVI. The English version was delivered to SARRNET in May 2002.

The second document translated was ***"Cassava in Dairy Feeding"***, published originally in Thai language and translated to English with financing from CIAT-Bangkok and CLAYUCA. The document is been handled to SARRNET as printer document and also as an electronic PDF file.

Additionally, various presentations and documents were delivered systematically during the period of this agreement, to SARRNET officers in Tanzania and Malawi. These documents contained information on processing technologies, quotations for processing equipment and other general aspects about cassava postharvest technologies.

They were delivered in the form of CDs, video, Power Point presentations and paper documents.

e. Participation in translation of cassava post-harvest handling and processing technology information system into English

To accomplish this objective, the following activities were realized:

a) Collection and incorporation of relevant additional information into the database on post-harvest handling and processing of cassava.
b) The design of an appropriate format for use in cd rom and Internet format.
c) Translation of the Spanish version into English.

The Cassava Post Harvest Management and Processing System is divided into the following sections for easy access and visualization of the information.

i. Cassava: Overall context. This section indicates to the user the scope of the system and general information about the importance of cassava, yields, production and nutritional value.

ii. Post-harvest handling. This section presents information on one of the principal limitations to increased utilization of cassava, as regards the rapid post harvest deterioration, which often makes the roots unsuitable for human consumption and other uses within 48 hours. Techniques for preventing deterioration are presented.

iii. Processing and utilization. This section provides technical and economic information on the different agroindustrial uses of cassava: traditional products, dry cassava and derived products, starch, foliage, co-products and solid and liquid by-products. For each process, information is provided on scales of operation, mass balances, equipment and investment costs.

iv. Quality control. This section includes the available information on the quality standards for fresh and processed products for national and international markets, together with the description of the methodologies needed to undertake laboratory analysis of key characteristics.

v. Future prospects for cassava. This section presents a synthesis of the most important aspects of the preceding sections, and highlights some of the on-going post harvest research on the crop.

vi. Contacts and additional sources of information. This section gives details of institutions, data bases, libraries, networks and other systems that can be contacted to obtain additional information related to the post harvest handling and processing of cassava.

vii. Bibliographic references. This section includes the references used in the development of the system.

The system has been developed to ensure a wide diffusion and information access to cassava farmers and processors, local development agents, rural agroenterprises, NGO's and governmental decision makers. The system has been placed on the website of CIAT's Rural Agroenterprise Development project for consultation using the FrontPage software both in Spanish and English. The English version is available on a cd rom. The front page of the system is shown in Figure 3.

3.4 Theme IV. Stakeholders trained in new skill to support the market driven strategy

3.4.1 Introduction

Participation of CIAT and CLAYUCA technical personnel in the implementation of the present agreement was conceived as an exercise in which, concepts, information and experiences gained throughout the last 20 years of work in Latin America, were to be shared with technical personnel from IITA and SARRNET, in the first instance, and to a lesser extent, with technical personnel from the national institutions and other agencies in Tanzania and Malawi that are collaborating with SARRNET.

3.4.2. Expected result:

Updated knowledge amongst key SARRNET stakeholders about cassava production and processing technologies existing in Latin America and with potential to be adapted to the specific conditions of some African countries.

3.4.3. Activities implemented:

1. Facts finding and planning trip to Africa (Tanzania, Malawi), by CIAT/CLAYUCA personnel (Rupert Best, Bernardo Ospina). November, 2000
2. First consultancy mission by CLAYUCA (Bernardo Ospina, Julián Buitrago).February- March. 2001
3. Training course in Agroenterprise Development. CIAT Instructors (Rupert Best, Carlos Ostertag). May 2001
4. Participation of CIAT (Rupert Best) in Steering Committee Meeting. Tanzania. May 2001
5. Second consultancy mission by CLAYUCA (Bernardo Ospina, Julián Buitrago). October-November . 2001
6. Scientific exchange mission of SARRNET personnel to Latin America (Colombia and Brazil). February-March. 2002
7. Participation of CIAT (Rupert Best) and CLAYUCA (Bernardo Ospina) in Steering Committee Meeting. Pretoria. April 2002
8. Third consultancy mission by CLAYUCA (Bernardo Ospina, Julián Buitrago). April-May. 2002
9. Fourth consultancy mission by CLAYUCA (Bernardo Ospina). March 2003.

Theme IV. Stakeholders trained in new skills to support the market driven strategy.

Activity and dates	Participants	Expected output	Indicator (s) for monitoring progress
1.Consultancy missions of CIAT&CLAYUCA technical personnel to Tanzania ands Malawi.	SARRNET Team CIAT CLAYUCA	Updated knowledge of key SARRNET officers about cassava production and processing technologies with potential to be adapted to African countries	Trip report Project Reports I, II and Final
2. Participation of CIAT&CLAYUCA personnel in SARRNET Steering Committee Meetings	R Best B.Ospina	Rupert Best and Bernardo Ospina participated in the Steering Committee Meetings that took place in Tanzania (2001) and Pretoria, South Africa (2002)	Report of the Steering Committee Project Reports I, II and Final
3. Scientific exchange mission of SARRNET team to Latin America	SARRNET Team	Updated knowledge of key technical personnel of SARRNET about cassava production and processing technologies with potential to be adapted to African countries	Trip report Project Reports I, II and Final
4. Training course in Agroenterprise Development.	Rupert Best -CIAT Carlos Ostertag - CIAT	Technical personnel of the national institutions collaborating with SARRNT trained on the basic concepts of design, execution and monitoring of root agro enterprise projects	Training Report Project Reports I, II and Final
5. Participation in the design, preparation and follow-up of a course on integrated root crop agro enterprise projects. NOTE: This training activity was not realized	R Best CF Ostertag M Lundy	Technical personnel of the national institutions involved in the integrated root crops agro enterprise projects trained in project design, execution and monitoring.	
6.Other training activities Two additional training activities proposed were not realized: a) Animal feed sector and technical personnel in Malawi and Tanzania trained on technologies for the use of cassava and sweet potato in animal feeding b) Selected personnel in Malawi and Tanzania trained as facilitators	R Best –CIAT C Ostertag - CIAT B Ospina-CLAYUCA J Buitrago - CLAYUCA S Kolijn -IITA S Ferris - IITA	Formation of a group of key technicians with updated information on strategies to promote market-driven approach for cassava and sweet potato sustainable development	

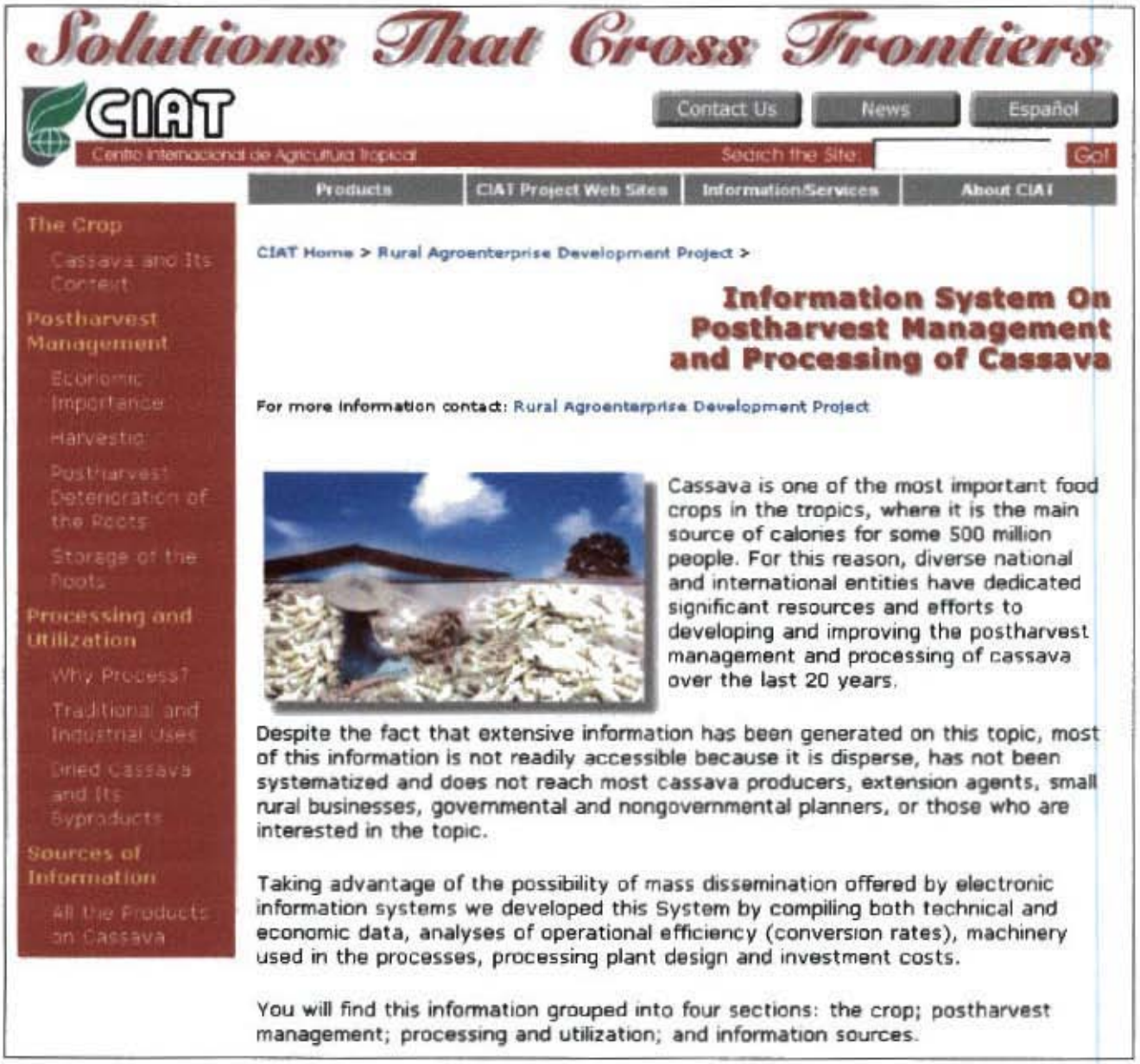


Figure 3. Web page of the Information System on Cassava Postharvest Management and Processing.

3.4.4 Results achieved:

After two years of activities it can be said that this objective was fulfilled satisfactorily. The execution of this collaborative agreement became an excellent opportunity for personnel of both International Centers (IITA and CIAT), to make a more efficient, complementary use of each institution skills and comparative advantages on behalf of the sustainable development of the cassava crop in Africa.

Benefits have accrued from this collaborative agreement in both directions. Stakeholders of SARRNET in Tanzania and Malawi have had the chance to know about the experiences of CIAT on cassava development in Latin America but also, CIAT and CLAYUCA technical personnel have gained invaluable experience about the current situation of cassava in this part of Africa, the challenges and the opportunities.

In general it can be said that some of the key stakeholders of SARRNET are now better informed about the potential opportunities that can be derived by applying a market driven approach to cassava research and development activities.

4.0. Conclusions and recommendations

4.1 Introduction

CIAT and CLAYUCA were invited by IITA-SARRNET to provide conceptual and practical input into the process of realigning SARRNET from a predominantly production focus aimed at meeting food security objectives to a more market and enterprise orientation, with a view to satisfying the increasing need for providing income and employment generating opportunities for cassava and sweet potato farmers.

4.2 Major achievements

The major achievements over the period November 2000 to September 2003 have been the following:

Theme IV. Stakeholders trained in new skills to support the market driven strategy.

Activity and dates	Participants	Expected output	Indicator (s) for monitoring progress
1.Consultancy missions of CIAT&CLAYUCA technical personnel to Tanzania ands Malawi.	SARRNET Team CIAT CLAYUCA	Updated knowledge of key SARRNET officers about cassava production and processing technologies with potential to be adapted to African countries	Trip report Project Reports I, II and Final
2. Participation of CIAT&CLAYUCA personnel in SARRNET Steering Committee Meetings	R Best B.Ospina	Rupert Best and Bernardo Ospina participated in the Steering Committee Meetings that took place in Tanzania (2001) and Pretoria, South Africa (2002)	Report of the Steering Committee Project Reports I, II and Final
3. Scientific exchange mission of SARRNET team to Latin America	SARRNET Team	Updated knowledge of key technical personnel of SARRNET about cassava production and processing technologies with potential to be adapted to African countries	Trip report Project Reports I, II and Final
4. Training course in Agroenterprise Development.	Rupert Best -CIAT Carlos Ostertag - CIAT	Technical personnel of the national institutions collaborating with SARRNT trained on the basic concepts of design, execution and monitoring of root agro enterprise projects	Training Report Project Reports I, II and Final
5. Participation in the design, preparation and follow-up of a course on integrated root crop agro enterprise projects. NOTE: This training activity was not realized	R Best CF Ostertag M Lundy	Technical personnel of the national institutions involved in the integrated root crops agro enterprise projects trained in project design, execution and monitoring.	
6.Other training activities Two additional training activities proposed were not realized: a) Animal feed sector and technical personnel in Malawi and Tanzania trained on technologies for the use of cassava and sweet potato in animal feeding b) Selected personnel in Malawi and Tanzania trained as facilitators	R Best –CIAT C Ostertag - CIAT B Ospina-CLAYUCA J Buitrago - CLAYUCA S Kolijn -IITA S Ferris - IITA	Formation of a group of key technicians with updated information on strategies to promote market-driven approach for cassava and sweet potato sustainable development	

1. The development and adoption of a systematic process for gathering and analysing opportunities for the industrial use of cassava and sweet potato that is both rapid and efficient in the use of resources. Through the use of this process, potential private sector interest was assessed, both in the use of these crops as raw materials and as partners in R&D activities.

2. Appropriate regions, or 'territories', where cassava and sweet potato have a comparative advantage for supplying certain markets were identified and the actors involved have been convened to initiate the process of consolidating value chains focused on specific market outlets.

3. There is raised awareness among the private sector of the potential for the use of cassava and sweet potato roots and leaves in animal feeding, especially for poultry and dairy cattle. Similarly, the competitive use of cassava-derived products in the non-food industry has also been confirmed, and in particular with respect to adhesives manufacture. A number of public-private R&D projects have been initiated where none existed previously.

4. A greater awareness among SARRNET personnel of the benefits that can be derived from enhancing opportunities for South-South interchange of technologies and information, especially with Brazil and other Latin American countries.

4.3 Conclusions

The major conclusions that can be derived from this experience are:

1. The basis has been established for quick and appreciable socio-economic impact through scaling-up of the on-going pilot activities in the areas of cassava flour for direct sale to consumers in Tanzania (Power Foods), and the use of cassava foliage in dairy feed in Malawi (Land O'Lakes).

2. The formation of Public-Private Partnerships is a process that does not occur overnight and is one that requires perseverance and patience. Time is required to consolidate partnerships as trust and confidence is built. Good starting points have been achieved in Tanzania and Malawi. It is evident that in each country at least one PPP needs to be established and consolidated, as show case pilot experience, before contemplating wider national PP consortiums.

3. The relative cost and quality competitiveness of the cassava and sweetpotato sectors is critical to the medium term economic sustainability of the fledgling production and processing enterprises and their respective supply chains. R&D on marketing and processing has to go hand-in-hand with complementary and well-targeted agronomic research and the provision of development services such as seed multiplication and other input supply.

4. An entrepreneurial spirit to program development is essential. This means being proactive in approaching the private sector, not only in terms of potential markets, but also in terms of engaging appropriate technological solutions. Immense benefit can be obtained from South-South exchange of information and technology, with the possibility of enhancing trade among continents. Both public and private sector personnel should be motivated (and perhaps facilitated) to look for novel approaches beyond national and regional boundaries.

5. The present project provided a focused and meaningful opportunity to make use of the complementary skills and comparative advantage of two international agricultural research centers. Much has been learned about the appropriate mechanisms for achieving this type of cooperation. Among the most important lessons are:

   a. Despite the relationship being contractual in nature, more is accomplished if synergy among the participating institutions can fostered by engendering a climate of mutual respect and trust. This creates a climate of joint ownership of the process.
   b. When this respect or trust is questioned, potential impact can be considerably curtailed, as the motivation for going beyond the immediate terms of a contract are reduced;
   c. Responsibilities and recognition of successes and failures must be shared among partners;
   d. Mechanisms for reorienting and correcting deficiencies in the execution of the contract, should they occur, need to established and adhered to. Communication should be open and transparent.

   These lessons should be taken into account in designing and carrying out future cooperation of this nature.

ANNEX 1.

A SUCESSFUL HISTORY OF SARRNET IN TANZANIA

Topic: **Development of small-scale cassava processing enterprises**
Title: **High quality cassava chips for human consumption: a promising income and employment option for cassava farmers in Tanzania"**

Background

- Cassava in Tanzania is a very important crop
- In some regions, with coconut and cashew production declining, it is the major source of food security and income
- Limited market alternatives is one of the principal constraints faced by cassava farmers
- Road access is not very well developed. High transport costs make it very difficult to sell cassava roots and cassava-based products in urban markets. Usually, farmers have to sell their harvest to middlemen
- Farmers use mainly traditional varieties with very little external inputs. Fertilizer use is virtually non-existent
- Traditional cassava processing technologies are common and products obtained (ej. Makopa dry cassava chips) have poor quality and are sold at very low prices
- Farmers work mostly individually with very little bargaining power.

The Intervention
"Technological and organizational innovation"

a. *Results from research in similar areas existed*

- IITA has conducted research and technology transfer activities in Africa, based on improved technologies for small-scale cassava processing agroindustries. These technologies had not been tested in Tanzania before.
- CIAT and CLAYUCA had experiences of the implementation in Latin America of the "Linking Farmers to Markets" and the "Integrated Cassava Development Projects" approaches.

b. *Pilot phase (Field trials of technological and organizational innovations)*

- IITA and SARRNET, with consultancy support from CIAT and CLAYUCA, started a pilot project with farmer groups in Bungu, Rufiji district, a major cassava growing region in Tanzania
- Key stakeholders (farmer groups, NARS) participated actively in the pilot project, evaluating the prototypes provided by IITA/SARRNET and making adaptations.
- Stakeholders accepted the innovation as a "winner".

Results of the Pilot Phase
The Adaptation

A. Technological innovation

- High quality chips are white, clean and can be used to replace partially wheat and maize used in the preparation of biscuits, home baked products and ugali.
- Drying cassava minichips on raised drying racks avoids fermentation and long periods of exposure to soil and dust contamination. Final quality of the product is very good
- Cassava processing activities are facilitated with the use of the prototypes introduced. Instead of chipping the roots with knives, farmers now use a chipper run with a petrol engine. Their efficiency has improved greatly. The quality of the chips (geometry, size uniformity, thickness) is better and drying time has been reduced.

B. Marketing innovation

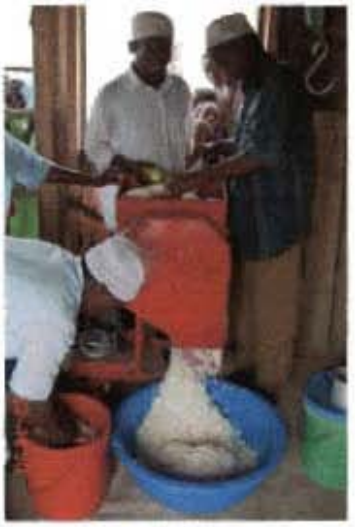
- Instead of selling the cassava roots individually to middlemen, farmers are now able to commercialize their crop transformed into high quality chips, in larger volumes and at higher prices.
- Besides the benefits of higher prices paid by their roots, farmers are also benefiting from lower transport costs and the possibility of selling old cassava plots

By selling their cassava roots to a processing plant located within their own village, farmers get a fair weight, a better price and payment is usually done on the spot. Their net income from cassava has increased.

technologies. With an improved, more profitable marketing system, farmers are now getting interested in cost-reduction technology components.

Results of the Pilot Phase
Economic benefits of the innovation

Costs of processing dry cassava chips Bungu, Tanzania, March 2002		
Cost of fresh cassava *(3.5 kg fresh for 1 kg chips,* *20 Tsh/kg fresh)*	(Tsh/kg dry chips) 70	
Cost of peeling *(5 Tsh/kg fresh)*	17.5	
Operators (3 persons/day ; 1000 Tsh/person; 1,000 kg dry chips 2 days)	6	
Other costs *(Depreciation, fuel, bags, loan, etc.)*	20	
Total cost	113.5	

Costs of commercialization, Bungu, Tanzania, March 2002 **Target Market: Dar es Salaam**		
Cost of processing *(1 kg of dry cassava chips)*	**(Tsh / kg)** **113.5**	
Cost of transportation *(25 Tsh / kg dry cassava chips)*	**25**	
Current selling price (Delivered in Dar es Salaam) (Ts / kg dry cassava chips)	**180**	
Net Profit for farmers (Tsh / kg dry cassava chips)	**41.5**	

The benefits for farmers participating in the dry cassava chips operation accrue from:

a. Higher price for roots
b. Employment opportunities for elder people and women
c. Less dependence on traders
d. Cassava older than 1 year has a market
e. Good quality dry cassava chips is allowing them to enter urban markets and demand is increasing

Income opportunities for cassava farmers in Tanzania		
Fresh Market Assuming: ➢ Yield of 15 t / ha) ➢ Fresh market price Tsh 15 / kg	(Tsh/ha) 15,000 x 15 **225,000**	
Dry cassava chips market (roots sold at the processing plant gate) Assuming: ➢ Yield of 15 t / ha ➢ Processing plant price 20 Tsh / kg	(Tsh / ha) 15,000 x 20 **300,000**	
Farmers Group (Owners of the processing plant) Assuming: ➢ Processing costs of 138.5 Tsh / kg dry cassava chips ➢ Selling price of 180 Tsh / kg of dry cassava chips	Income per kg of dry cassava chips **41.5 Tsh**	

One group of cassava farmers in Tanzania can now, with the technological and organizational innovation obtained developed by SARRNET, establish a different cassava production, processing and commercialisation system. For example, if 20 farmers get together and organize a dry cassava chips cassava-processing plant, and each farmer sells to the processing plant 15 t of cassava roots, the plant will be able to operate 100 days a year, will process 100 t of dry cassava chips (1 t per day) and net profit would be around 4.950.000 Tsh per year. This amount is equivalent to approximately US$ 4,620. Divided by 20 members, it means an extra income of around US$ 230 per farmer.

ANNEX 2.

CASSAVA PRODUCTION IN MALAWI–FIELD TRIALS

SARRNET initiated in October 2001 some field trials aimed at evaluating the technical and economic feasibility of intensive production systems for cassava and sweet potato leaves and roots in Malawi. These trials were conducted at the experimental site Kindajani, at the Chitedze research station in Lilongwe. These trials were kept growing for two consecutive years. Throughout this period, SARRNET team in Malawi used this experimental site as a demonstration site, very easy to access, in which several field days and demonstrations took place. Some of the experimental results obtained are presented as follows:

Cassava leaves production trial–Ratooning system

Three varieties (Silira, Mbundumali,Maunjiri)
Four planting distances: (1x 1); (0.5 x 0.5); (0.9 x 0.50) and (0.30 x 0.30) meters
Three repetitions, planting date: October 2001.
Four harvest periods: 15, 24, 44 and 56 weeks after planting
Area harvested: 15,6 sq.mt
Harvest system: ratooning

Table 5. Cassava leaves trials in Malawi–2001–2002. Ratooning harvest system.

Treatment (Variety x planting distance)	Fresh weight (ton/ha)
Silira (1 x 1)	35.7
Mbundumali (1x1)	41.1
Maunjiri (1x1)	39.8
Silira (0.5x 0.5)	40.4
Mbundumali (0.5x 0.5)	39.4
Maunjiri (0.5 x 0.5)	39.2
Silira (0.9x 0.5)	25.1
Mbundumali (0.9x 0.5)	38.9
Maunjiri (0.9x 0.5)	29.9
Silira (0.3 x 0.3)	44.9
Mbundumali (0.3 x 0.3)	46.2
Maunjiri (0.3 x 0.3)	33.0

Fresh weight is the average of five harvests at 15, 24, 44, 55 and 65 weeks after planting

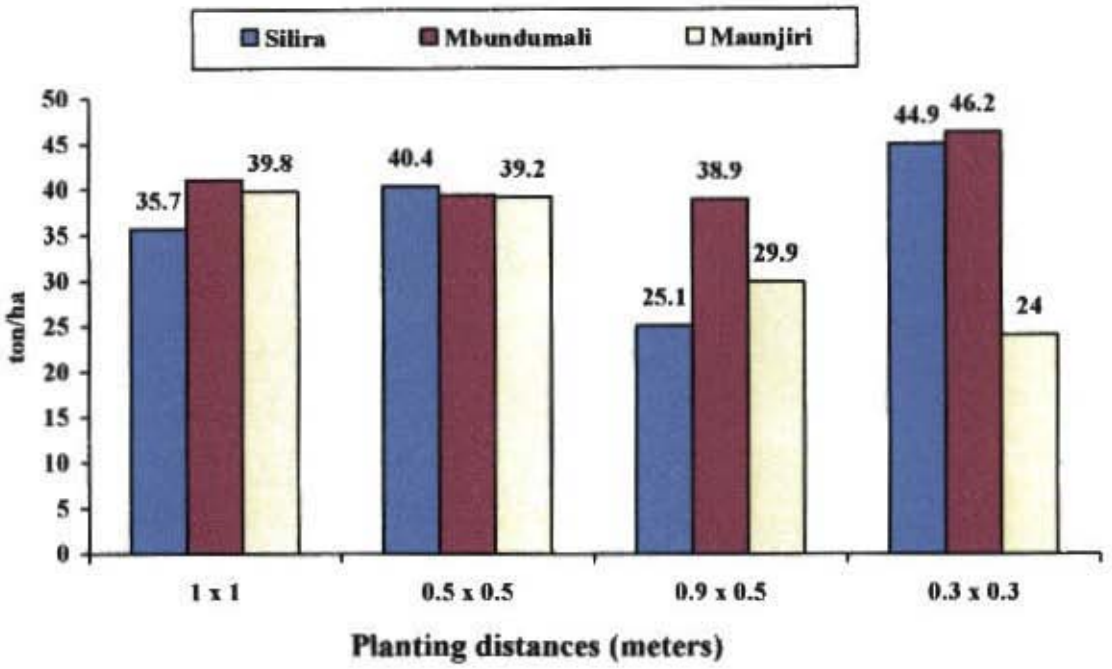


Figure 4. Cassava leaves production trial in Malawi. Ratooning system, total yield in five harvests.

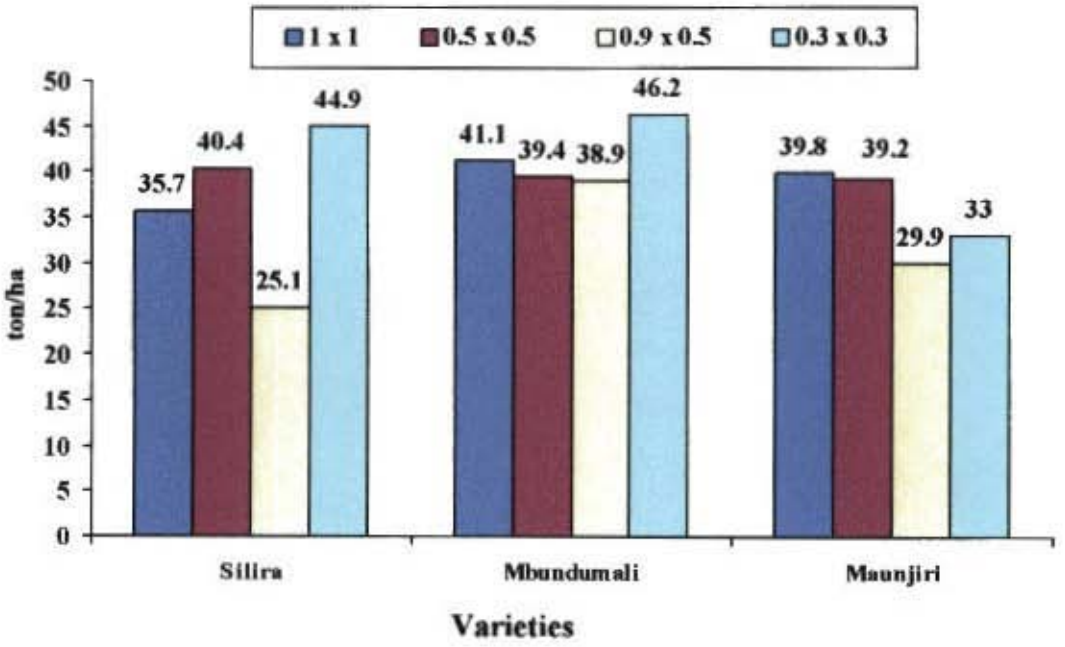


Figure 5. Cassava leaves production trial in Malawi. Ratooning system, total yield in five harvests.

Cassava leaves production trial–Detopping system

The experimental work with intensive cassava leaves systems in Malawi also included a comparison between the ratooning and the detopping system. The main difference is that the height of the plant at which the harvest is done. With the ratooning system, the cutting is done at the same height, about 20 cmts from the floor whereas with the detopping, the height at which the cut is done is usually higher.

The treatments, repetitions, planting distances and management of the crop were the same.
Three varieties (Silira, Mbundumali, Maunjiri)
Four planting distances: (1x 1); (0.5 x 0.5); (0.9 x 0.50) and (0.30 x 0.30) meters
Three repetitions, planting date: October 2001.
First harvest: February 12, 2002
Area harvested: 15,6 sq. mt.;
Harvest system: detopping

Table 6. Cassava leaves trials in Malawi–2001–2002. Detopping harvest system.

Treatment (Variety x planting distance)	Fresh weight (ton/ha)
Silira (1 x 1)	35.3
Mbundumali (1x1)	38.2
Maunjiri (1x1)	30.2
Silira (0.5x 0.5)	35.8
Mbundumali (0.5x 0.5)	30.8
Maunjiri (0.5 x 0.5)	34.7
Silira (0.9x 0.5)	21.2
Mbundumali (0.9x 0.5)	32.0
Maunjiri (0.9x 0.5)	28.0
Silira (0.3 x 0.3)	45.1
Mbundumali (0.3 x 0.3)	40.4
Maunjiri (0.3 x 0.3)	27.8

Fresh weight is the average of five harvests at 15, 24, 44, 55 and 65 weeks after planting

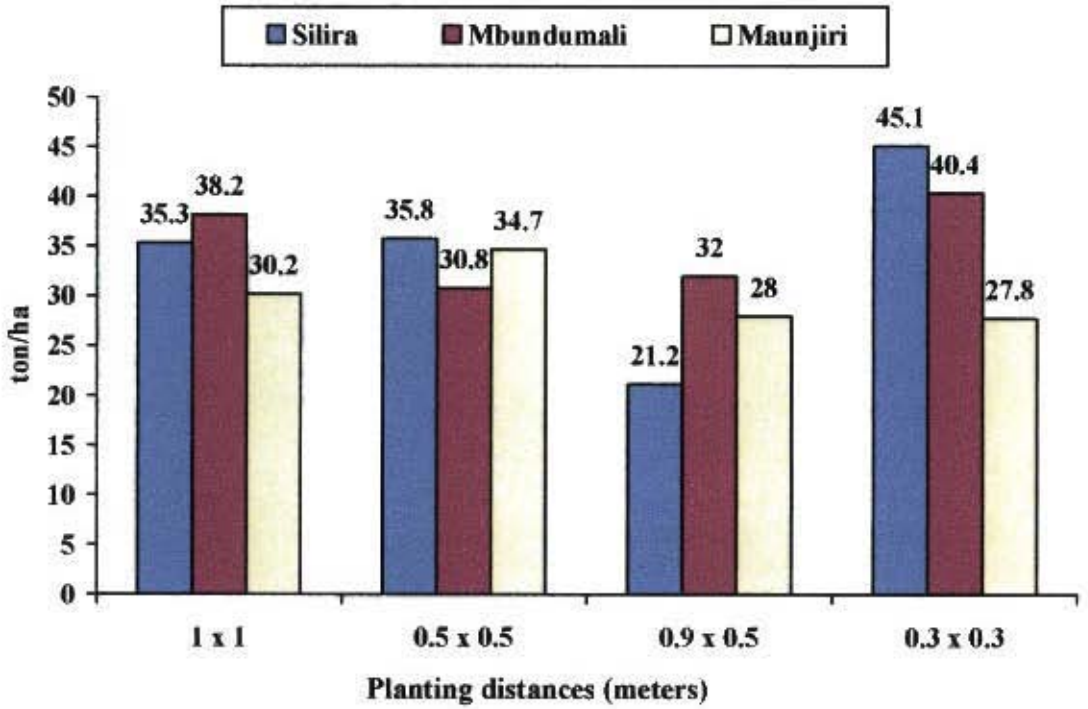


Figure 6. Cassava leaves production trial in Malawi. Detopping system, total yield in five harvests.

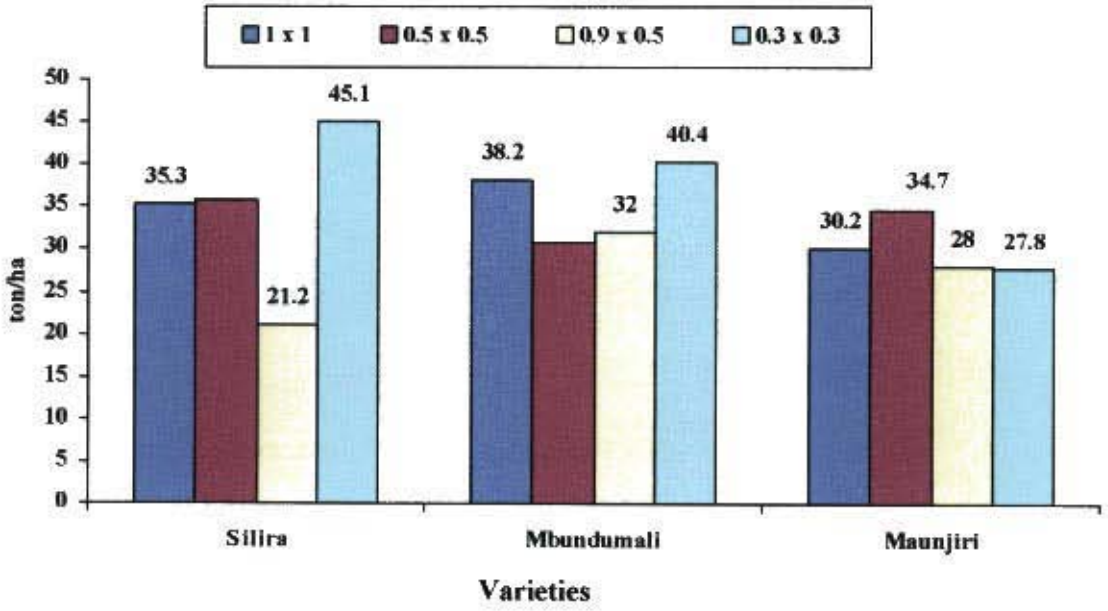


Figure 7. Cassava leaves production trial in Malawi. Detopping system, total yield in five harvests.

The results obtained in the experiments conducted during the last two years allow the following preliminary conclusions:

- The ratooning system was consistently a more productive system for production of cassava leaves. For the three varieties evaluated and with the four planting distances tested, total yield was higher when the ratooning system of harvest was utilized.

- The best results were obtained with the varieties Silira and Mbundumali suggesting a good adaptation of these two varieties to this intensive production system. Planting distances of .30 x 0.30 meters gave the highest yield, for both varieties.

- The rainfall pattern prevailing in one given region is by far the most determining factor in the establishment of intensive cassava leaves production systems, especially in cases where supplementary irrigation is not available.

- From the data obtained it can be observed that cassava plants grow satisfactorily up to the first harvest, then, with the dry season setting in, plant growth is almost stopped and several months later, with more rainfall, plant growth is recuperated. This suggest that in very dry regions, with more than 5-6 months of very low rainfall, the establishment of farming systems for intensive production of cassava leaves could be very risky.

Cassava roots production trial

Taking advantage of the existing experimental plots for cassava leaves production systems; the SARRNET team in Malawi conducted another experiment with the objective of looking at root yield of cassava plants after the last harvest of the foliage, and comparing it with similar plots that have been kept unharvested throughout the period of the experiment (72 weeks, 18 months). Table 7 and Figure 8 present the data obtained

Table 7. Yields of cassava production systems in two growing cycles. Malawi, 2001-2003.

Treatment (Variety x planting distance)	Fresh weight (ton/ha)		
	Detopping system	Ratooning system	Untouched plants
Silira (1 x 1)	18.4	13.0	44.9
Mbundumali (1x1)	28.4	14.3	40.4
Maunjiri (1x1)	33.5	24.6	56.6
Silira (0.5x 0.5)	22.0	11.8	35.0
Mbundumali (0.5x 0.5)	15.2	11.5	31.2
Maunjiri (0.5 x 0.5)	37.2	18.4	48.5
Silira (0.9x 0.5)	18.4	13.5	38.5
Mbundumali (0.9x 0.5)	32.3	17.5	34.2
Maunjiri (0.9x 0.5)	38.2	23.1	45.1
Silira (0.3 x 0.3)	8.3	5.8	20.3
Mbundumali (0.3 x 0.3)	8.8	6.5	13.4
Maunjiri (0.3 x 0.3)	24.8	15.1	44.9

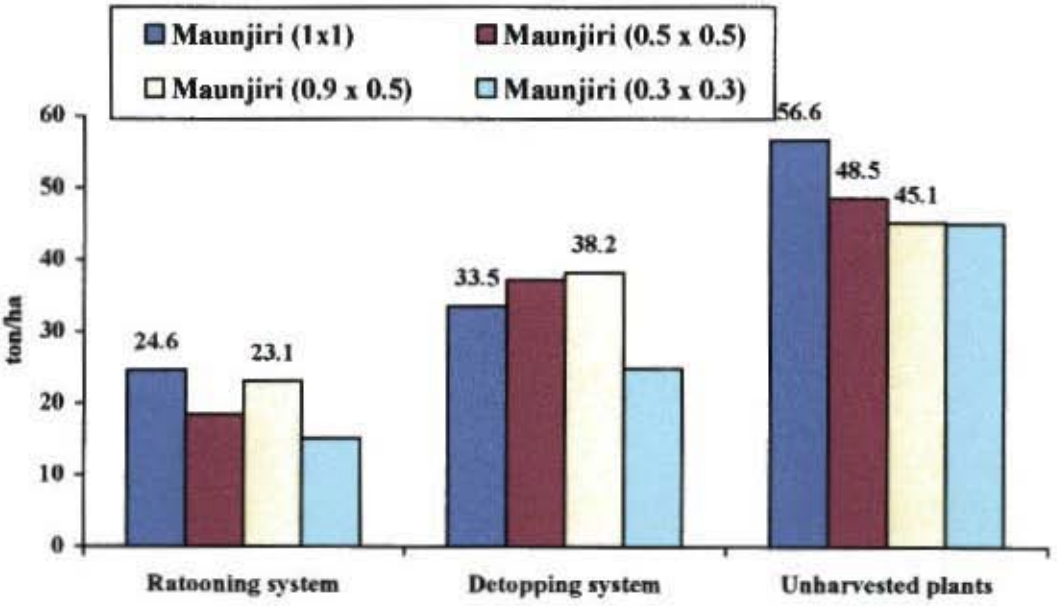


Figure 8. Yields of cassava production systems in two growing cycles. Malawi, 2001-2003.

The results obtained are very interesting. It can be noticed that despite the fact that plants were harvested five times, during the last harvest conducted 67 months later, there was still a significative production of roots. Data on dry matter of these roots was not available at the moment of preparing this report, so the information of the quality of the roots at this moment is missing. However, yields obtained were good and this suggests a crucial question: is it better to let the cassava crop grow for two cycles instead of one?

In a country like Malawi, with a short rainfall season and long dry season, what this preliminary experience is suggesting is that cassava plants when allowed to have two rainy periods, over a growing cycle of 15 to 18 months, could give very good yields (40-50 t / ha). This type of crop management is practiced widely in advanced cassava production systems such us South of Brazil , with average yields of 30 –40 t / ha.

To corroborate this, another piece of information was obtained recently by SARRNET-Malawi. It seems to indicate the same type of data. In November 2001, three farmers in Malawi decided to invest in a commercial scale cassava-growing scheme, and planted 55 has at a farm located in the outskirts of Lilongwe (Chitipi Farms). When it was time to harvest (September 2002), there was a huge demand for cassava planting material in Malawi and many internationally-funded projects, NGOs and even local institutions ended up purchasing cassava cuttings from these three farmers. They made a lot of money ratooning the crop that was presenting a vigorous development. The crop was let to grow for another cycle. Recently, SARRNET did an exercise at this farm to determine quality and yields of the crop. With planting distances of 0.90 x 0.70 (15.873 plants / ha), the yield assessment done by SRRNET-Malawi indicated an expected yield of 39.1 t per ha. The data obtained with cassava plants growing for two cycles deserves to be investigated further. It could be an alternative to develop and establish more competitive, efficient and sustainable cassava farming systems.

ANNEX 3

CASSAVA PRODUCTION IN TANZANIA - FIELD TRIALS

SARRNET personnel in Tanzania also established, in close collaboration with technical personnel from local institutions, a set of trials to test varieties and crop management practices for both, sweet potato and cassava (roots and leaves). The aim of these trials was to determine the potential yield gaps for both crops, when production packages that include external components are used. These components are mainly the fertilizers and the improved varieties. The comparison was made using the local, traditional cropping system as the check.

Data obtained in these trials and some of the preliminary conclusions are presented as follows:

Sweet potato fertilization trial-2001

Treatments: One variety (Eliasi)
Four fertilization methods: chicken manure, cattle manure, NPK and without fertilization
Planting date: May 14th, 2001.
Harvest date: October 2nd, 2001
Three repetitions

Table 8. Sweet potato fertilization trials in Tanzania, 2001.

Treatment (Variety x planting distance)	Fresh weight (ton/ha)
Elias without fertilization (check)	5.20
Elias with cow manure	7.04
Elias with chicken manure	6.38
Elias with NPK	5.94

Fresh weight is the average of three repetitions

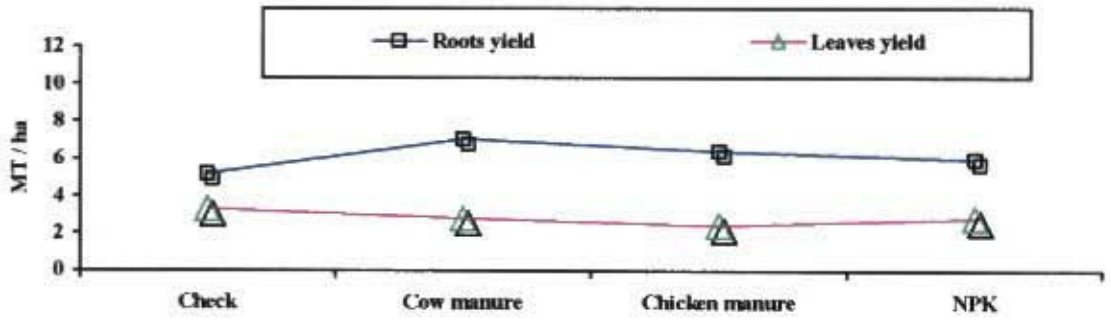


Figure 9. Sweet potato fertilization trial, Tanzania, 2001.

Sweet potato fertilization trial-2002

Treatments: three varieties: Eliasi, Simana, Ukerewe
Four fertilization methods: chicken manure, cattle manure, NPK and without fertilization
Planting date: April 4th, 2002.
Harvest date: August, 30th, 2002
Area harvested: 42 sq.mt

Table 9. Sweet potato fertilization trials in Tanzania, 2002.

Treatment (Variety x planting distance)	Fresh weight (ton/ha)
Eliasi without fertilization (check)	9.5
Elias with cow manure	12.1
Elias with chicken manure	16.9
Elias with NPK	16.1
Simana without fertilization (check)	5.1
Simana with cow manure	8.3
Simana with chicken manure	8.1
Simana with NPK	9.1
Ukerewe without fertilization (check)	8.4
Ukerewe with cow manure	9.9
Ukerewe with chicken manure	8.0
Ukerewe with NPK	13.5

Fresh weight is the average of four repetitions

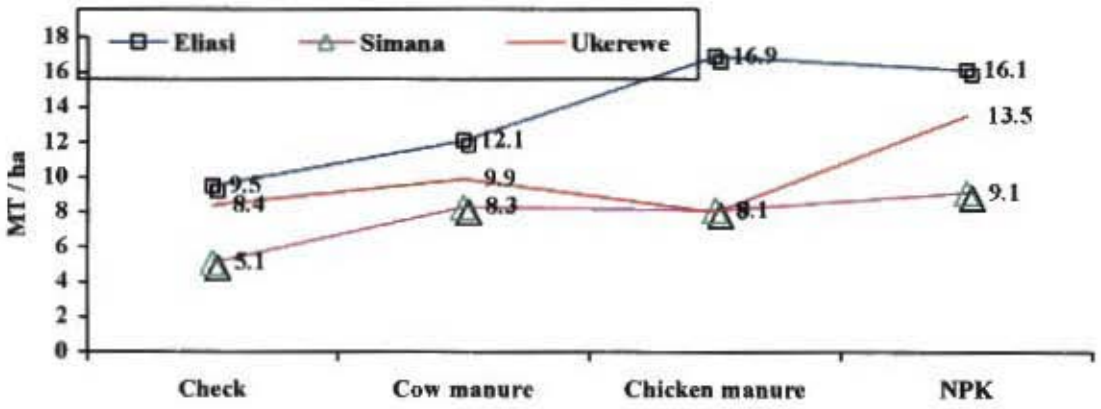


Figure 10. Sweet potato fertilization trial, Tanzania, 2002.

Data obtained in two consecutive years of trials indicates the importance of using fertilizers in sweet potato production systems. The best results were obtained with NPK and chicken manure. The variety Eliasi, one of the most popular in Tanzania, gave the poorest performance in all treatments. The variety Ukerewe gave the best yields, around 16 t/ha, for treatments, NPK and chicken manure. Although planting dates in both years

were almost similar and growing period length was similar (19 weeks), yields in 2002 were almost 50% superior to those obtained in 2001, for all treatments. Main conclusion from this work is that with adequate crop management (improved varieties, fertilizer application), reasonable yields of sweet potato can be obtained in a relatively short period of time. If this production can be used in processing activities for human consumption and animal feed markets, sweet potato can become a very important crop for helping farmers to increase food security, employment opportunities and incomes.

Cassava leaves production trials–Tanzania

The experimental work conducted in Tanzania to evaluate the potential yields that can be obtained with intensive cassava leaves production systems initiated in 2002. Plants were harvested at the same height (ratooning system) and only two varieties, the most popular, *Kibaha* and *Kiroba* , were used.

Treatments: two varieties (Kibaha, Kiroba)
Two planting distances: (0.5 x 0.5); and (0.30 x 0.30) meters
Two repetitions
Planting date: January, 2002.
Four harvests in 14 months
Area harvested: 15,6 sq. mt.;
Harvest system: ratooning

Table 10. Cassava leaves trials in Tanzania, 2002.

Treatment (Variety x planting distance x fertilizer application)		Total fresh weight (ton/ha/14 months)
Chicken manure	Kiroba (0.3 x 0.3)	43.0
	Kiroba (0.5 x 0.5)	33.1
	Kibaha (0.3 x 0.3)	37.9
	Kibaha (0.5 x 0.5)	40.9
Cow manure	Kiroba (0.3 x 0.3)	21.4
	Kiroba (0.5 x 0.5)	17.9
	Kibaha (0.3 x 0.3)	22.4
	Kibaha (0.5 x 0.5)	15.5
Without fertilizer (check)	Kiroba (0.3 x 0.3)	21.9
	Kiroba (0.5 x 0.5)	15.7
	Kibaha (0.3 x 0.3)	21.5
	Kibaha (0.5 x 0.5)	17.6

** Fresh weight is the average of two repetitions*

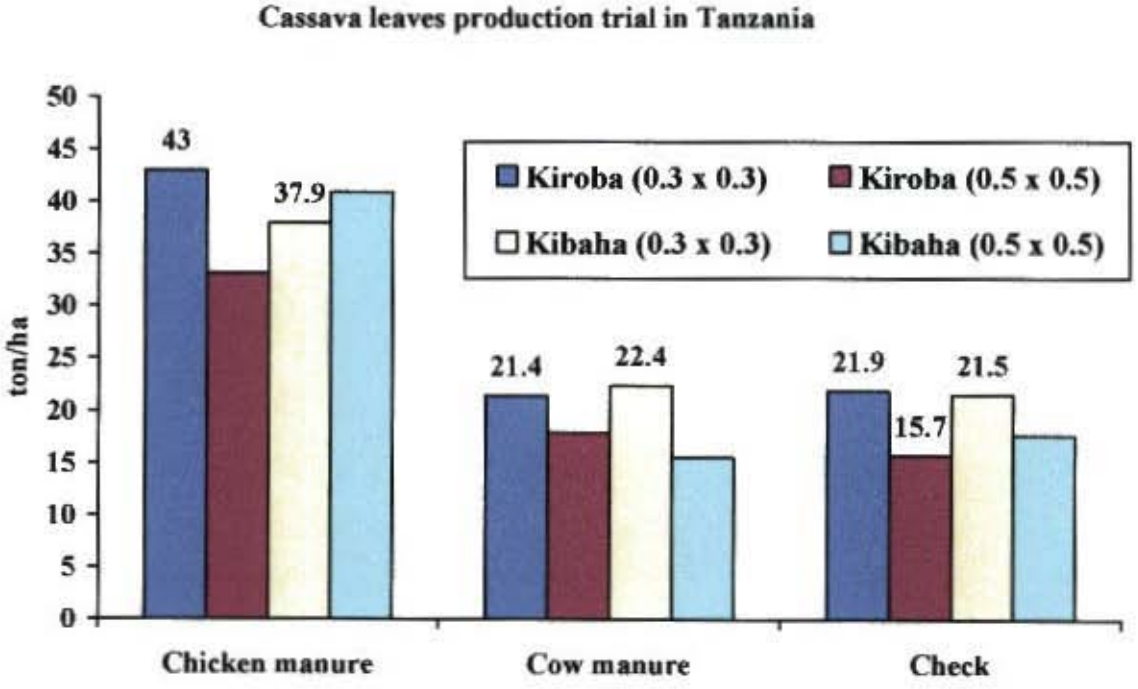


Figure 11. Cassava leaves production trials in Tanzania, 2002.
Yields are the average of the fourth harvests (at 120, 240, 360 and 450 growing days)

Data obtained indicates that in all treatments (varieties, fertilization method), the use of chicken manure gave better results and planting distances of 0.30 x 0.30 gave the best yields. The use of cow manure gave similar results to those obtained with the check.

Cassava root production trials–Tanzania

Some experiments were conducted to determine the effect of fertilization management on cassava roots production. The experiment was harvested with 11 months. Treatments used were as follows:

Two varieties (Kibaha, Kiroba)
One planting distance: (1.0 x 1.0) meters
Three repetitions
Planting date: 26th January, 2002.
Harvest date: 19th December , 2002
Area harvested: 100 sq. mt

Table 11. Cassava root production trial, Tanzania, 2002.

Treatment (Variety x planting distance x fertilizer application)		Total fresh weight (ton/ha/14 months)
Green manure	Kiroba	13.3
	Kibaha	7.0
Chicken manure	Kiroba	10.2
	Kibaha	9.8
Without fertilizer (check)	Kiroba	14.7
	Kibaha	4.8

** Fresh weight is the average of three repetitions*

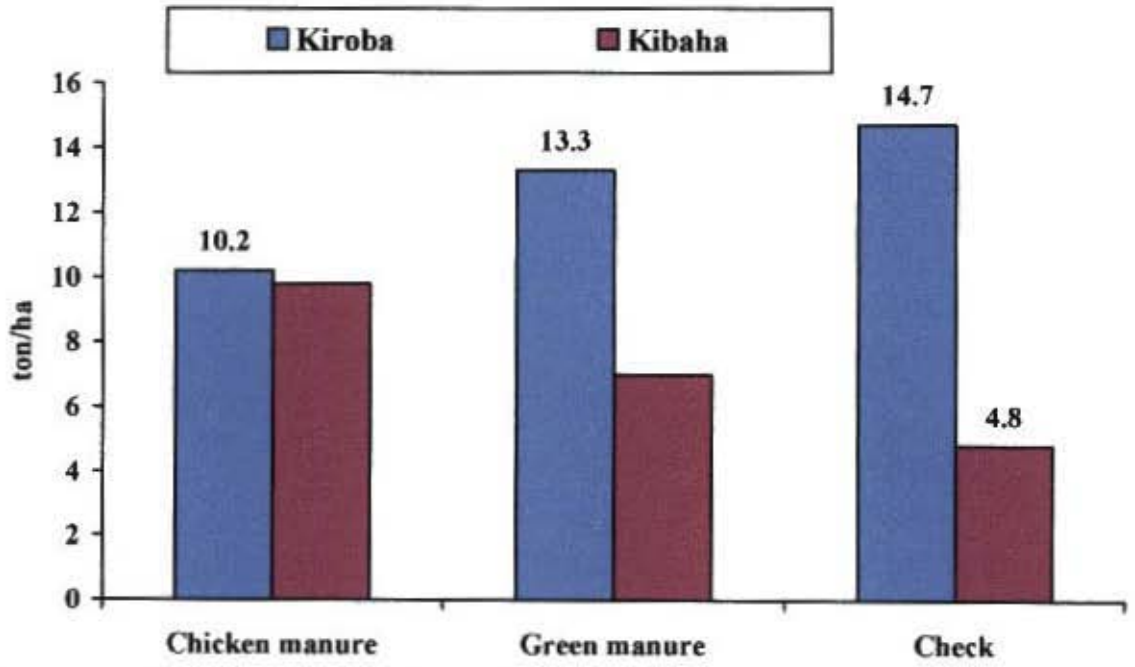


Figure 12. Cassava roots production trial in Tanzania.
Yields are the average of tree repetitions.

Data obtained indicates that yields are relatively low; Kiroba variety responded better to fertilizer application and green manure gave better results than chicken manure. This work could serve as the basis for a more in-depth study about the importance of proper management of soil fertility in cassava roots production systems in Tanzania.