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The East Africa Root Crop Research Network (EARRNET)
End of Phase II Technical Report 2003

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Acronyms

ASARECA: Association of Strengthening Research Systems in East and Central Africa
AYT : Advanced Yield Trial
CBSD : Cassava Brown Streak Disease
CIP : Centre for International Potato
CMD : Cassava Mosaic Disease
DRC : Democratic Republic of Congo
EARRNET: East Africa Root Crops Research Network
ESPP : Ecologically Sustainable Plant Protection
OFDA : Office for Foreign Disaster Assistance
FAO : Food and Agriculture Organisation of the United Nations
FOODNET is the regional network conducting research on Marketing and Post harvest research
IITA : International Institute of Tropical Agriculture
PYT : Preliminary Yield Trial
PSC : Production Consumption System
R4D : Research for development
SC : Steering Committee
UNIDO : United Nations Industrial Development Organisation
UYT : Uniform Yield Trial

Executive Summary

The East Africa Root Crops Research Network operates among national cassava research programs in Burundi, Democratic Republic of Congo, Kenya, Madagascar, Rwanda and Uganda with a mission to transform cassava into a broad-based commercial commodity for sustained food security, poverty alleviation, and income generation through integrated regional production, utilization, marketing and trade. This entails development, transfer and promotion of sustainable market oriented technologies broadly defined as "technologies that respond to a market opportunity, are developed at the behest of and with potential users, based on previous market experience and are economically viable in a significant number of market settings.

A cassava sub-sector analysis was commissioned to provide a comprehensive database, identify opportunities, constraints and needs and propose areas for technological, institutional, organizational and policy interventions. The outcome of the study formed the basis of a regional workshop under the theme "Strategies for Transforming Cassava Sub-sector to Assure Food Security, Income Generation and Economic Growth in East, Central and Southern Africa" that took place in Nairobi April 8-12, 2002 with 89 participants from research institutions, public and private sector, NGOs and donors. Recommendations from the workshop influenced networks activities and its priority setting exercise.

The post harvest theme sought to identify, develop and promote post harvest technologies to increase domestic and industrial utilization and expand cassava markets. Activities conducted covered traditional processing and utilization of cassava and cassava-based products, assessing the efficiency of a range of cassava processing equipments for product safety, improving the nutritional quality of chikwangue, and evaluating performance of selected genotypes for the production of gari, a dehydrated instant cassava based food, eaten cold or hot, stores well, easy and quick to prepare A number of women's groups in Uganda are making various fortifications using fish, groundnuts, beans, soybean flour and simsim to improve the nutrition quality of the product. A survey was conducted on starch utilization in seven industries in Kenya, which resulted in the comparison of starches derived from six improved cassava varieties to four industrial starches. Most of the cassava varieties fell within the range of corn based commercial starches with a conclusion that cassava starches compared favourably with cornstarches.

The germplasm enhancement, development, evaluation and distribution module developed improved adapted populations and varieties acceptable for (to) different end uses and distributed them among network member countries. Breeders from member countries participated in the evaluation and selection of germplasm from the regional nurseries established at Serere Uganda, representing the mid altitude medium rainfall zone, Mtwapa, Kenya, for the lowland low rainfall ecologies and Rubona, Rwanda for the highland medium to high rainfall ecology. This ensured access to semi finished products at advanced stages for evaluation.

Between 1995 and 2002, approximately two million seeds representing several hundred families of improved broad-based and special trait populations segregating for pest/disease resistance, high yield, dry matter and cooking quality and 30,000 clones were evaluated. All member countries now have access to improved populations and continue to introduce improved clones from the regional nurseries. Open quarantine facilities were established to fast track germplasm transfers to enrich the genetic base of national collections. A number of clones have now been released in member countries. The phytosanitary structure at PQS, Muguga was upgraded to receive, clean and virus index improved/local adapted germplasm for international exchange and conservation of a regional core collection against unexpected/unforeseen losses. The upgrade included refurbishment of the virology lab, washing area, media preparation room, screen houses, growth rooms, repair and installation of air conditioners, change of roofing material, fitting adjustable thermo-control systems in the thermotherapy chamber and installation of lamina flow facilities.

The network initiated a number of farmer participatory on-farm trials using augmented design in member countries to hasten evaluation of larger numbers of genotypes. Farmers acceptance of a genotype was generally correlated with its end use characteristics, suitability for inter cropping, yield, disease and pest resistance. It was however recommended that the number of clones assigned to a farmer should not exceed five for ease of management and allow them to make better decisions whilst cultivation practices be taken into consideration when evaluating genotype performance.

The ecologically sustainable plant protection theme dealt with evaluation, development and integration of relevant management systems that reduce pre and post harvest losses due to diseases and pests. This spanned monitoring surveys to ascertain spread and incidence of the major pests and diseases and the establishment of predators and phytoseeids that control the pests. Establishment and spread of the phytoseeids were influenced by varieties with particular shoot tips. Heritability studies are being conducted with the aim of introgressing genes responsible for the characteristic into the breeding scheme. The larger grain borer is assumed to have been accidentally introduced from neighbouring Tanzania. A survey was conducted to assess infestation levels of the larger grain borer on stored dried cassava chips in Kenya. The larger grain borer was not considered as a serious pest as cassava is stored over short duration which does not favor establishment, however, creation of awareness through short term training and dissemination of control technologies was found to be essential especially in the western province where other storage weevil *Sitophilus zeamais* is already reported to be causing damage to stored chips. A Polymerase Chain Reaction (PCR) was established to routinely diagnose cassava mosaic gemini viruses as supplement to the more traditional enzyme-linked immunosorbent assays (ELISA). The PCR allowed the Uganda cassava mosaic variant (UgV) to be distinguished from both African cassava mosaic virus (ACMV) and East African cassava mosaic virus (EACMV) using three specific virus detection oligonucleotide primer pairs: a) ACMV AL1/F and AR0/R, b) UgV UV-AL1/F1 and UV-AL1/R1 and c) EACMV UV-AL1/F1 and EACMV-CP/R. Studies aimed at understanding the identity, dynamics, relationships and specific circumstances surrounding the whitefly vectors populations in cassava in relation to the new

begomovirus epidemic and ACMV/EACMV/UGV were also conducted. The cassava brown streak virus is now a serious threat to cassava production in the lower coastal altitudes of eastern, central and southern Africa causing reduction in root yield and producing a dry necrotic rot in the storage roots leading either to complete spoilage or significant reductions in quality. A workshop was held October 27-30, 2002 in Mombasa to assess opportunities for controlling the disease.

The apical meristem plays a large role in determining plant development and storage root differentiation and as a result determines the physiological basis for adaptation to altitudes. Studies aimed at quantifying competitive ability of component crops in major cassava cropping systems were initiated to identify and describe selection indices for cassava under inter crop using selected legumes and maize to guide variety generation and selection process.

Multiplication and distribution of improved germplasm were carried out in collaboration with extension personnel of Ministries of Agriculture, Non-Governmental and Community-Based Organizations to accelerate impact at farm levels. Results from CMD monitoring surveys used to establish CMD disease movement influenced germplasm distribution efforts with significant improvements in cassava production and reduced CMD spread and increased adoption of cassava as a cash crop. The diffusion and adoption patterns of improved varieties in Uganda revealed a slight decrease around 1998 due to the tuber qualities of the early releases. Subsequent improvement of root quality attributes together with farmer participation in selection reversed this trend, increased household level multiplication and spread among farmers. Different categories of training (regional, in country and attachment) programs were implemented, benefiting over 800 persons including NARS scientists, technicians, extension personnel and other stakeholders.

The network's priority setting exercise was conducted with representation from traders, feed millers, farmers, NGOs, policy makers, Universities and NARS. ASARECA, ISNAR and IITA provided technical inputs. Four chains were identified but the focus will be growth along three prioritized chains (Food, Flour and Feed). Eleven constraints affecting the sub-sector were identified from which nine consolidated projects were developed as the network's portfolio for the next phase. Priority areas for R4D have been identified and the necessary activities to achieve growth have also been determined. There is need to strengthen the private sector, farmers groups and create linkages between processors and farmers in order to assure efficient market linkages. EARRNET along with other development partners will lobby for necessary policy changes/reforms to spur private sector growth and participation in the development of the sector. To achieve this EARRNET will work in partnership with private sector, NGOs, farmers groups, donors, national research systems and regional and international research centres. Efforts should be made to improve the legal framework, investigate financial options, improve physical market infrastructure, and support development of private sector support groups. There will be need to revise punitive taxes that discourage trade and promote market efficiency through improved market information.

The East Africa Root Crop Research Network (EARRNET)

1. Introduction

The East Africa Root Crops Research Network (EARRNET) operates among national cassava research programs in Burundi, Democratic Republic of Congo, Kenya, Madagascar, Rwanda and Uganda, which are the main cassava producing countries in eastern and central Africa. The relative importance of the commodity as a commercial crop and the type of activities being implemented are attracting the participation of other ASARECA member countries including Ethiopia, Sudan and Eritrea. Tanzania is conspicuously not a member of this network due to their participation in our sister network in southern Africa. Close collaboration with Tanzania is however maintained in planning and implementation of network activities.

Vision
Transform cassava into a broad-based commercial commodity for sustained food security, poverty alleviation, and income generation through integrated regional production, utilization, marketing and trade.

Goal
Enhanced, sustainable and competitive regional cassava productivity, marketing and trade

Objectives
Expand potential utilization of cassava through provision of market-oriented technologies to public and private sector stakeholders with strengthened capacity to identify and exploit local, regional and international market opportunities.

Purpose
- Develop and transfer market-oriented technologies, which will contribute to economic growth and development of the ECA region
- Provide a forum for rapid exchange of technologies such as post harvest processing and marketing, improved varieties, integrated control of diseases and pests and natural resource management practices.
- Foster collaborative approach to setting regional priorities for research and training. Minimize duplications of efforts and share complementary scientific responsibilities among member countries based on their respective comparative advantages.
- Provide technical and financial support that will enable the NARS with lead roles to effectively discharge their research responsibilities
- Strengthen NARS and their linkages with stakeholders

1.1 Work plans and activities
The guiding principles for the network's R4D activities continued to be poverty alleviation, food security, environment, gender, building participatory partnership

and promotion of trade. Specific network activities covered research, training, information exchange and building of institutional capacities. Paramount to attaining the network's goal was the establishment of closer links among the sub-sector stakeholders in training, information exchange and sharing research and development tasks. EARRNET thus facilitated inter/intra country cooperation through strategic participation of major stakeholders or select target groups, based on their individual comparative advantage, in the cassava development process. Representation of the major stakeholder groups on the Steering Committee provided an enabling forum for reviewing, prioritising, planning, implementing and monitoring the impact of approved research and development activities.

Due to wide range of agro-ecologies, diverse farming systems, utilization patterns and consumer preferences for cassava, the network oriented itself to target among others: untapped market opportunities, inadequate market infrastructure, post harvest handling technologies, shortening fallow periods and declining soil fertility, insufficient and poor quality planting material, the cyanide scare and availability of reliable data, while closely monitoring the emerging pre and post harvest health issues; cassava green mite, root scale in the humid forest, cassava brown streak disease in the coastal and larger gain borer in the mid altitude ecologies, respectively.

The network mission of transforming cassava into a broad-based commercial commodity entailed addressing a number of issues pertaining to development, transfer and promotion of sustainable market oriented technologies. The definition of market oriented technologies was debated at length with due consideration to present, potential and emerging utilization potentials, national, regional and international implications, policy requirements, roles of different stakeholders, inter commodity sub-sector interactions, food for increasing population, etc. Discussions cumulated in its definition as "technologies that respond to a market opportunity, are developed at the behest of and with potential users, based on previous market experience and are economically viable in a significant number of market settings. EARRNET therefore introduced a number of changes within the network's operational framework to enable it to respond effectively to ASARECA's strategic plans and objectives. The transitional process from a production to market oriented commodity network, which was evident during the latter part of EARRNET's phase 1 program, was consolidated through further changes to guide priority setting, planning, implementation, monitoring and impact assessment.

An interactive four task forces (socio-economic, post harvest, production, protection) was approved to reduce the skewed disciplinary distribution among heads of programs and optimize regional thematic deliberations with inputs into staff exchange and backstopping. Responsibilities and functions of thematic task forces/leaders were discussed to include development, synchronization and reporting of task force activities. This provided a better operational system than the thematic-based-lead-country system used during the first phase of EARRNET's program. Task forces did not eliminate any in-country program leaders or thematic

leaders that had been operational to date. They rather re-enforced them through linkages across member countries. It was also proposed that task-force leaders should be voting members of the SC. In addition, two other prominent persons with knowledge of market oriented research and a private sector representative was proposed as potential voting members.

2. Cassava sub-sector studies

Cassava has long been used as a famine reserve food security crop produced mainly through subsistence farming with characteristic low input, rudimentary technology, large post harvest losses and minimal processing though it has high economic potential if its unique characteristics are capitalized on as raw material for different end uses and markets. Transforming the status of cassava in the sub region therefore needed a production to consumption system (PCS) analyses to identify opportunities and constraints at each stage of the commodity development cycle to achieve greater returns to both producers and processors. The SC unanimously agreed to increase knowledge on the cassava sub-sector, analyse production to consumption chains, and synthesise a regional sub-sector data to serve as benchmark information necessary to support the shift to market oriented program, monitoring, evaluation and impact assessment. The sub-sector analyses, was conducted across member countries to identify and prioritize market opportunities to which issues related to constraints and needs would be addressed by network members.

The cassava sub-sector analysis was therefore commissioned to provide a comprehensive database of the sub-sector, identify opportunities, constraints and needs and propose areas for technological, institutional, organizational and policy interventions that could contribute to the improvement of the sub-sector, propose research development programmes and dissemination of end-user preferred technologies for equitable sub-sector and highlight access, equity, sustainability and gender issues for technical options, assess costs and returns of technologies and the potential for increased cassava trade through increased production, utilization and commercialisation.

The study followed the following approach; formation of country task forces, literature review and stakeholder consultations, draft status report, national stakeholders workshops, review of questionnaires and pilot testing at national level, data collection, entry and analysis.

2.1 Production

Cassava is widely produced and plays an important role in food security. Though largely grown as a food crop at household level there are indications of market driven cultivation in almost all the countries surveyed. The range of varieties grown is diverse and predominantly traditional. Farmers' selection of varieties is dependent on a number of factors including but not limited to yield, maturity, dry matter content and resistance to major pests/diseases. Improved varieties are slowly being adopted across the region due to lack of efficient multiplication and

distribution system. The crop is grown both under mixed and mono-cropping systems in all the countries. New strains of the cassava mosaic are noted in DRC and these are also complicating advances in technology development and transfer.

In DRC, cassava is the most important food crop where both leaves and roots are used as cash and food while in Uganda it is second to banana at national level. Production has steadily increased after introduction of high yielding disease resistant varieties. The main cassava growing areas in Kenya are Western, Coastal and then Central Province where it is gaining popularity both as a food crop as well as a main source of income for small scale producers. Cassava is the third important crop in Rwanda and Burundi after plantains and sweet potatoes. In Madagascar cassava is the second most important crop after rice and mainly grown in Southern part of the country. Although cassava occupies only about a third of the area occupied by rice its production is more than half that of rice, indicating that cassava has a better chance of addressing food security problems when compared to rice.

Except for Uganda, cassava production trend for 1991 to 2003 in the five EARRNET member countries Kenya, Rwanda, Burundi and Madagascar shows no increase (Fig. 1). For the same period, the mean yields (t/ha) in Rwanda Madagascar and D R Congo remained below 8t/ha and much below mean yield for Africa. In Kenya and Burundi, yields steadily increased exceeding that of Africa up to 1999. After Kenya yield dropped while Burundi yields remained stable. Along with the increase of cassava production, the yields in Uganda increased and exceeded that of Africa (Fig. 3)

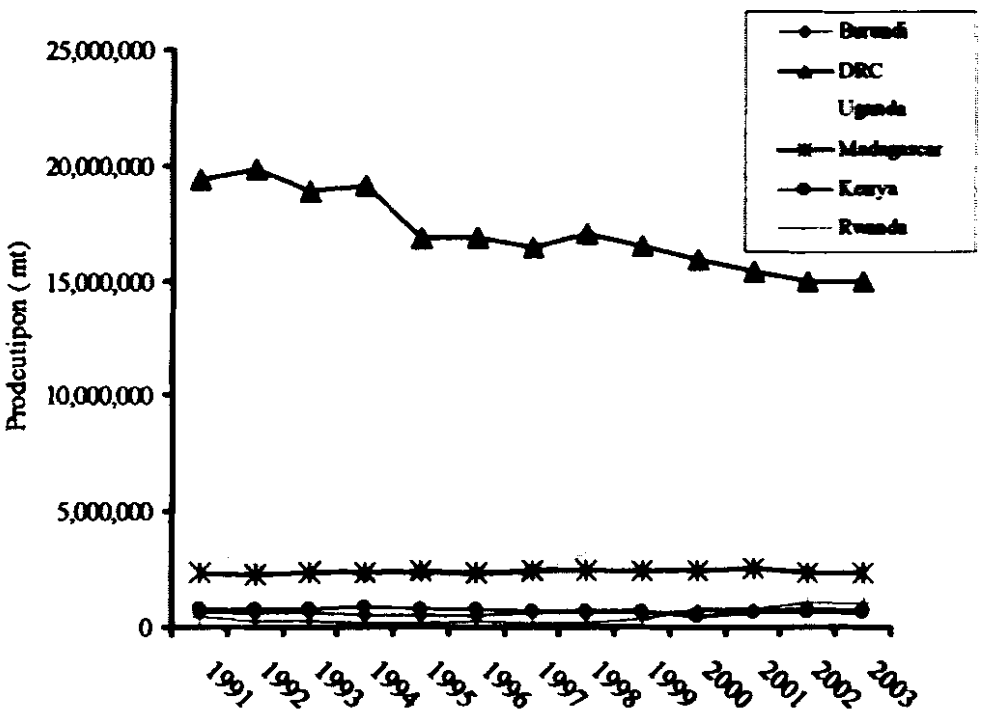


Fig. 1. Cassava production (tons) in EARRNET member countries from 1991 to 2003 (Source: FAO, Statistics 2003)

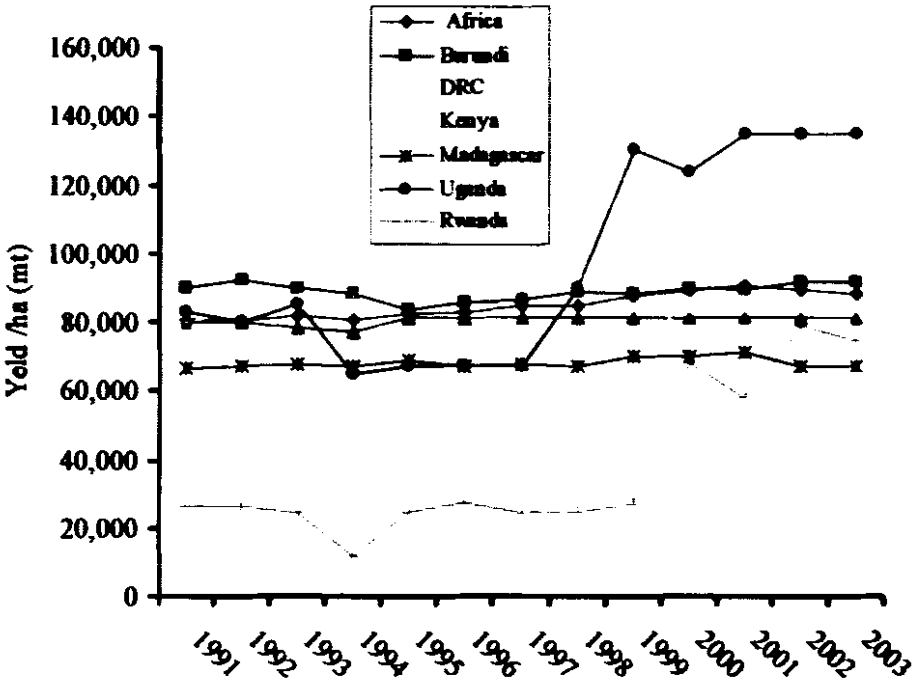


Fig. 2. Cassava mean yield (t/ha) in five EARRNET from 1991 to 2003 (Source: FAO, Statistics 2003)

Major production constraints include among others cassava mosaic disease and cassava green mite, attack by wild animals, termites etc as well as lack of planting material of the improved varieties. Diseases and pests vary from country to country (Table 1) except the cassava mosaic disease that is a common problem across the region. Lack of planting material is exacerbated by inadequate multiplication and distribution systems and low investment in extension services.

Table 1. Country specific constraints

	Kenya	DRC	Rwanda	Madagascar	Burundi
CMD	30.4%	52.7%	64.9%	25.2%	54.2%
CGM	16.3%	11.2%	35.1%	-	8.1%
Scales	7.7 %	-	-	-	-
Termites	7.1 %	-	-	10.8%	0.8%
CMB	-	60.2%	-13.5%	17.9%	27.1%
Rats	-	-	-	36.7%	-
Criquet	-	-	-	-	3.8%

2.2 Processing and utilization

Cassava is largely utilized as human food in the region and the form in which it is used at household level varies from country to country. Roots are normally transported by head load and by trailers and small trucks where road networks permit. Processing of cassava remains largely traditional with a narrow range of processed products of relatively low quality and without any standardization. Predominant processed and consumed products in the region range from fresh roots, boiled roots, fried cassava chips, hardened porridge (Ugali/Fufu), cakes, bread to crisps, dried cassava chips and flour, and other recipes such as chikwangue in DRC, Rwanda and Burundi. Advances in developing different recipes and other cassava-processed products in the region have been slow. Improved processing technologies are being adopted from elsewhere, but the dissemination is rather slow. Few established medium industrial scale processing units exist in some countries. In Madagascar statistics show that 3% of cassava is used in formulation of animal feeds with estimated potential of 18,000 tons per year. A number of industries have shown some interest in using cassava in the confectionery, textile and food but are concerned about quality and regular supplies of the raw material if they venture in using cassava.

2.3 Marketing

No organised marketing system is in place and is often carried out by rural and urban retail traders. Very little market research work has been done except in Uganda. Level of trade is still very low with products dominated by fresh tubers, leaves, dry chips flour and other processed products. Problems associated with marketing of cassava are lack of efficient market structures and information flow, poor infrastructure (roads, communication, market facilities etc.). In addition, growers and traders are faced with the bulkiness, the perishability of the raw tuberous roots and leaves that make transportation costly with low returns. The problem is made worse by lack of appropriate processing technologies capable of transforming the roots into long shelf life products and less bulky in transportation. Main constraints facing cassava marketing include; quality of marketed products (chips, flour), high taxes, insecurity on the highways (DRC, Burundi), fluctuation of prices, lack of capital for building stocks, shortages of cassava processed products especially during the wet season, poor infrastructure, means of transportation was also mentioned as a problem and lack of market information.

2.4 Opportunities

Madagascar has vast opportunity for transforming cassava from subsistence to a commercial crop. The country has experience in the commercial operation of the sector and had grown cassava on a large scale for commercial purposes during the colonial era and some of the traditional export markets such as France, Mauritius and Reunion still exist and efforts should be made to expand these markets through supply of high quality products. The estimated 3% of the cassava production used in manufacture of animal feeds industry can be expanded through increased production coupled with necessary policy support while consumption can be expanded through diversification of consumable products. The processing technologies can be improved in order to increase the shelf life of the consumable products. In the short-term the biggest potential lies in

promoting cassava as a food crop since most of the countries in the region are facing food shortages and declining per capita food production.

In Burundi and Rwanda the biggest potential lies in promoting cassava as a food crop. Due to civil strife experienced in the two countries, food production has greatly declined and a large part of the population is dependent on relief supplies. Efforts need to be made to supply farmers with planting material and appropriate processing technologies that can transform cassava into products that can be stored for a long time so as to improve on their market acceptability

In the DRC cassava is the main food crop the emphasis should be in promoting cassava as a food as well as an income-generating crop. Cassava leaves trade is a major source of income for cassava growers with export markets to some European countries especially Belgium.

In Uganda, Kenya and Madagascar the potential is in both for industrial use as well as for food (animal feeds, textiles, wood making industry, food manufacturing and adhesives). Efforts should be made at tapping on the animal feeds industry especially in Kenya and Madagascar through establishing the potential demand for fresh cassava roots in the feed manufacturing in each country followed by analysis of the potential savings by the feed manufacturers by substituting cassava chips for cereal-based carbohydrates as part of the promotion information. The third step would be to educate the feed manufacturers and the livestock farmers on the use of cassava based feeds. Mbeere district (Kenya). The raw materials consist of fresh cassava tubers, sunflower cake, wheat bran, fish-meal (omena) and minerals. Peeled fresh cassava tubers are chopped and sun dried for 5 to 7 days in polythene container before it is milled. The milled product is then mixed with fish meal, wheat bran, mineral supplement. The recommended ratio is 16% cassava. Cassava Leaves: Air dry fresh leaves for 1 to 2 days in shade, mash dry leaves while in the bag to minimize losses. Blend with the following and feed to animals; cassava tubers meal, maize/wheat bran, fish-meal, calliandra leaves and mulberry leaves. The recommended cassava ratio is 16%.

A mechanism of assuring constant supply of cassava to the industry should also be established while the food processing industry, flour millers and confectionery should get involved in the cassava processing and make cassava flour and other products available in supermarkets and retail outlets in ready to cook/eat form

The food policy needs to be strengthened by putting more emphasis on traditional crops that require less input and can grow under marginal conditions. The well trained personnel in cassava research and the extension services should be utilized by providing the right policy environment and resources to enable them promote the crop. Linkages with other stakeholders such as the industry will also strengthen the case of cassava. In the area of post harvest technologies there are needs to identify appropriate storage and processing technologies that will improve the shelf life of the commodity and guarantee quality products. Packaging should be made more attractive using shelf life enhancing technologies to make cassava available to more people and for longer seasons in the year.

2.5 Recommendations

Production level:

- Improve multiplication and distribution of farmer preferred varieties
- Improve dissemination of extension messages
- Improve linkages with other agencies such as NGOs, donors, private sector and international research agencies.
- Improve research funding base

Processing and Utilization

- Improve drying technologies for cassava chips
- Improve processing technologies for cassava flour to achieve desired attributes
- Improve linkages between farmers and processors in urban centres
- Promote industrial use of cassava such as in large scale milling, confectionary etc.
- Need to diversify consumable cassava products
- Improve the quality and standardization of existing products through improved technologies
- Develop and disseminate appropriate feed meal formulations for different stock
- Develop and disseminate cassava recipes and extension manual for use for nutrition by extension staffs

Marketing:

- Establish a market information service for main commodities including cassava
- Need to have appropriate market infrastructure in main urban centres (space, storage, sanitation etc).

Policy:

- Promote cassava for food security. Coordinate all cassava activities among various institutions in the country through establishment of a cassava working group
- Make a deliberate attempt to promote improved processing technologies for cassava
- Revise punitive taxes that discourage cassava trade
- Consider availing credit to cassava traders *(Micro-credit scheme can be established)*

Apart from providing food security, opportunities exist in utilization of cassava in animal feeds, for food security, in food manufacturing and in other industrial applications. In research, focus should be on testing and adoption of disease resistant varieties, participatory farmer research, post-harvest technology development and transfer, appropriate and sustainable multiplication and distribution of planting material and appropriate marketing system and promotion of cassava for industrial use.

The generic diagram (Fig. 3) of a desirable cassava production to consumption systems (PCS) shows that production takes place in small farms with inputs covering the whole

spectrum for agricultural production using small hand tools by small farmers, tractors, machinery, fertilizer etc used mainly by medium to large scale farmers. Agricultural policies and infrastructure constraints variably affect the cassava sub-sector at different stages, and the system contributes significantly to employment creation, income generation and has an impact on the environment

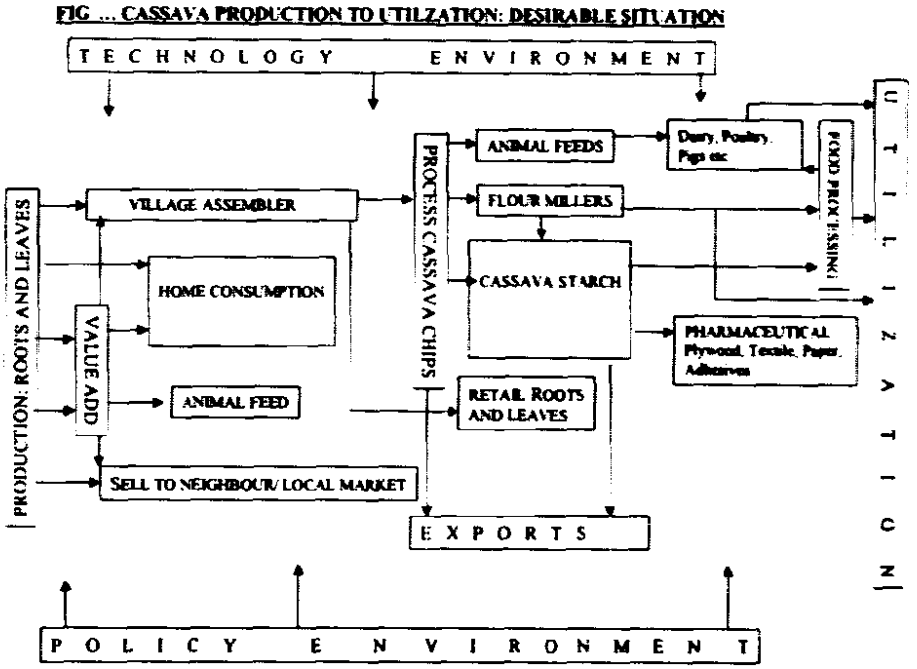


Fig. 3: Cassava production to consumption system (PCS) in sub-Saharan Africa

A regional workshop on improving the cassava sub-sector under the theme "Strategies for Transforming Cassava Sub-sector to Assure Food Security, Income Generation and Economic Growth in East, Central and Southern Africa" took place at the ICRAF Nairobi April 8-12, 2002. A total of 89 participants from research institutions, public and private sector, NGOs, donors and the press from 15 countries attended. Over 47 papers (13 from SARRNET countries) covering Thematic, Regional and national cassava sub-sector issues, Commissioned papers, Industrial Application of cassava and Advances towards market-led research and development issues were presented. Synthesis of workshop is found in Annex A.

3. Development of post harvest technologies

The objective is to identify, develop and promote post harvest technologies to increase domestic and industrial utilization and expand cassava markets.

3.1 Traditional processing and utilization of cassava and cassava-based products in Kenya.

A study on various traditional methods of processing and utilization of cassava and cassava-based products was conducted in Nyanza and Coastal provinces of Kenya

where cassava is a major staple. The study covered processing methods, storage, nutritional issues, storage and storage pests, desired quality attributes for food and seasonality of supplies. The study revealed that farmers in western Kenya cultivate bitter and sweet local cultivars targeting various end uses and processing methods. Processing is at subsistence level using one or two stage heap fermentation followed by pounding and drying. The dried cassava is the main form in which cassava is traded while for food, it is often mixed with maize or sorghum before grinding into composite flour for making ugali. At the coast, cassava is boiled, mixed with beans and coconut while deep fried chips are important snacks in the urban areas. Dried unfermented chips are sold to cassava processing plants.

3.2 Processing equipment

The efficiency of a range of cassava processing equipment and product safety of the resulting cassava flour were compared in Masindi District, Uganda. The motorized grater outperformed all other processing equipment with a throughput of 400 - 700 kg per hour, followed by manual chipper (200 kg per hour), the manual disk grater and then the tin and nail graters. Incubation period of 3 hours after grating further reduced the cyanogenic potential of the flour. Chipping and drying was recommended for processing of cassava with low cyanogenic potential. These technologies were pilot demonstrated for acceptability in three sub counties in the same district (Masindi) with acceptable results among small-scale farmers. They greatly appreciated the quality of the resulting cassava flour for its whiteness and absence of any scent. The network in oollaboration with FOODNET has since distributed a number of equipment in different countries (Table 2).

Table 2: Number, types and status of cassava processing equipment distributed in collaboration with FOODNET

	Equipment types			
Country	Chipper	Graters	Press	Status
Kenya	8	6	12	Installed 4 chippers and 1 grater, with the latter not very popular, products not much preferred in composite flour
Uganda	8	24	48	The Matilong group closed down due to insecurity in North Eastern Uganda
Rwanda	12	12	24	
Tanzania	12	12	24	

3.3 Improvement of chikwangue

Cassava is the principal food crop of the majority of the Congolese people. Both leaves and storage roots are eaten in various processed forms. Chikwangue and fufu form the bulk of processed products of the storage roots and is eaten by both children and adults. It is however very low in protein content and this frequently leads malnourishment in the family households. A trial to improve the nutritional quality and acceptability of chikwangue was conducted using yellow maize flour, soybean and white cowpea in the province of Bas-Congo and in the town of Kinshasa. Different ratios (0, 20 and 30% of each of the flours were mixed with chikwangue. Maize grains and roasted cowpea were

processed into flour and mixed with a 4 to 5-day fermented cassava paste and matured for a period of 3 to 4 days. The paste was then cooked partially before petrifaction, packing in leaves, cooked under pressure and evaluated for colour, taste, consistency, smell and a general appreciation.

Generally the mixtures with maize, soybean and cowpea flour improved the protein content of the chikwangue with the average crude proteins increasing with increases in the percentage of maize, soybean and cowpea incorporated (Table 3). Chikwangue with soybean had the highest crude proteins compared to the other substituted products.

Table 3. Average crude proteins content of chikwangue

Percentage	Maize	Soybean	Cowpea	Mean
Manioc + 00	1.83	1.83	1.83	1.83
Manioc + 20	3.15	9.27	5.77	6.06
Manioc + 30	3.67	10.32	6.65	6.88
Mean	2.88	7.14	4.75	4.92
LSD (0, 05)	0.11	0.250	0.398	
LSD (0, 01)	0.165	0.388	0.603	
CV (%)	3.29	3.27	3.33	

Acceptability of the colour, consistency, taste, smell and general appreciation (Table 4) decreased with increase in the percentage of maize though none was rejected. The yellow colour of the products containing maize was not usual to consumers, thus the decrease in its evaluation. Chikwangues mixed with soybean were less appreciated compared to the local chikwangue (Table 5) mainly due to the brown and off smell of roasted soybean even though it did not influence the consistency. Chikwangue containing cowpea was much more appreciated due to the cream colour imparted by the cowpeas (Table 6).

All the fortified chikwangue hardened after 72 hours, while those made of cassava alone still remained soft after that period. This analysis demonstrated the possibility of enriching chikwangue if the problems of colour and hardening can be resolved. Cowpea and maize can be mixed with cassava to produce an acceptable chikwangue.

Table 4. Acceptability of chikwangue of maize

%	Colour	Consistency	Taste	Smell	Appreciation
Cass. + 00	1.38	2.07	1.9	2.03	1.75
Cass.+ 20	2.30	2.01	2.54	2.79	2.71
Cass. +30	3.32	2.79	2.93	3.04	3.29
Mean	2.66	2.30	2.45	2.62	2.59
LSD (0, 0.5)	0.44	0.37	0.40	0.4	0.43
LSD (0, 01)	0.58	0.49	0.54	0.53	0.57
CV (%)	30.60	30.19	30.74	28.54	31.13

1 =Excellent, 2 = Very good, 3 = Good, 4 = Not good, nor bad , 5 = Bad and 6 = Worse

Table 5. Acceptability of chikwangue of soybean

Parentage	Color	Consist.	Taste	Smell	Appreciat.
00	2.05	2.26	2.10	2.31	2.05
20	4.26	2.73	2.89	3.57	3.15
30	4.57	2.78	3.89	3.68	3.63
Mean	2.63	2.59	2.96	3.19	2.94
LSD (0,05)	0.59	NS	0.71	0.84	0.81
LSD (0,01)	0.79	NS	0.96	1.13	0.09
CV (%)	24.86	41,00	36.76	40.20	42.21

1 = Excellent 2 = Very good 3 = Good 4 = Not good nor bad 5 = Bad and 6 = Mediocre

Table 6. Acceptability of chikwangue of cowpea

Parentage	Color	Consistence	Taste	Smell	Appreciation
00	2.12	2.26	1,155	2,160	2.39
20	2.65	2.34	2.32	2.35	2.58
30	3.82	2.50	2.61	2.48	2.62
Mean	2.53	2.36	2.36	2,33	2,53
LSD (0.05)	0.48	NS	0.31	0.15	0,210
CV %	25.50	30.24	28.60	30.20	29,51

1 = Excellent, 2 = Very good, 3 = Good, 4 = Not good nor bad, 5 = Bad and 6 = Mediocre

3.4 Evaluation of improved cassava clones for 'gari' production

'Gari' is dehydrated instant food made from cassava that can be eaten cold or hot, with milk or water and with soup, stew or sauces. It can store well for a long time, easy and quick to prepare making it the choice of food among urban as well as rural population in West and Central Africa. Fourteen improved cassava clones were evaluated for garification in collaboration with Afrika Sana, an NGO promoting gari utilization in Lira district, Northern Uganda as part of a a series of planned routine evaluation of cassava genotypes for making gari. The purpose is to identify clones that give high yield of high quality gari per unit area. Preliminary results indicate that while all clones evaluated produce good quality gari, they differ in the quantity of peeled cassava required to produce 1 kg of gari. The ratio of peeled weight to finished product (Table 7) indicates that MM96/0161 produces the highest quantity of gari per unit area (2.4 kg of peeled cassava to 1kg of gari) and the lowest producer is MM96/0580 (3.4 kg per 1 kg of gari). Given that the yield of MM96/0161 is 35t/ha fresh weight and 15% waste as peels, a farmer can easily get 11800kg of gari per hectare. The selling price of one kilogram of gari was quoted by Afrika Sana as 1000 Uganda shillings ie, 11,800,000 shillings approximately US$6,820 per ha. (1$ = 1720 Ushs). Afrika Sana has since joined together with Lira District Private Sector Promotion Center to expand their scope of operations. The group has received funding from the Maendeleo Agricultural Technology Fund for expanded promotion of gari in 9 other districts of Uganda. Through farmer participatory on farm evaluation in Lira district in 2001, nine improved

varieties selected by farmers are being multiplied at household levels to target the emerging gari market.

Elsewhere, the Akazaalibwa and Kakolyoto women groups in Kamuli, Iganga district, Eastern Uganda have introduced and are popularising gari. This followed an exposure visit to Ghana by the groups representatives sponsored by the Sasakawa Global 2000 in 1998. The groups were supplied with improved cassava variety, cassava graters and press, which are enabling them to process 1,000kg fresh cassava per day, and sell 100kg gari per week at 440,000 Shs. (≅US$ 350). They are also involved in making various fortifications using fish, groundnuts, beans, soybean flour and simsim to improve the nutrition quality of the product. Originally, the group's major problem was irregular supply of fresh cassava. To overcome the bottleneck, the group has contracted over 80 of its members to grow and supply fresh cassava. EARRNET is collaborating with the Global 2000 project to provide necessary training in the waste disposal and linking them to markets

Table 7. Garification characteristics of some improved cassava clones

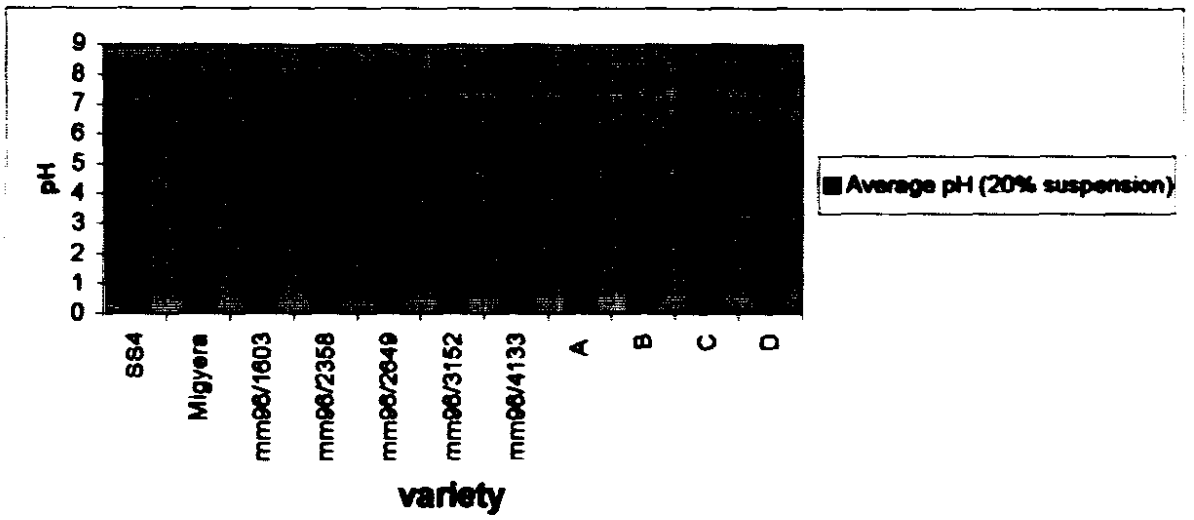
Clones	Unpeeled wt	Peeled wt.	Wt after grating	Wt after squeezing	Finished product	Wt of peeled to 1kg gari
I92/0057	30	20	19	11	7	2.7
TME12	26	18	18	11	6	3
MM95/0414	25	16	16	10	6	2.5
TME14	27	16	16	10	6	2.7
MM96/0580	40	24	24	13	7	3.4
Abbey Ife	34	20	20	12	7	2.9
I92/0427	35	20	20	11	7	2.9
MM96/0161	39	24	24	17	10	2.4
I91/02327	40	23	23	16	8	2.8
I92/0067	26	12	12	8	5	2.5
I91/2627	23	13	13	9	5	2.6
I91/2324	17	10	10	6	4	2.5
Migyera	39	23	23	16	9	2.6
SS4	41	24	24	15	8	3

3.5 Cassava starch quality characteristics

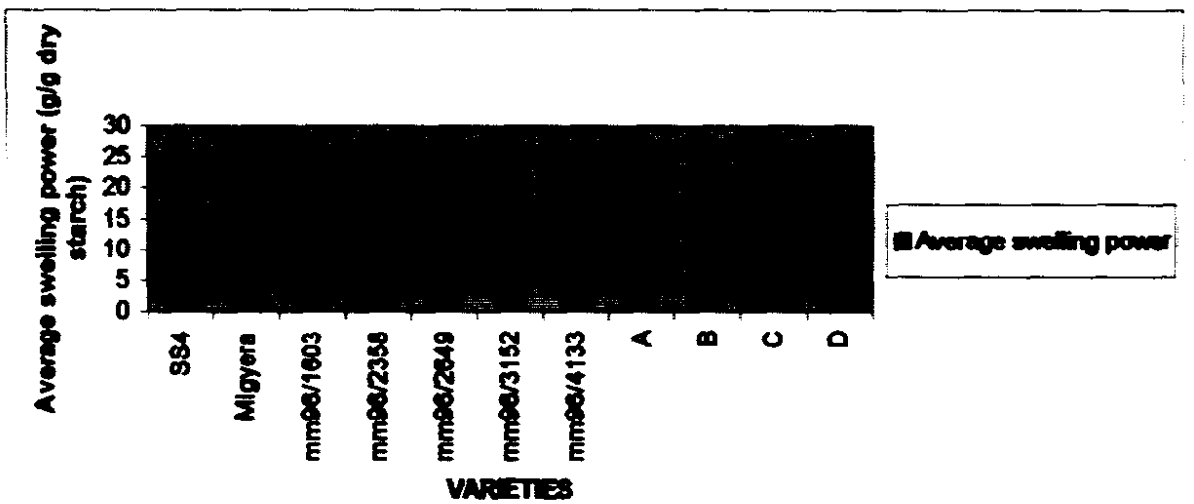
Industrially, cassava starch can be used in food, pharmaceutical, and textile industries, to mention but a few. However in East Africa, lack of understanding of the utilization potential of cassava starch, demonstration of cassava starch qualities to facilitate formulations, the economics of substitution with other industrial starches have contributed to non use in industrial application.

A survey was conducted on starch utilization in seven industries in Kenya, which resulted in the comparison of starches derived from six improved cassava varieties to four industrial starches. According to the Glaxo Wellcome analytical standard specifications, the higher the swelling volume and power of starches and the lower the acidity, the higher are their industrial qualities. Most of the cassava varieties showed

low pH and high swelling power except Migyera, MM96/2358 and MM96/3152 whose pH were slightly above 7.0. The rest fell within the range of corn based commercial starches (Fig. 4 (a & b). It was concluded that cassava starches compared favourably with corn starches and can actually substitute the latter if the economics of substitution can be demonstrated. Detailed comparison of cassava starch characteristics against the commercial starches from corn are summarised in annex B.



(a)



(b)

Fig. 4. Average pH (a), swelling volume and power (b) of starches from six cassava genotypes compared to four industrial starches

In Uganda, the industrial plant that had processed cassava into starch in Lira was closed down in the early 1980s due to civil unrest. Since that time, the country has imported its starch needs to the tune of 1000 to 1500 MT/year, liquid glucose consumption of 1000-1500 MT/year and dextrin consumption of 400-500 MT/year with a combined value of between $ 2 to 3,000,000/year. A small enterprise called Sibuku that started by producing storage roots for supply to school and sales of planting material in the early 90s has since adopted cassava starch production technologies. The network in collaboration with the National Root Crop Program provided the necessary training and improved germplasm to support the private enterprise in starch production. The Company now employs 30 workers at the plant, contracts 100 out growers to produce and supply fresh tubers. Although the exact quantity of starch produced per unit time is not documented, it is known that the product is marketed to Riham Biscuits 500 kg., Makka Packaging 5-10 tons, Organic Chemicals 2-5 tons Nytil Picfare 5-10 and Formula Feeds 5-10 tons flour/month. In a related study concluded by FOODNET, it was observed that starch processing could be more profitable if conducted alongside flour processing which employs similar equipment and the waste from the starch processing could be incorporated into flour, an option that the Sibuku Company intends to introduce for long-term sustainability of its processing unit.

4. Germplasm Enhancement, Development, Evaluation and Distribution

The objective of this theme is to develop improved adapted populations and varieties acceptable for (to) different end uses and distribute among network member countries. The positive response of cassava production and utilization to improvements in environmental, biological and socio-economic conditions has influenced the market driven germplasm enhancement strategy initiated to develop improved, adapted populations and varieties acceptable for (to) different end use(r) s. The application of sib-family evaluation, clonal characterization and performance evaluation ensures that selected genotypes have the necessary resistance/tolerance background to major biotic stresses, good agronomic and quality characteristics.

With the participation of national breeders from member countries, evaluation and selection of germplasm continued to be carried out at Serere Uganda, representing the mid altitude medium rainfall zone, Mtwapa, Kenya, for the lowland low rainfall ecologies and Rubona, Rwanda for the highland medium to high rainfall ecology on regular basis. This ensures that member countries have access to semi finished products for evaluation at advanced stages. These sites were selected to promote spill over into neighboring countries with similar ecologies. Advanced germplasm from Rubona services Burundi and Eastern DR. Congo. Those from Mtwapa feed into national programs along the East Africa coastal lowlands while Serere contributes germplasm for mid-altitude regions of Eastern Africa.

Between 1995 and 2001, approximately 1.5 million seeds of cassava representing several hundred families of improved broad-based and special trait populations segregating for pest/disease resistance, high yield, dry matter and cooking quality

were evaluated in stage one of the established germplasm development scheme. During the same period, over 23,000 clones were evaluated as clonal evaluation. 4,261 clones as performance 1 from which 3,245 have been selected and cumulatively bulked into broad-base population that combine multiple pest/disease resistance and desired agronomic and quality characters (Table 8). Among the populations, a number of clones such as MM96/0414, MH97/2961 and I91/2324 have very high levels of resistance to CMD that they can be considered as near immune. The former has already been released in Uganda while the latter two have been recommended for release by the national program in Uganda. Currently, a study is underway to establish the genetic diversity and relationships among the improved populations and their local relatives provide information on potential parents to maximise heterosis in cassava breeding programs and to correlate the DNA profiles with CMD.

Table 8. Number of sib-families and clones evaluated and cumulatively retained as improved populations between 1995 and 2000

	Stages of evaluation			
Seasons	Sib-families	Clonal	Performance	Improved populations
1995/96	1,670	426	-	-
1996/97	858	10,040	130	-
1997/98	1,083	5,800	2,005	
1998/99	181	4,928	740	626
1999/00	-	138	695	1,162
2000/01	462	1,780	691	1,457
Total	4,254	23,112	4,261	3,245

4.1 Regional germplasm distribution

Phytosanitary regulations require that cassava germplasm be moved between neighbouring countries only as botanical seeds, pathogen tested *in vitro* or pathogen-tested *in vitro* material that has been grown under containment. Due to lack of local capacity in tissue culture handling within the national cassava programs failure rates are high and the process of screening the new material takes a long time before a variety can be released. Multiplication and distribution of planting material is an expensive venture and the cassava seed sector in the region is not well developed making planting material of improved varieties not readily accessible to farmers within the region. At the time of disease epidemics, hunger or any natural disaster, timely availability and supply of clean planting materials of improved varieties to where it is needed can be a major problem. This can have serious effects on food security and cash income among the households who derive their livelihood from cassava.

The open quarantine facilities established in 1997 has enabled the network, in collaboration with the national collaborators, to move thousands of improved clones

for further evaluation under their own ecologies (Table 9). The facilities enabled a fast-track introduction of improved germplasm from the regional improvement program in Serere for one-year observation by plant quarantine officials before release to the national programs for further evaluation. The clones after release from quarantine supervision formed the basis of multi location evaluation by national programs. The list of countries using open quarantine facilities has expanded to include Southern Sudan. The highest number of clones was exchanged between 1997 and 2000 with Kenya taking the lead with 1567, followed by Rwanda with 1171 and Tanzania with 977 clones, respectively. The peak movement was associated with outbreak and spread of the CMD pandemic and signified the desperate needs for improved clones resistant to CMD. There after, Kenya concentrated on evaluation of the introduction and farmer participatory on farm evaluation. Clones that have been marked with stars have been developed to target cassava brown streak and the East African Cassava Mosaic virus diseases, respectively. Similar approach is being utilized in the coastal lowlands to tackle CBSD. Tanzania is already benefiting from this by introducing 444 improved clones from programs in Coastal Kenya in a period of two years. The use of open quarantine facilities has significantly avoided the high cost of establishing cassava using tissue culture material. The use of fast track system has shortened the time required for evaluation to release of a variety by approximately three years. This new process has greatly enriched the cassava genetic base of national germplasm collections in the region and under the current epidemic situation has provided a highly efficient regional solution for the cassava farming community. As a result of the success of this new approach, it is now being proposed for application in both West and Southern Africa and if adopted will provide new access routes for germplasm exchange, which will improve on the food security of the region, reduce crop losses and increase local incomes of farmers in these areas. The use of open quarantine facilities and increased farmer participation in the selection of improved cassava clones have contributed greatly to slowing the spread of the pandemic in the region.

Table 9. Number of advanced cassava clones distributed under open quarantine facility since 1997

	Advanced cassava clones							
Countries	1997	1998	1999	2000	2001	2002	2003	Total
Ethiopia	-	-	-	-	-	-	28	8
Rwanda	506	473	187	5	-	308		1479
Kenya	503	219	600	245	-	-		1567
Tanzania	-	-	497	500		25*	419*	1441
Burundi	-	-	81	-	-	-		81
DR C	-	-	84	-	350	-		434
S. Sudan	-	-	-	10	-	-		10
Mozambique						25*	110*	135
Total	1009	692	1449	760	350	358	529	5175

*clones from lowland low rainfall ecology targeting cassava brown streak mosaic virus disease. The rest are from mid altitude medium rainfall ecology in Serere, Uganda.

4.2 Phytosanitary structures at Plnat Quarantine Services (PQS)

The upgraded phytosanitary structures at PQS, Muguga to receive, clean and virus index for international exchange of improved/local adapted germplasm and conservation of the regional core collection against unexpected/unforeseen losses is fully operational. Chemicals and supplies for germplasm cleaning and indexing were received from KARI. The upgrading of the facilities included completion of virology lab, washing area, media preparation room, air flow cabinets, growth rooms, lamina flow facilities, screen house and thermotherapy chamber fitted with adjustable thermo-control systems, repair and installation of air conditioners, change of roofing material. The laboratory facilities are conveniently located within the same building and had been made possible by funding from EARRNET, OFDA, UNIDO and CIP. Power fluctuation has been minimised by direct connection to a more stable line.

A total of 28 clones have been received by the national root crops program in Ethiopia for evaluation while 250 plantlets have been multiplied for distribution to Sudan and Eritrea. Initial virus tests using *Nicotiana benthamiana* indicated no virus present but confirmation with ELISA is necessaryA second set of 60 clones (Table 10) are a various levels of field, glass house, acclimatization and short term storage.

Table 10. Inventory of cassava germplasm at PQS

Site/activity	Number of clones	Remarks
Field	15	Water shortage
Glass house	29	Repair of glass house
Acclimatized	8	Poor performance
Short term storage	8	Good condition
Total	60	

4.3 Seedling, Clonal, Multi location and farmer participatory evaluation

All member countries now have access to improved populations and continue to introduce large number of improved clones from the mid altitude or lowland ecologies at Serere and Mtwapa, respectively. As such, both quantity of seeds evaluated and number of countries implementing seedling evaluation dropped to only Uganda, DR Congo and Madagascar. A total of 39,000 seedlings derived from several half sib families, 5,573 clones derived either from seedlings or introduced, were evaluated in addition to 994, 470 and 260 at clonal, PYT, AYT and UYT, respectively (Table 11). The time taken for the NARS to release varieties has been considerably shorter through elimination of early stages of evaluation. All clones evaluated in Kenya, Rwanda and Burundi were introductions, making it possible to

make faster progress in releasing or moving towards release of improved varieties as evidenced by the proposed number ready for release. Not much progress was evidenced in Madagascar during the phase mainly due to civil unrest in the early part of the years. Concerted efforts are planned this year to move improved germplasm as tissue culture plantlets from the Plant Quarantine Services, Muguga to make faster progress.

Table 11. Estimated number of improved clones evaluated at various stages and released or proposed for release from 1999 to 2003 in EARRNET member countries

Countries	Seedlings	Clonal evaluation	PYT	AYT	Uniform	Released or proposed
Uganda	25,000	2,500	150	100	75	6 released (12 proposed)
W. Kenya	-	1,567	280	80	40	2 released (15 proposed)
Rwanda	-	495	105	33	30	9 being grown
Burundi	-	81	50	20	15	5 being grown
DR Congo	8,000	630	249	77	50	9 being grown
Madagascar	6,000	300	160	60	50	
Total	39,000	5,573	994	470	260	

In DR Congo, a total of 192 clones were evaluated at M'vuazi for resistance to ACMV, CBB, CAD and CGM, using five plants per row and a local variety Mpelolongi as check. At twelve months after planting (MAP), harvest index and average of marketable storage root number and disease and pest scores were used to determine the clones to be retained. Only 26 clones selected from 5 families were advanced to preliminary yield trial. In another trial, 6 clones evaluated in six locations (M'vuazi, Kimpese, Yanga, Kisantu, Mbandana, and Mampu) using 10x4 m plots, with four replications and one local and improved RAV as checks showed huge variability among mean tuber yield (t/h) across locations. Varieties 92/127, 92/322 and the local checks were very susceptible to CMD in all locations. There were significant differences between varieties for storage root yield across locations. RAV and 92/278 had the best mean tuber yield 16.11 and 15.21t/ha, respectively. The variety 92/377 showed high yield instability across locations, 23.37, 15.02, 11.30 and 5t/ha at M'vuazi, Yanga, Mampu and at Kimpese, respectively (Table 12) which contributed to the high CV of 41.56%. Varieties 92/278 and 92/377 with good resistance to CMD have been proposed for on-farm trial M'vuazi, Yanga and Mampu locations.

Table 12. Mean yield (t/ha) of fresh storage roots of 6 clones evaluated in multi-location trial in DRC.

Variety	Site					
	M'vuazi	Kimpese	Yanga	Mbankana	Mampu	Mean
			Tonne/hectare			
91/127	25.42	07.60	06.60	02.35	05.25	09.20
91/278	29.80	13.70	18.57	04.85	09.12	15.21
91/322	27.37	09.72	11.60	03.07	10.87	12.53
91/377	23.57	05.07	15.02	03.75	11.30	11.74
RAV	34.87	12.17	19.50	06.47	07.55	16.11
Local	24.20	04.90	04.37	02.97	03.37	08.21
Mean	27.54	08.86	12.61	03.91	07.91	12.16
CV %	41.56					
LSD (0.05)	03.17					
LSD (0.01)	04.21					

In Rwanda 202 clones planted as multi location performance trial at Rubona (1800m asl.) and Karama were evaluated in a 3 x 8 m plots with three replications. Cassava mealy bug was most serious in Karama compared to cassava green mite and bacterial blight disease. Indicative root yields were generally low at both locations. Soil variation caused by steep slopes and shading were noted in Rubona while in Karama, the soil was shallow and stony. These factors in combinations could have contributed to the low yield in all the introductions. Mean tuberous root yields for both locations were 7.09 and 14.4 tons/ha in Karama for improved and check, respectively while it was 18 and 27.5 tons/ha in Rubona for improved and check, respectively (Table 13). The improved check (Gakiza) out yielded almost all the entries at both locations underlying the needs for deployment of broader genetic resource base. Due to the poor yield performance, selections were based on comparison of yields of the clones with that of Gakiza.

Table 13. Summary of the yield data of clones evaluated in two locations in Rwanda

Parameter	KARAMA				RUBONA			
	Min.[a]	Max.[b]	Average	*Average*[c]	Min.	Max.	Average	
	Average							
MktNo[d]	0	58	13.1	27.0	0	80	29.1	45.4
nMktNo[e]	0	102	29.6	29.1	6	80	37.2	34.7
MktWt[f]	0	20.0	3.2	8.5	0	26.0	9.8	17.4
NMktWt[g]	0	13.0	2.5	3.0	0.5	29.0	5.3	4.5
TbNo[h]	2	117	42.6	56.1	9	126	66.3	80.0
TbWt[i]	0.02	1.08	0.14	0.21	0.09	0.78	0.22	0.27
Yield[j]	0.13	28.8	7.09	14.4	1.9	52.5	18.9	27.5

[a]Minimum; [b]Maximum; [c]average for the check; [d]number of marketable tubers; [e]number of non-marketable tubers; [f]weight of marketable tubers; [g]weight of non-marketable tubers; [h]number of tubers; [i]weight per tuber; [j]fresh yield (ton/ha).

The results from a multi-location advanced yield trials conducted in Uganda are presented in Table 14. Significant differences were observed among clones for tuber yields with a range of 9.93 in MH95/0024 to 30.1 t/ha in MH95/0414 while DM ranged from 32 (TME 14) to 39.7% (95/SE-00088). The National Agricultural Organization (NARO) restricts release of clones with high cyanogenic potential. In this trial, all clones had cyanogenic potential levels lower than the upper limit of 300mg cyanide equivalent/kg dry weight and this is confirmed by the sweet taste. Though CMD incidence are high, severity is medium to low with 8 clones having score of either 1 or less than 2.5 indicating high levels of tolerance in the material evaluated, MH95/0414 and 95/SE-00087 did have no CMD/UgV symptoms. Clone MH95/0414 has been released as a variety and to date has shown no CMD symptoms.

Table 14. Mean performance of selected cassava clones planted in multi-locational trials in Uganda.

Clone	Yield CMDS[d] tons/ha	%dry matter	Taste[a]	Tuber no. /plant	HCN[b]	CMDI[c]	
MH 95/ 0414	30.71a***	36.7	1.26	8.64	90.8**	0.0***	1.0***
95/SE- 00094	29.22ab	37.6	1.00***	6.76	204.0**	27.6	2.2
95 SE- 00050	28.08abc**	38.4	1.42	7.64	109.0	25.5	2.7
MH 95/ 0420	24.71abcd**	35.7	1.47	7.77	154.9	15.6	2.1
MH 95/ 0134	*23.74bcde*	*38.3*	*1.70*	*6.66*	*110.0*	*40.2*	*3.0*
MH 95/ 0161	22.93bcde	36.8	1.26	5.77	133.0	41.7	3.0
95/SE-00087	21.91cde	37.4	1.19	8.00	110.0	0.00***	1.0***
MH 95/ 0349	21.53cde	34.5	1.21	8.88	272.6***	53.5	3.0
MH 95/ 0311	20.28def	37.8	1.16	6.88	134.4	28.4	3.0
SS4 (check)	19.15defg	37.4	1.40	6.65	110.8	10.6	3.0
MH 95/ 0080	19.06defg	36.5	1.56	6.77	122.1	61.2***	3.0
TME 14	18.29defg	32.0	1.17	5.82	144.5	3.30	1.3
95/SE-00044	17.97defg	39.3	1.35	10.3***	179.0	33.3	1.3
95/SE-00088	17.37defg	39.7	1.26	6.44	144.5	0.00***	1.0***
MH95/ 0204	16.16efgh	37.6	1.37	6.94	264.3***	17.3	2.2
Nase 2 (check)	12.41gh	39.7	1.04	5.16***	179.0	93.0**	3.3
MH95/ 0192	12.20gh	36.7	1.21	5.38	193.0	65.5**	3.0
MH95/ 0024	9.93h	34.5	1.50***	7.12	166.0	41.0	2.9

[a]Taste scored on a 1-3 scale (1=sweet, 2=slightly bitter, 3=bitter)
[b]Cyanogenic potential determined as mg HCN/kg dry weight
[c]CMDI = mosaic incidence (score for the highest pressure area (Namulonge) at 6 months after planting. [d]CMDS= mosaic severity-scored on a 1-5 scale, 1=no symptoms, 5=very severe symptoms.

Evaluation in Serere was carried out during September 2001 on performance 1 trials. Dry matter contents (DM) ranged between 26.1% in MM97/2332 to 49.5% in MM97/2490. Over 58% of the clones had DM percentage greater than 40 (Table 15). Root yield ranged from 6.5 to 48.7 ton/ha on fresh weight basis. All clones performed

better than the local check, Bao with 6.4 ton/ha. Ninety percent of the clones had cyanogenic potential levels lower than the upper limit of 300mg. cyanide equivalent/kg dry weight.

Table 15. Summary of the yield components of Performance 1 clones evaluated in Serere in 2001.

	Minimum	Mean	Maximum
Plants harvested	4.0	14.3	15.0
Number of marketable tubers	9.3	55.9	111.7
Number of non marketable tubers	3.7	33.4	125.7
Weight of marketable tubers	2.1	20.3	38.8
Weight of non marketable tubers	0.5	4.1	35.8
Number of tubers per plant	1.3	6.2	13.9
Weight per tuber	0.1249	0.2890	0.5973
Yield	2.8	16.2	38.8
Percentage dry matter	23.0	33.0	45.3

Following de-emphasis of Namulonge as a selection site in favour of Serere for the mid altitude, medium rainfall ecologies, 1,198 clones were transferred to Serere for further evaluation. The remaining set of 92 clones introduced from IITA, were evaluated and the selected clones transferred to Serere. Tuberous root yield indicators for this trial are shown in Fig. 5. Over 40 clones out of 92 yielded between 20 and 40 t/ha while 20 and 10 yielded between 41 to 60 and 61 to 90 t/ha, respectively. These positive performances are being further testes in various field evaluations across locations.

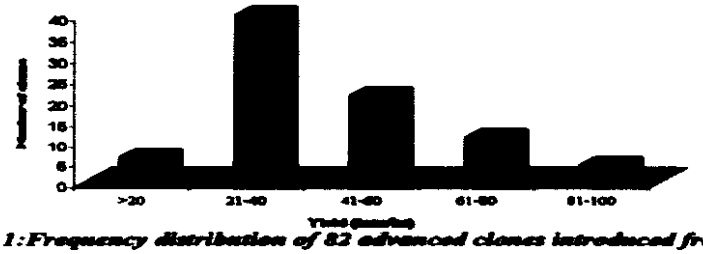


Fig 1: Frequency distribution of 82 advanced clones introduced from IITA, Ibadan (1999)

Fig. 5: Frequency distribution of tuberous root weights across 82 in advanced yield trial at Serere, Uganda

Evaluation of 400 clones in performance 1 trials in Namulonge, revealed large differences in storage root yield from 8.33t/ha in MH96/1070 to 114t/ha in MH96/1265. Clones MH96/1265, MH96/0601, MH96/0600 and MH96/0861 each yielded more than 100t/ha. Thirty percent of the clones out-yielded the improved check variety Migyera (47t/ha) while 99% of the clones out-yielded the local check variety Bao (14t/ha). High DM values were estimated with only 8 clones having values less than 30% and 21 with values greater than 45%. Of the clones selected from clonal characterization, 58 (7%) had DM equal to or greater than 45%, MH97/2006 and MH97/1395 having DM of 49%. Using picric acid method, the cyanogenic potential scores ranged from 1-7 (where 1 is almost no cyanide and a score of 7 indicates high cyanide content). Clones MH97/1463, MH97/1690, MH97/2257 and MH97/2471 had scores of 1, these are being monitored for reactions to other biotic reactions. Two sets each of 354 clones and 54 introductions were evaluated and 34 and 48 selections made, respectively.

In another performance trial a total of 691 clones were evaluated in groups of 100s with Nase 2, 3 and 4 checks. Significant differences were observed for all yield components. Root yields ranged from 3 t/ha in MH97/1329 to 40 t/ha in I96/0860 with 30% of the clones yielding more than the three improved checks Nase 4, 3 and 2, respectively. Tuber number ranged from 1.3 in MH97/0302 to 14 in MH97/0342, while weight per tuber ranged from 0.1 to 0.6kg in MH97/1045, respectively. Dry matter (DM) ranged between 30-40%, but significantly affected by age of the trial. Trials harvested at 9 months after planting (MAP) had higher dry matter compared to those harvested at 11 (MAP). This is consistent with early observations of higher DM at 9 MAP and confirms that we have significantly shortened maturity periods of the improved clones. A total of 561 clones were selected and added in the maintenance block.

Results of performance evaluation 1 of the open quarantine introductions planted in Alupe, Western Kenya are presented in Table 16. Fresh yield ranged from 0.7 ton/ha in MM96/2673 to 32.2 in MM96/3665 and from 7.7 in MM96/5739 to 37.6 in MM96/4570 in clonal and performance evaluation, respectively. There were significant differences among clones for tuber weights. Lower tuber weights estimated in introductions were likely to be associated with soil factors.

Table 16 Summary of the yield data collected at Alupe, W.Kenya (1999-2000)

	Clonal characterization			Performance evaluation		
Parameter	Min.	Mean	Max.	Min.	Mean	Max.
PltHt[a]	90	151	210	22.8	182.4	127.5
BraHt[b]	20	54.7	145	32.5	66.2	151
BraLvl[c]	3	3.6	5	2	3.4	5
MktNo[d]	*2*	*19.4*	*62*	*7*	*22*	*40*
nMktNo[e]	0	8.8	38	1	10	39
MktWt[f]	0.7	9.9	29	3	9.3	17.3
nMktWt[g]	0	1.3	4.9	0.2	1.8	3.9
TbNo[h]	2	28.1	96	8	32	63
TbPlt[i]	2	6	14	2	7	13
TbWt[j]	0.205	0.412	0.750	0.185	0.359	1.694
DM[k]	27.3	39.6	53.7	32.3	39.7	46.1
Yield (t/ha)[l]	0.7	11.2	32.2	7.7	21.0	37.6
Dyield[m]	0.3	4.6	13.6	3.0	8.3	14.9
Cnp[n]	-	-	-	2.3	3.7	6.3

[a]Plant height; [b]Branch height; [c]Levels of branching; [d]Number of marketable tubers; [e]Number of non marketable tubers; [f]Weight of marketable tubers; [g]Weight of non marketable tubers; [h]Number of tubers; [i]Number of tubers per plant; [j]weight per tuber; [k]Dry matter (%); [l]Fresh yield (ton/ha); [m]Dry yield (ton/ha), [n]Cynogenic potential.

High dry matter percent (39.6 %) was estimated in clonal evaluation. Over 42% of the clones had equal to or higher than 40 % dry matter and this is consistent with earlier trials. In the performance evaluation most clones had percent dry matter ranging from 36-45 %, while MM96/3900 had the highest estimate of 46.1 %. Cyanogenic potential estimation characterized 70.2 % of the clones as low (1-4), 29.2 % as medium (5-6) and only one clone MM96/2103 was high on picrate scale of 1-9 indicating their suitability for food. High variability among genotypes and within replications for all the yield parameters was observed. Negative relationship between cassava mosaic disease (CMD) incidence, severity, marketable tuber numbers and weight at all stages, seems to justify its use as a major selection criteria. Eighty six clones advanced from the trial are being evaluated in 4 locations (KARI-Alupe, Siaya farmer training center, ICIPE station in S. Nyanza, Oyani sub-center of KARI Kisii and RRC Kakamega).

4.4 Farmers' knowledge in selection of a variety.

In order to capture farmer knowledge in cassava variety identification, strengthen farmer researcher linkages in variety development there is need to get them participate in the exercise in the early selection process. One hundred and fifteen clones were evaluated in a three-replicated advanced yield trial (AYT) at 2 sites, Mtwapa and Msabaha with different agro-ecological characteristics where cassava

is very important during 2001/2002 growing season (Table 17). Three monthly data were recorded on major biotic stresses in collaboration with farmers starting three months after planting. At harvest, farmers evaluated and selected or rejected clones based on their own criteria

Table 17. Agro-ecological characteristics of the trial sites

Agro-ecological characteristics	Mtwapa	Msabaha
Agro-ecological zone	Lowland Coconut/Cassava Zone (CL_3)	Low Land Cashewnut-Cassava Zone (CL_4)
Soil type	Well drained, deep sandy albic Arenosols	Well drained, deep sandy clay loam rhodic Ferralsols
Average rainfall (mm)	Over 1200	Over 1100
Altitude (Metres)	15	91
Rainfall pattern	Bimodal with 1st rains starting end of March. Second rains starting in Mid October are short and unreliable	Similar to RRC-Mtwapa.
Annual mean temperature	24-26.6	24.9-26.6

Source Jaetzold R. and Schmidt H. 1983 pp.325-332.

Results indicated site, clone, and the interaction between site and clone were all significant ($P<0.01$). Clones generally performed better at Msabaha compared to Mtwapa. The best clone across the 2 sites for total roots yield was 2000LML/2095 (53.3 t/ha), slightly 410% better than the check Kibandomeno (Table 18). Clone 2000LML/900 had the highest number of marketable tubers (51) per plot. Highest dry matter % was recorded at Msabaha and the best clone across the 2 sites was 2000LML/1306 with 34 % that was also higher than the check. The highest % incidence for CMD, CGM and CMB were recorded at 6 months after planting (MAP) and CMD at this stage was higher at Mtwapa while the reverse was true for CGM and CMB. The top 11 clones were assessed by farmers on the basis of yield, dry matter content, root shape, size and colour of the skin and flesh, taste, ability to produce sufficient quantities of planting materials, suitability for intercropping and ease of marketing. Clones that were fibrous, bitter and, low dry matter content irrespective of yield potential and other positive attributes were rejected. Results of farmers evaluation is presented in Table 19. It is clear from this that farmer evaluation is directly correlated to end use characteristics, suitability for intercropping, yield, disease and pest resistance. That this is in line with KARI/network selection emphasis is demonstrated by the fact that out of 11 best selected clones the farmers selected 80%. Involvement of farmers in the earlier stages of evaluation on station could ensure that all clones identified by scientists have better chances of being accepted by farmers.

Selected clones are at national performance evaluation by KARI for recommendation for release to farmers

Table 18. Tuberous root yield (t/ha) and yield components of the 10 best clones across Mtwapa and Msabaha

Clone	Roots/plot	Marketable roots/plot	Marketable yield /plot	Total yield/plot
LML2000/2095	203	79	43	53.3
LML2000/2033	172	81	47	50.8
LML2000/715	148	68	47	50.8
LML2000/900	124	72	51	50
LML2000/1980	149	67	47	50
LML2000/1543	136	66	44	49.2
LML2000/1270	126	67	47	49.2
LML2000/1486	117	68	46	45.8
LML2000/2059	110	71	48	45
LML2000/1521	126	70	43	45
Kibandameno	67	28	10	13
R^2	0.6	0.5	0.6	0.6
Mean	127	57	32	43
CV	27	34	42	35
MSE	35	19	14	15
Minimum	65	81	51	64
Maximum	203	28	10	16

Table 19. Farmer evaluation criteria of the best 11 clones

Clone	Farmer evaluation	Remarks
LML2000/2208	High yield, good plant structure for intercropping and high dry matter content	Selected
LML2000/2211	Moderate dry matter content, bitter and poor planting material	Not selected
LML2000/2213	High dry matter content, sweet medium yield, good root shape and very marketable. However most plants have mosaic disease.	Selected
LML2000/2265	High yield, moderate dry matter content, sweet and economical to grow	Selected
LML2000/2292	Moderate dry matter content and sweet	Selected
LML2000/2320	Good yield, good planting material, moderate dry matter content and sweet	Selected
LML2000/2330	Good yield, sweet dry matter content like Kibaandameno but severely affected by mites	Not selected
97/119	Good yield, sweet and high dry matter content	Selected
97/290	Uniform roots, moderate dry matter content and sweet	Selected
97/461	Moderate dry matter content and sweet	Selected
97/695	High dry matter and sweet	Selected

4.5 Farmer/researcher participatory on-farm evaluation

Collaborative farmer participatory on-farm evaluation of the improved clones is key in the early variety identification and improved technology uptake. The network initiated a number of on-farm trials using augmented design in Uganda and Kenya to be extended to other countries to hasten evaluation of larger number of genotypes coming out of the regional improvement program. Fourteen clones were evaluated in seven sites representing six agro-ecological zones of the major cassava growing areas of Western Kenya (Table 20). Two improved varieties SS4 and Migyera were used as checks. Cultivars were laid in an un-replicated augmented design where four farmers at a site were assigned five cultivars such that only the two checks (Migyera and SS4) appeared on each farm and this arrangement constituted a cluster. A total of 20 farmers were used and where possible, inclusion in the trial of farmer's best local landrace was encouraged. Each plot measured 10x10 metres and cuttings were spaced 1m x 1m per hills. The district crop officers in the participating districts carried out selection of farmers within the districts using the following criteria: acceptance to work together in a community based organization, visit each other and assess the new cultivars together, provision of land, security and maintenance of the trials. The farmers provided land, labour and ensured security of the trial in collaboration with community. The researchers provided new planting materials and provided regular consultancy visits with the farmers. The extension officers and farmers took data on; germination at one months after planting (MAP), incidence and severity of cassava mosaic disease (CMD), cassava bacterial blight (CBB), cassava anthracnose disease (CAD), cassava green spider mite (CGM) and mealy bugs there after at three, six and nine months respectively from date of planting. Diseases were scored using the scale of 1-5 where 1 means clean and 5 means severely infected. Stakeholders evaluated the clones before and after harvesting based on the health status of the clones, branching habit and the height; tuber size shape, colour of skin, ease of peeling, texture of boiled tubers and cooked tastes.

Table 20. Agro-ecological classifications of the 5 districts in Western Kenya where the trials were conducted

Locations		Agro-classificationn
Divisions	***Districts***	
Ukwala	Ssiaya	LM_2
Matungu	Mumias	LM_{2-3}
AAmukura	Teso	LM_3
Kasipul	Rachuonyo	LM_{3-4}
Muhuru	Migori	LM_4
Sabakuria	Kuria	LM_{4-5}

LM_2 = Marginal sugarcane zone with long cropping season (good yield potential)
LM_3 = Lower midland cotton zone long to medium cropping season
LM_4 = Marginal cotton zone, short intermediate rains and medium to short cropping season

There were no significant differences observed for CMD severity among cultivars evaluated (Table 21) with 32% of the clones showing no symptoms across locations.

Table 21. CMD % incidence and severity in brackets at 9 map across locations

	Kuria	Migori	Ruchuonyo	Mumias	Siaya
SS4	6 (2)	0 (1)	0 (1)	0 (1)	0 (1)
Migyera	0 (1)	0 (1)	0 (1)	6 (2)	0 (1)
MM96/1871	0 (1)	- -	- -	7 (2)	0 (1)
MM96/3868	11 (2)	0 (1)	0 (1)	0 (1)	0 (1)
MM96/4052	0 (1)	0 (1)	13 (2)	0 (1)	5 (2)
MM96/4466	6 (2)	0 (1)	0 (1)	0 (1)	0 (1)
MM96/4684	0 (1)	- -	0 (1)	0 (1)	0 (1)
MM96/4884	0 (1)	0 (1)	0 (1)	15 (2)	0 (1)
MM96/5280	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
MM96/7151	0 (1)	- -	0 (1)	0 (1)	0 (1)
MM96/7688	0 (1)	- -	0 (1)	0 (1)	0 (1)
MM96/9308	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
MM96/9362	18 (2)	0 (1)	18 (2)	17 (2)	10 (2)
TME14	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
MH95/0183	13 (2)	15 (2)	22 (2)	8 (2)	5 (2)
CK2	1 (2)	35 (2)	68 (2)	73 (3)	4 (2)
Unknown 2	0 (1)	0 (1)		0 (1)	- -
55329	- -	- -	- -		- -
Unknown 3	- -	- -	- -		- -

Significant differences were observed for fresh root weight. Genotype rankings varied from location to location indicating lack of stability across locations (Table 22).

Table 22: Genotype tuberous root yields (kg/36m^2) and rankings across districts/cells

	Locations/cells					
Clones	Kuria	Migorii	Rucuonyo	Mumias	Siaya	Teso
SS4	5.5 (14)	5.6 (11)	7.2 (15)	8.5 (18)	12.3 (13)	13.9 (10)
Migyera	4.7 (17)	4.3 (13)	8.3 (13)	12.3 (8)	20.6 (8)*	13.5 (11)
MM96/1871	7.8 (5)	-	-	8.7 (16)	-	15.6 (7)
MM96/3868	6.7 (8)	6.3 (10)	22.3 (1)	26.3 (1)**	26.5 (4)*	19.7 (3)
MM96/4052	5.6 (13)	10.0 (5)	9.2 (12)	13.8 (4)	17.0 (11)	12.2 (12
MM96/4466	15.0 (2)*	8.4 (6)	9.9 (11)	18.0 (3)	21.0 (7)	4.5 (15)
MM96/4684	4.9 (16)	-	12.3 (7)	9.0 (14)	24.6 (5)*	-
MM96/4884	6.6 (9)	13.3 (1)	10.0 (10)	11.1 (10)	11.0 (14)	14.3 (9)
MM96/5280	8.9 (4)	10.1 (4)	12.0 (8)	13.0 (6)	22.8 (6)*	19.0 (4)
MM96/7151	6.6 (10)	-	11.6 (9)	11.2 (9)	18.1 (9)	15.2 (8)
MM96/7688	19.8 (1)**	-	14.9 (3)	13.5 (5)	26.7 (3)*	17.3 (6)
MM96/9308	5.9 (11)	6.6 (8)	14.9 (3)	7.5 (19)	6.6 (15)	21.2 (2)
MM96/9362	!0.9 (3)	6.4 (9)	12.9 (5)	8.7 (17)	31.6 (2)**	9.1 (14)
TME14	5.0 (15)	11.0 (3)	13.8 (4)	12.4 (7)	17.6 (10)	18.9 (5)
MH95/0183	6.7 (7)	7.1 (7)	12.7 (6)	10.2 (12)	40.2 (1)**	9.5 (13)
CK2	7.3 (6)	11.0 (2)	6.9 (16)	10.0 (13)	16.7 (12)	24.8 (1)
Unknown2	5.8 (12)	5.2 (12)	7.7 (14)	19.2 (2)	-	-
55329	-	-	-	8.9 (15)	-	-
Unknown3	-	-	-	10.9 (11)	-	-

* Significantly different P≤ 0.05, ** significantly different at both P ≤ 0.05 and P≤ 0.01

In the Lake Region of northern Tanzania, the establishment of eight technology transfer centres in Bukoba, Muleba, Tarime, Mwanza and Musoma within the established farmer groups has greatly improved farmer participation in identification of potential varieties. Ten fast track clones identified from the early introduction are now being multiplied for distribution to contract farmers for further multiplication and distribution.

In Rwanda and Burundi two surveys conducted by IITA scientists and NARS collaborators in 2001 and 2003, respectively confirmed that severe form of African cassava mosaic disease (ACMD-UG2) associated with cassava mosaic disease (CMD) had hit the two neighbouring countries causing panic among households that depend on the crop for their livelihoods. The widely grown local varieties Creolina, Gitamisi and Gakiza had succumbed to the disease and it was no longer possible for farmers to select clean planting material as everything in farmers' fields was infected. Root yields had declined from about 15-20t/ha to almost zero (Plate 1a). Farmers visited in the two most important cassava growing areas of Gitarama and Karama confirmed that the severe symptoms started appearing two years ago and had worsened in 2002/3. Improved clones distributed by EARRNET (Plate 1b) and tested in collaboration with

Istitut des Sciences Agronomiques du Rwanda (ISAR) scientists have shown remarkable resistance against the disease threat.

Plate 1a Plate 1b

Plate 1. A field devastated by cassava mosaic disease (a), almost zero yields is expected compared with IITA/EARRENT improved resistant genotype MH95/0414 (b).

Elsewhere, eighteen advanced clones (Table 23) are being evaluated at both stations as well as on farm in Gitarama and Bugesera. Rubona is high altitude ecology for cassava and a low CMD pressure area, as such very mild symptoms were expressed, tip dieback caused by low temperature were observed in some varieties while low cases of CGM were also reported despite very dry conditions.

Table 23. List of 18 clones evaluated at on-farm trial at Bugesera and Gitarama in 2002/3

Clones	Comments	Clones	Comments
MM96/9488	Very good stand no CMD	MM96/7204	Performing well on station
MM96/7212	Poor stand mild CMD	MM96/5391	Has mild CMD
MM96/1961	Stand good & in multiplication	MM96/3920	Very good, in multiplication
MM96/5280	Good stand, being multiplied	MM96/4266	Clean but non-uniform
MM96/8299	Poor establishment high CGM	MM96/7214	Performing well
MM96/7459	CBB, CGM	MM96/4722	Has CMD and non-uniform
MM96/7688	Fair and no CMD	MM96/2354	Has CMD and dieback
MM96/4266	Less vigor but no CMD	MM96/0287	Low level of CMD, yellow root
MM96/4935	Clean, poor planting material	MM96/4618	Poor planting material

Farmers' acceptability of a clone was strongly influenced by root yield, resistance to CMD and end uses as had earlier been observed in the case of coastal Kenya. Genotypes MM96/ 5280, MM96/1871, MM96/ 4466 and MH95/0183 had high priority frequency of acceptance across locations while MM96/7151, MM96/7688, TME14, MM96/4684, MM96/3868, Unknown 2 and MM96/4884 were selected at specific locations. Many farmers retained all the clones evaluated. This is significant because it is an indication of farmers desires to expand cassava genetic resource base at household level. It is recommended that the number of clones assigned to a farmer should not exceed 5 for ease of management and to allow farmers make better decisions, genotypes be replicated within a site and farmers' cultivation practices be taken into consideration when taking data.

Clone MM96/7688 has also performed well in the Democratic Republic of Congo (DRC), Burundi and Rwanda. In this experiment it shows relatively good stability compared to others.

The evaluation at on-farm consists of the same 18 clones laid out in a kind of augmented design in Gitarama and Karama with each farmer receiving 5 clones but one less than the other to permit evaluation of large number of clones with farmer participation and enable the capture of farmer knowledge and criteria for variety selection as already described. Ten farmers from each location visibly evaluated the clones and the mean rankings are shown in Table 24. Clearly rankings are variable from location to location though it can be seen that MM96/3920, MM96/5280 appeared more preferred by the three farmers on the basis of emergence vigor, disease free and cracking of the soil around the stool. Genotype MM96/5280 shows remarkable performance in Kenya, Northern Tanzania, DR Congo and Rwanda and therefore has wide adaptation and can be a best bet clone to go in for with high chances of success.

Table 24. Mean ranking of some improved clones across locations in Rwanda

On-station	Gitarama	Karama
MM96/3920 (1)	MM96/5280 (1)	MM96/3391 (5)
MM96/4266 (2)	MM96/7212 (4)	MM96/0287 (1)
MM96/7212 (5)	MM96/4266 (5)	MM96/8299 (4)
MM96/5280 (3)	MM96/3920 (3)	MM96/9488 (2)
MM96/7204 (4)	MM96/4618 (2)	MM96/4618 (3)
Gakiza	Creolina	Gakiza (6)
Creolina	Gasashari	

In Uganda 20 clones (Table 25) were evaluated in three northern districts involving a total of 80 farmers using the same design. Each farmer received 5 improved clones plus SS4 as a standard check and a local cultivar of the farmers' choice and these were planted in May 2001.

Table 25. List of improved clones in farmer participatory on farm trial in 3districts of Uganda

1. MM96/4004	6. MM96/4589	11. Oko Iyawo 2	16. MM96/561
2. Oko Iyawo 1	7. MM96/0264	12. MM96/4614	17. I92/0427
3. I91/2324	8. Alice Local	13. TME 12	18. I/60142
4. MM97/044	9. MM96/5312	14. MM96/1419	19. TME 5
5. MM97/2961	10. MM96/3585	15. MM96/0245	20. Abbey Ife

At harvest more than 30% of clones including MM96/4614, MM96/0425, I92/0427 and TME 12 withstood CGM with good leaf retention despite extreme high temperatures of Northern Uganda. Leaf canopy retention is a desirable characteristic of a good clone in that it ensures continuous photosynthate assimilation through the dry spell and root quality characteristics at the onset of rains as well as a good resistance to CGM. Leaf losses in a number of genotypes were due to drought stress with small proportion attributed to a combination of drought, CGM and CBB causing die-back of the tips. No mosaic symptoms were reported throughout the growth stages. Goats were a major problem as cassava remained the only green crop seen during the dry spell. Providing early maturing varieties or varieties that shed off leaves during drought spell may provide a temporal solution though this alternative may affect tuberous root qualities at the onset of rains. For the former, long term storage of planting material may be a bottleneck to this alternative. Although farmers tended to retain all the clones, a total of 12 clones were selected across the three districts and the information on them have been compiled for release.

5 Ecologically Sustainable Plant Protections (ESPP)

This theme seeks to evaluate, develop and integrate relevant management systems that will reduce pre- and post harvest crop losses due to diseases and pests. Although historically cassava had few serious pests and diseases, the situation changed over time as cultivation intensified and exotic pests introduced. It is now accepted that cassava in Africa is attacked by a number of pests and diseases that together seriously reduce yields. Major cassava pests and diseases include cassava green mite, variegated grasshoppers, root mealy bug in the rain forest eco-zones, cassava mosaic virus diseases, cassava bacterial blight, cassava anthracnose disease and root rots in the humid lowlands. Highlights of accomplishments during the phase II are provided.

5.1 Cassava mealybug

Monitoring survey carried out in Kenya to confirm presence of CM, spread and establishment of *E. lopezi* indicated the presence of the pests both in the eastern and coastal regions but the population was low. Some hymenopterous parasites were recovered from CM and sent to IITA for identification. In western Kenya CM was recorded in three sites and population was also low. In eastern region empty *E. lopezi* cocoons observed indicates that CM was accompanied by the parasitoid in its spread. The low CM population in coastal and western provinces can be explained by the establishment of *E. lopezi*

5.2 Larger Grain Borer Prostepahnus truncatus (Horn), a potential pest of dry cassava

Larger grain borer (LGB) *Prostephanus truncatus* (Horn) is the most serious potential pest of dried cassava in storage. As high as 70% of stored cassava can be lost after four months of storage has been reported. In Kenya, LGB is assumed to have been accidentally introduced from neighboring Tanzania (Mutambuki et al. 1991) and has since been reported in Coast, Eastern, Rift valley, Central provinces. Its spread countrywide is not known, neither is there any comprehensive information on the damages caused to dried cassava chips in Kenya. A survey was conducted to determine the status of LGB infestation of cassava in the eastern, western and coastal provinces of Kenya using structured questionnaire.

Results showed that farmers used cassava tubers in various ways including home consumption, cash, animal feed, famine crop, vegetable and for soil conservation (Table 26). Although the major stored form is dried chip, duration of storage varied from one to 12 months (Table 27) and this has influence on the outbreak of LGB in an area. The study reported no LGB in western Kenya (Table 28). The study concluded that damages caused by the storage weevil *Sitophilus zeamais* are widespread. Low levels of extension services and uneven coverage caused by inadequate transport (Table 29) call for complimentary delivery pathway to the government extension service. The study draws the following:

1. In Eastern and Coast Provinces, LGB is not potentially a serious pest of stored cassava because cassava is not commonly stored as dry chips and storage is for a very short duration of time < 2 months, which may not favor successful LGB establishment.
2. In Western Kenya, although LGB was unknown to the farmers, there is a great potential of it becoming a serious pest of cassava in this region due to the current storage systems. This can be aggravated by the presence of other storage weevil *Sitophilus zeamais* already reported to be causing damage to stored chips.
3. There is need for creation of awareness especially among women who are heavily involved in food production at household level that LGB is a major pest of stored cassava. Short training and dissemination of LGB control technologies is essential as a complimentary delivery pathway to the government extension service.

Table 26. Uses of cassava in Coast, Eastern and Western provinces of Kenya

Province	Percentage of farmers					
	Home consumption	Sale	Animal feed	Famine crop	Leaves	Soil conservation
Coast	100.00	100.00	93.1	100.0	3.5	3.5
Eastern	100.0	95.6	21.7	97.3	0	0
Western	100.0	100.0	5.0	100.0	0	0

Table 27. Storage form and duration of storage of cassava chips

Province	Percentage of farmers			
	Cassava stored as chips	Period of storage of the chips		
		One Month	Two Months	Over one year
Coast	58.6	57.1	37.9	5.0
Eastern	28.3	91.3	8.7	0
Western	95.0	19	29.2	51.8

Table 28. Seriousness of damage by larger grain borer

Province	Percentage of farmers				
	Serious	Moderate	Slight	Not serious	No LGB
Coast	13.8	3.4	10.3	27.6	44.9
Eastern	10.9	21.7	6.5	0	60.9
Western	0	0	0	0	100.0

Table 29. Dissemination pathways for pest control in cassava - Farmer opinions

Province	Percentage of farmers					
	Extension Agents	Prefer Women	Prefer Men	Women groups	Farmer Association	Extension teach pest control
Coast	51.7	10.3	6.9	93.1	75.9	44.8
Eastern	36.9	19.6	23.9	52.2	39.1	17.4
Western	47.2	9.6	32.4	67.2	43.2	29.5

5.3 Cassava green spider mite

CGM infestation and damage to cassava in eastern province was high, ranging from about 1.4 to 3.5 (on a scale of 0 to 5) and 76 to 100%, respectively (Table 30). CGM abundance varied from site to site but more serious in western Kenya. The phytoseeids *N. idaeus* was recovered in the dry hot area of Katumani. Follow up surveys show establishment of *T. aripo* in the released and non released areas of the coast and nearly all released sites in W. Kenya. In-field method of mass production of *N. idaeus* for the control of red spider mite (RSM) was successfully demonstrated. It shows that this method could be adapted when a large number of RSM is needed to boost production of *N. idaeus* in the laboratory.

Table 30. Cassava green spider mite population dynamics in Western and Coastal Provinces of Kenya

Site	Mites/leaf	Damage score	% infestation
Western Kenya			
Siaya	17.67	1.52±0.55	61.72
Busia	51.60	1.04±0.73	100.00
Katuru	7.47	1.50±0.59	85.00
Port Victoria	52.54	2.33±0.74	91.67
Mukuro	57.94	2.16±0.42	100.00
Central Suna	38.12	2.19±0.83	94.00
C. Province	0.67	1.61±0.36	0.66

A study was conducted to investigate the impact of *T. aripo* on the population density of the cassava green mite and cassava production under farmers field conditions, respectively. The study confirms the effect of *T. aripo* in reducing CGM population and severity on cassava (Fig. 6). Although total exclusion of *T. aripo* was not achieved, its reduced number in the fields treated with selective acaricide had significant impact on CGM. Similar impact was achieved on yield of treated and non treated check. CGM population was reduced from a mean of over 300 to less than 30 mites per leaf on variety Obarodak and from over 150 to 20 mites per leaf in variety Shude. A mean difference in yield of about 2-8 t/ha in cassava yield was observed for the two cultivars in fields with and without *T. aripo* (Fig. 7)

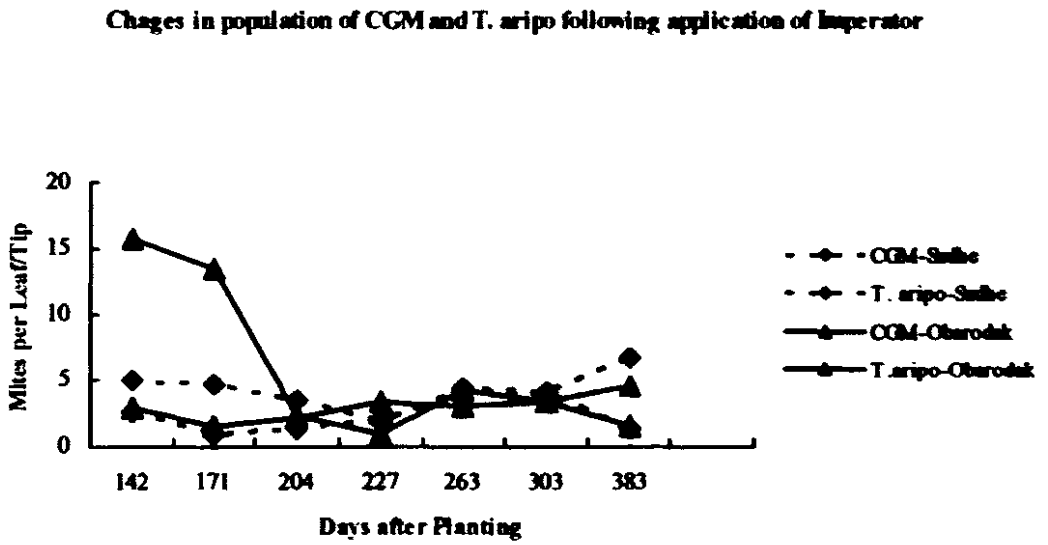


Fig. 6. Changes in population of cassava green mite and *T. aripo* following application of imperator

The Impact of *T. aripo* population levels on cassava yield of two local varieties in farmers' field

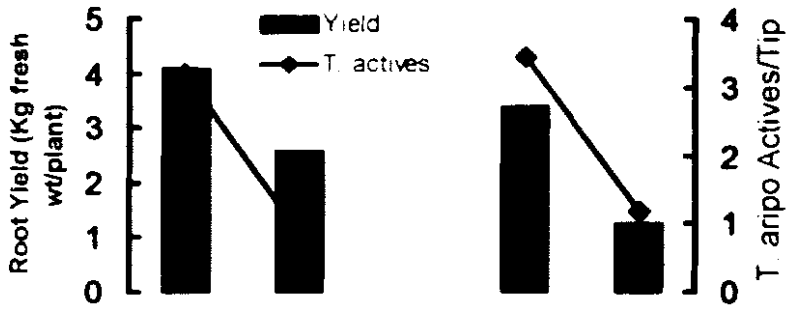


Fig.s 7. Impact of *T. aripo* population levels on cassava yield of 2 local cultivars in farmers fields.

5.4 Evaluation of cassava clones for preference/non-preference by T. aripo

From several field surveys and preliminary experimental trials, it was observed that the establishment and spread of the predatory mite *Typhlodromalus aripo* were influenced by the cassava variety cultivated. Some varieties harboured more *T. aripo* than others. Further observations showed that the more attractive varieties could have particular shoot tip characteristics that differed from the less or non-attractive varieties. In 1999, a study was initiated in collaboration with IITA Plant Health Management Division PHMD, Cotonou to explore the relationship between cassava host and *T. aripo*. Based on the preliminary characteristics such as tip size, tip hairiness, greenness of the plant especially in the dry season, 40 cassava clones were selected from 600 improved clones maintained at Serere and planted in no-replicated plots of 10 x 10 m and evaluated 4 times for several characters including tip size, tip compactness, tip hairiness, branching type, flowering, stay-green score according to a scale developed by the CGM Project. CGM densities and the presence/absence of *T. aripo* were also recorded at each sampling date.

Out of the 40 clones, 32 were retained for their performance based especially on the presence/absence (attractiveness) to *T. aripo* as indicated in Table 31. These were replanted in non-replicated plots and re-evaluated 4 times for the same tip characteristics and CGM densities and the presence/absence of *T. aripo* in 2000-2001. Results from both plantings (1999-2000 and 2000-2001) at Serere consistently show differences in *T.aripo* attractiveness between clones in relation to their tip characteristics. In a follow on experiment twenty clones out of those retained were planted in 3 replicated plots of 9 x 7 m. In addition to the field evaluation, the cassava shoot tips were measured and/or quantified to relate them to

T. aripo attractiveness. The pedigree of the most attractive clones will be identified and the heritability of some of the characteristics of the most attractive varieties determined to be incorporated into breeding program.

Table 31. Classification of 31 cassava genotypes for preference by *T. aripo*

Highly attractive	Moderately attractive	Less attractive
MM96/4496	MM96/2662	MM96/6889
MM96/5725	MM96/4460	MM96/0929
MM96/5173	MM96/4225	MM96/7344
MM96/7333	Nase2	I91/00453
MM96/5615	MM96/5301	MM96/8433
MM96/0414	I91/02030	MM96/2135
MM96/6814	MM96/7488	MM96/3903
	MM96/1954	MM96/0287
	MM96/8354	MM96/2075
	MM96/5333	MM96/7204
	MM96/5674	Nase4
	Alice local	MM96/9519

5.5 Cassava yield loss due to Meloidogyne spp. attack

Two trials were established in June 2002 in Mtwapa and Msabaha located in the coastal lowlands of Kenya to establish yield losses to cassava caused by *Meloidogyne* spp attack using split plots in randomised blocks with 2 factors and six replications. Data was recorded on nematode densities at pre-planting and harvesting, percentage establishment 2 weeks after planting, days to emergence, plant height, plant girth, plant weight, tuber yield (marketable and non-marketable), tuber numbers (marketable and non-marketable), root galling index and galls per 50 cm. at harvest. There were significantly ($P<0.05$) high number of galls per 50 cm where no nemacur was applied (10 galls per 50 cm) than where it was applied (3 galls per 50 cm) for both cultivars. Nematode populations were higher where no nemacur was applied and tuber numbers and sizes were significantly affected by nemacur treatment but total yield per plot was affected by nemacur treatment for both cultivars.

In Msabhaa, significantly ($P<0.05$) higher galling index was observed where no nemacur was applied for cultivar Kibandameno. More galls per 50 cm of root were equally observed in both cultivars where no nemacur was applied (2-4 galls/50cm) than where it was applied (1-2 galls/50cm) but these were not significant. Though no *Meloidogyne* spp. were recovered in the root system for both cultivars, the soil had a significantly ($P<0.05$) higher number of *Meloidogyne* spp. populations where no nemacur was applied (4 nematode/5g of soil) than where it was applied (no nematodes recovered) for cultivar Kibandameno. *Scutellonema* and *Pratylenchus* spp. populations were also higher where no nemacur was applied than where it was applied in the soil though results were not significant. There were significantly ($P<0.05$) higher tuber numbers and weights per plot (123 tubers and 40.5 kg per

plot) where nemacur was not applied than where it was applied (93 tubers and 28.3 kg per plot) for variety Kibandameno. This was contrary to what was expected. No significant effects by nemacur treatment were observed for variety BRRT. Yield/ha was not significantly affected by nemacur treatment for both cultivars.

5.6 Effects of M. incognita on sprouting

Severe root-knot nematode problems on cassava have been reported from a number of African countries. National and international cassava breeding programs have attempted to screen their germplasm for resistance to nematode using short term pot screening. Extrapolation of results from such trials in forecasting yield loss in the field is usually inaccurate. Experiments carried out to investigate the effects of *M. incognita* on sprouting, field performance, cyanogenic glucoside (CNp) and the effects of CNp on nematode development were concluded as follows: Nematodes considerably reduced and delayed sprouting and this can seriously affect plant vigour and early establishment. The trial revealed variety differences that could be attributed to rooting behaviour. Breeding programs should consider ability to sprout in nematode infested soils in selecting superior genotypes. Where rapid multiplication is used to produce large amounts of planting material, efforts should be made to keep the multiplication blocks nematode-free. Both storage root numbers and yield were significantly reduced. The two clones MH95/0161 and MH95/0324 with the highest yield in the inoculated treatments also had significant reductions in storage root weights and large root number

5.7 African cassava mosaic disease

The dramatic change in disease and pest problems in Africa has been due to intensified cultivation and accidental introduction of exotic pests. Intensification tended to erode the environmental stability inherent in the balanced ecosystems while local cultivars succumbed in the absence of indigenous natural enemies and traditional practices which had not had time to evolve to cope with the exotic pests. Current estimates put losses to mosaic disease in Uganda and Kenya at US$ 75 million annually. Yearly surveys are conducted in Rwanda, Uganda, Tanzania and Kenya to provide detailed distribution of major cassava pests and diseases, (cassava mosaic disease and cassava green mite, anthracnose and mealybug). In 1997, modest increases in CMD incidence of 15% and 5% in Rakai and Masaka districts, respectively, were observed. Cutting-derived infection was more important compared to white fly transmitted incidence suggesting reduction in innoculum pressure perhaps due to farmers exploitation of improved variety diversity. Observations made in the Rakai-Uganda and Kagera-Tanzania border area in September 1999 indicated that the severe CMD pandemic 'advanced' across the Tanzania border from a January 1998 position of approximately 30km north of the border. Cassava green mite was widespread but damage was low apparently due to presence of biological control predator that was found everywhere. Cassava mealybug was not observed and cassava bacterial blight was of minor importance.

A survey conducted in 11 district of the Lake Zone on a total of 142 farmer fields indicates higher incidence and more severe symptoms in the pandemic areas of Biharamulo, Geita, Ngara and Karagwe. In Bunda and Ukerewe, the situation was

exacerbated by the bad practice of use of infected planting material. A total of 117 leaf and 43 whitefly samples were collected for DNA analysis

During 2003 a survey was conducted in Burundi to assess the status of CMD. Fifty-three fields were sampled from ten of the country's 16 regions. CMD-diseased leaf samples were collected and diagnosed using both specific primer PCR and restriction digestion with *Eco*RV and *Mlu*I of near full length DNA-A fragments amplified using universal begomovirus primers. Assessments were made of CMD incidence, severity (using the standard 1-5 scale), infection type (either cutting or whitefly-borne) and abundance of the whitefly vector, *Bemisia tabaci*. EACMV-UG, ACMV, EACMV and mixed ACMV+EACMV-UG infections were identified from 17, 34, 1 and 3 sites respectively. EACMV-UG occurred at all sites in the north-eastern regions of Muyinga and Kirundo was present at some sites in northern Gitega, Ngozi, Karuzi, Kayanza, Ruyigi and northern Rutana, but was not recorded from southern Gitega, southern Rutana, Muramvya or Bujumbura. The EACMV-UG affected regions of Muyingo and Kirundo were distinct from the others in having higher CMD incidence (79% vs. 42%), a greater proportion of whitefly-borne to cutting-borne infection (1.9 vs. 0.6), more severe symptoms (4.17 vs. 3.26) and a greater abundance of *B. tabaci* (4.9 vs. 1.0). These data provide clear evidence for the rapid spread of severe EACMV-UG associated CMD in the north-eastern regions of Kirundo and Muyinga. The occurrence of EACMV-UG at sites in northern, central and eastern Burundi also suggests that similar changes in CMD epidemiology are likely to occur here in the near future.

Cassava mosaic diagnostics protocols: A Polymerase Chain Reaction (PCR) was established to routinely diagnose cassava mosaic gemini viruses (CMGs) as a supplement to the more traditional enzyme-linked immunosorbent assays (ELISA). The PCR allowed the Uganda cassava mosaic variant (UgV) to be distinguished from both African cassava mosaic virus (ACMV) and East African cassava mosaic virus (EACMV) using the following specific virus detection oligonucleotide primer pairs.

1. ACMV AL1/F and AR0/R
2. UgV UV-AL1/F1 and UV-AL1/R1
3. EACMV UV-AL1/F1 and EACMV-CP/R

154 samples from 12 districts of Uganda were diagnosed using both ELISA and PCR approaches. Most diseased samples contained only UgV, and only a small proportion contained ACMV alone. UgV was dominant in areas affected by the severe CMD epidemic (north, central, and eastern) though mixed infections with ACMV were observed at few locations.

Identity and distribution of whitefly vector associated with cassava in E. Africa
Studies to (a) apply a PCR-based methodology to determine the identity and map the distribution of whitefly vector biotypes associated with cassava-infecting begomoviruses (b) develop a PCR-based or combined PCR-restriction enzyme approach for identifying the common genotypes of *B. tabaci* in cassava to permit

on-site monitoring of whitefly activities are being undertaken in collaboration with the University of Arizina, Tucson, USA. The studies aim at better understanding the identity, dynamics, relationships and specific circumstances surrounding the whitefly vectors populations in cassava in relation to the new begomovirus epidemic and ACMV/EACMV/UGV results indicate:

- Indigenous *B. tabaci* from Uganda (ahead of the front) form a cluster with Congo 1 and 2, part of collections from Kenya, all collections from Rwanda and Tanzania; indicating a common genotype associated with cassava or non cassava hosts and the possibility of its origin from cassava despite their collection also from other sources (pepper and cabbage)
- A second cluster contains *B. tabaci* associated previously with the epidemic together with the Kenyan samples
- Sweet potato form distinct group with others from sub-Saharan Africa
- Several samples from Rwanda indicates that the whiteflies are probably B. afer, a *Bemisia* species that colonizes a range of host species including cassava and is not a beomovirus vector.

5.8 Cassava Brown Streak Disease

Cassava is a key food security crop throughout much of sub-Saharan Africa, has greater total fresh weight production than any other crop in Africa, and this production is set to double by 2020. However, these potential gains are seriously threatened in a large part of eastern, central and southern Africa by the effects of a devastating virus disease, cassava brown streak disease (CBSD) caused by the Ipomovirus, which attacks cassava plants causing reduction in root yield and producing a dry necrotic rot in the storage roots leading either to complete spoilage or significant reductions in quality (Plate 2 a & b).

(a) (b)

Plate 2. BSD leaf symptom expression (a) and severely affected roots symptoms complexed with other root rots (left), mild symptom (centre) and no symptom (b).

- Distribution of CBSD shown in Fig. 8 illustrates a ravaging situation in Mozambique, Zanzibar and Pemba Islands, devastating along coastal Tanzania

and Kenya and Malawi and reported but not confirmed in DR Congo, Uganda and other W. African Countries.

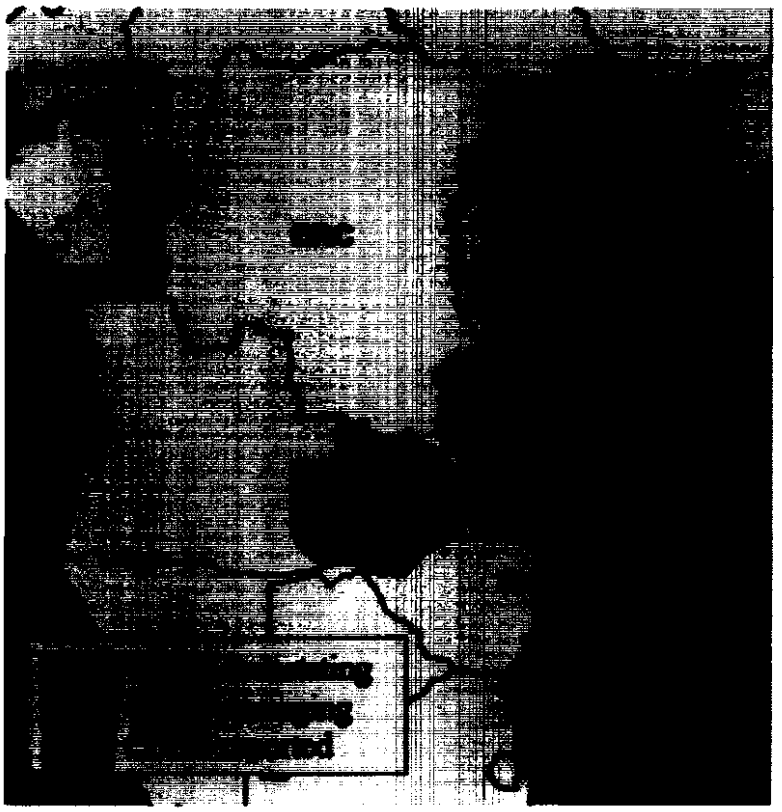


Fig. 8. Distribution and intensity/pressure of CBSD along the Coastal, East and Central Africa

During the 2001 the network received the Rockefeller Foundation support to backstop the national efforts in the Germplasm generation and deployment for enhanced and sustainable food availability and poverty alleviation in the coastal lowlands of Eastern and Southern Africa. This marked the beginning of intensified activities in collaboration with KARI and other stakeholders to:

- generate improved populations with multiple resistance background to major pests and diseases and with end user acceptable qualities.
- avail populations to target countries for evaluation and selection under specific agro-ecosystems

establish special backup populations

5.9 Stakeholder workshop Mombasa Kenya

A Workshop on Cassava Brown Streak Virus was held in October 27-30, 2002 in Mombasa, Kenya attended by over 30 participants from Tanzania, United Kingdom, Malawi, Zambia, Mozambique, Uganda and the host Kenya. Key presenters included Dr. Derek Jennings one of the pioneer cassava breeder at the Amani Station in the early 1940s. Presentations covered CBSD past and present, current status of the disease in Tanzania, Kenya, Mozambique and Malawi. Work on current research focused on epidemiology, yield loss and control, transmission

studies, virus characterization and diagnostics and the social impact of CBSD on livelihoods of the people in the affected areas. Historical perspectives on breeding for resistance was discussed in relations to the roles of Regional networks, the regional plant quarantine, open quarantine facility in germplasm exchange including the potential role of South Africa in facilitating germplasm for CBSD management. The workshop also discussed the objectives of the on going and planned CBSD projects under CPP/NRI, Rockefeller/IITA, INIA, KARI, USAID/SARRNET and IFAD/IITA cassava IPM and how to streamline activities. The field trip enabled the participants see the CBSD situation on the ground, interact with farmers and appreciate the genetic gains being made on KARI/EARRNET germplasm development activities. The summary and the outcomes of the workshop provided in annex B provides the framework on the planned/ongoing strategies.

EARRNET tapping on the experience of colleagues from Mozambique and Tanzania where the disease pressure is high jointly participated in evaluation of over 3,000 seedlings from which 2,428 clones were selected for further evaluation based on reactions to major pests and diseases in Kenya with emphasis on CBSD. The scientists agreed on some CBSD selection procedure to follow such as; simple scoring scale for leaves and stems as follows: 1 no symptoms; 2: moderate symptoms; and 3: high intensity of symptoms and suggested additional measure such as de-topping of resistant clones was suggested as a mean to promote symptom development. Impact of soil gradient fertility on CBSD symptoms was proposed as an area requiring some investigations.

Number of tubers per plant is a strong and stable selection criteria for yield improvement. Frequency distribution indicates 3, 4 and 5 tubers per plant with highest frequencies (27.3, 22.8 and 13.3%), respectively signifying greater chances for making rapid yield gains (Table 32). There was correlation among tuber numbers and branching habits. Slight positive but not significant correlation between was observed between non-branching and branching habits.

Table 32. Frequency distribution of tubers among 2428 seedlings selected during seedling evaluation in Mtwapa 2002

Tuber number	Frequency	Percent
1	163	6.71
2	436	17.96
3	663	27.31
4	553	22.78
5	323	13.30
6	179	7.37
7	59	2.43
8	29	1.19
9	10	0.41
10	7	0.29
11	3	0.12
12	1	0.04
14	1	0.04
18	1	0.04

The team also evaluated two preliminary yield trials each consisting of 69 and 77 clones for their agronomic desirability, yield and yield components. The top 24 clones based on resistance to CBSD (Table 33) were selected for further evaluation. Due to heavy CBSD pressure along the coastal Tanzania and Mozambique, respectively compared to Kenya, the team agreed to collaboratively evaluate these clones in the other two countries including Kenya. Preliminary observation indicated that 10 out of 25 clones showed symptoms in Mozambique and not in Tanzania and Kenya while LML 2000/51 showed symptoms in both locations and was discarded. This confirms appropriateness for the rational for evaluation on more locations as key to selection for true resistance to CBSD. A total of 12 improved and 2 local cultivars (Guzo and Chokolokote) showed no symptoms at both locations and could be used to making crosses. While further evaluations are necessary to confirm the resistance background of these clones, Tanzania has initiated multiplication of LML 2000/1380. The joint evaluation exercises have since set the stage for stronger collaboration/linkages between East and Southern African partners working to solve a common problem (CBSD). The Ugandan and Kenyan cassava breeders have benefited from these exercises.

Table 33. Status of clones introduced from Mtwapa, Kenya evaluated at Kibaha and Nampula, respectively

	Locations		
Clones	Kibaha	Nampula	Comments
1. LML 2000/1380	X[1]	X	
2. LML 97/119	X	X	
3. LML 2000/1833	X	X	
4. LML 2000/2133	X	X	
5. LML 2000/1260	X	X	
6. LML 2000/1094	X	X	
7. LML 2000/2308	X	X	
8. LML 2000/939	X	X	
9. LML 2000/2258	X	X	
10. LML 97/28	X	X	
11. LML 97/28	X	X	
12. LML 97/461	X	X	
13. LML 97/28	X	X	
14. LML 2000/2024	NC[2]	X	
15. LML 2000/51	-[3]	-	Infected by CMD at both stations
16. LML 2000/1879	X	-	Infected by CMD at Nampula
17. LML 97/2204	X	-	Infected by CMD at Nampula
18. LML 2000/2021	X	NC	
19. LML 2000/2213	X	-	Infected by CBSD at Nampula
20. LML 2000/16	X	NC	
21. LML 2000/1543	X	-	Infected by CBSD at Nampula
22. LML 2000/1424	X	NC	
23. LML 2000/1361	X	-	Infected by CBSD at Nampula
24. LML 2000/1819	X	-	Infected by CBSD at Nampula
25. LML 97/290	X	-	Infected by CBSD at Nampula
26. LML 97/695	X	-	Infected by CMD at Nampula
27. LML 2000/2114	NC	-	Infected by CBSD at Nampula
28. LML 2000/1420	NC	-	Infected by CBSD at Nampula
29. Clone 16	NC	X	
30. Guzo	X	X	
31. Mtwapa 1	NC	X	
32. Chokolokote	X	X	

[1]The clone being multiplied; [2] Clone not collected at Mtwapa; [3] Clones discarded

6. Crop and natural resource management studies

This theme seeks to study crop and natural resource management systems that will improve and sustain productivity in major cassava ecologies

6.1 Cassava-based cropping systems

Strong need was felt to initiate studies aiming at quantifying competitive ability of component crops in major cassava cropping systems. This study was initiated in Kenya, and aimed at identifying and describing selection indices for cassava under inter crop with selected legumes and maize. The expected output of the studies is better understanding of selection guidelines based on morphological characteristics as a contribution to variety generation and selection process. The study looked at the dry matter partitioning of three local cassava varieties (Guzo, Kibandomeno and Kaleso in intercrops with maize, cowpea and sole systems. It was observed that all cassava varieties were affected by the intercrops between 4 and 8 months after planting. Combined land equivalent ratios (LER) were greater than 1 for all the intercrops indicating the benefits of intercrops and the complementarity in the resource use. The LER values for 4, 8 and 12 months after planting were similar and stable and can be used as an index to measure competitive ability of cassava in an intercrop. Investigation of cowpea, lablab and velvet beans as relay crops in the short rains indicates that relaying legumes in a cassava/maize intercrop reduced cassava leaf area, leaf number but not tuber number and yield. This system is therefore beneficial for use in the short rains on sandy lowland soils of Kenya

6.2 Pphysiological basis of cassava adaptation to altitudes (Uganda)

Ten genotypes representing lowland, mid-altitude and high altitude of East Africa, lowland and mid-altitude of West Africa were evaluated (a) in pot experiment to determine physiological and morphological determinants of yield and (b) in field at Bulisa (650m asl), Namulonge (1250m asl) and Kapchorwa (1750m asl) to determine growth and development process and their components. The objectives were to understand the phenotypic and physiological basis of stability, adaptation, develop indices of selection and predict genetic relationships among characters. Results from potted experiments revealed variability among genotypes for all characters studied, among sources but not within source. Apical meristem size seems to play significant roles in determining plant development and storage root differentiation.

In the field experiments crop growth rates, storage root number and weight were affected by altitudes (Fig. 9) for storage roots, being higher in the mid and low altitudes, respectively compared to high altitude. However, storage root dry matter, percent sugar content and cyanogenic potential increased with altitude. Analysis of G x E interaction indicated that root yield was more sensitive to environment compared to root number each accounting for 52.5% and 21.6% respectively of their sum of squares. AMMI analysis (Table 34) and bi-plot categorized Migyera as unstable though high yielding, SS4 poor adaptation to high altitude, TMS I91/0057, TMS I 91/0067 average stability across locations and TMS I91/0397 adapted to high altitude. It was inferred that G x E interactions caused production delay in genotypes that are sensitive to temperature change and that this was severe at low temperature because more days were required for

completion of the vegetative development prior to tuberization. These were also associated with lower number of stomata opening at high altitude or cool temperature. The study concluded that apical meristem size plays significant roles in determining plant development and storage root differentiation. Mid-altitude ecology was more stable compared to high and lowland ecologies and could be considered ideal for selection for wide adaptation

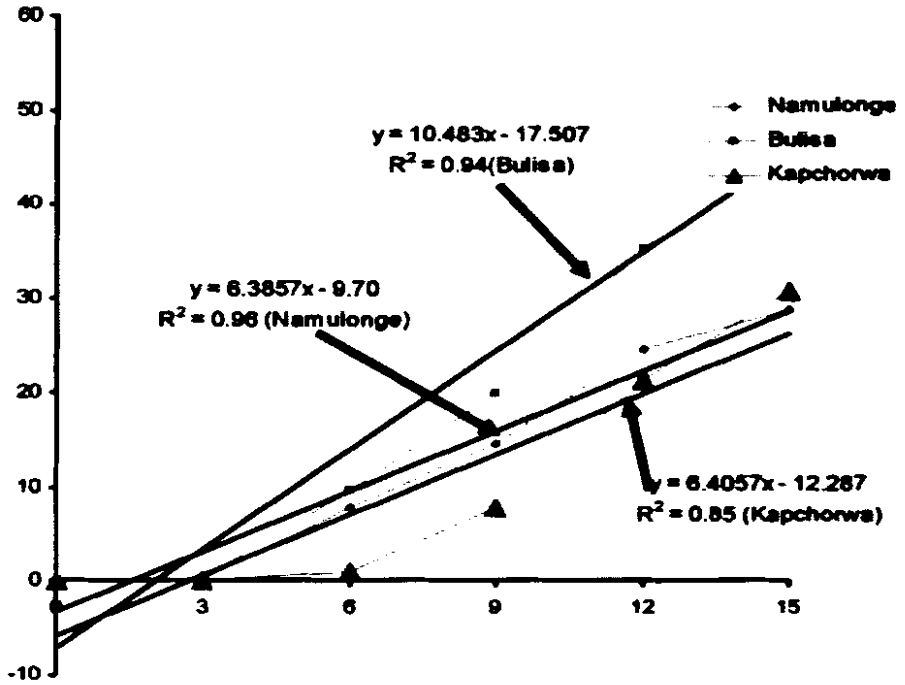


Fig. 9. Effects of altitudes on storage root number and weight, dry matter, percent sugar content and cyanogenic potential.

Table 34. AMMI analysis for storage root yield of 10 cassava genotypes grown in six environments (3 locations over 2 years).

Source	df	SS	MS	Probability
Total	154	13531.828	87.869	
TRT	59	11989.375	203.210	***
GEN	9	3439.115	382.123	***
ENV	5	6299.741	1259.948	***
GXE	45	2250.519	50.011	***
I PCA 1	13	1003.884	77.222	***
I PCA 2	11	843.076	76.643	*
Residual	21	403.557	19.217	ns
Error	95	1542.453	16.237	ns

*, *** Significant at P<0.05; P<0.001, Ns: not significant at P<0.05

7. Multiplication of and distribution of clean planting material

Although many improved varieties are being identified by the national programs, the system of multiplication and distribution of planting material is inefficient due to non existence of national seed production schemes or low priority given to cassava. The objectives of rapid multiplication and distribution of improved planting material are to establish and improve multiplication systems and to develop effective and sustainable systems of delivery of improved varieties.

All EARRNET member countries are implementing rapid multiplication and distribution of improved planting material in collaboration with various stakeholders to accelerate impact at farm levels. In the Great Lake Region, CMD monitoring surveys have been used in establishing the disease movement and disease-threatened areas, results from such surveys have been rigorously utilized in the regional germplasm distribution with significant changes in cassava production and CMD spread.

In Uganda, more and more farmers are inspired to adopt cassava as a cash crop due to increased sale of planting material. The Masaka district administration bought from individual farmers or farmer groups approximately 500 bags of cassava planting material worth 7,500,000 shillings ($4,400) and distributed them to about 1300 beneficiaries in the sub counties of Malongo and Bukulula that had been hit by storm. A total of 145 ha have been established in Lira and Apac districts in collaboration with ACDI-PL480 project of USAID to target the war-torn districts of Kitgum, Gulu and Pader. Additional 100ha are being bulked by the Catholic Relief Services (CRS) and Hunger Alert in Gulu itself. These are expected to generate approximately 7.5 million cuttings worth planting 7,350 hectares. Four technology transfer centres (TTCs) have been established for demonstration of improved technologies, training, transfer of improved technologies in addition to multiply and distribute planting material. A total of 231 households have benefited from improved planting material from these centres. Elsewhere in the country, significant changes in CMD/UgV situations following release of additional 6 new improved varieties have been recorded. It is estimated that the levels of cassava production since the outbreak has significantly changed with more than 450,000 hectares planted to at least four improved cassava varieties throughout the country. The rate of use of improved varieties in some target areas has increased by 18% and reduced CMD incidence from 76% to 66% with reported yield increase of 218,466 tones over 1998 level, equivalent to US$ 21.9 million.

In Western Kenya the three-tier systems of multiplication and distribution were put in place initially with the improved varieties from Uganda, later all the farmer selected clones were fed into the scheme. Multiplication at the primary stage is largely institutional (schools, government institutions or church organizations) geared towards increasing planting material of high quality; at secondary sites, multiplication is managed by district steering committees aimed at bringing the planting material closer to target farming communities while the tertiary multiplication are organized and managed by NGOs, CBOs and farmers themselves. The project systematically organized and implemented various training programs, field days, demonstrations in crop husbandry, plant health, cassava-based product development and operations of simple processing

equipment to ensure sustainability. Over three million mini cuttings estimated to plant more than 3,397 ha (Table 35) have been distributed. National and district committees were set to provide forums that enabled broad participation for efficient and effective implementation of approved work plan.

Table 35. Number of mini cuttings of improved cassava cuttings distributed in W. Kenya 1998 to 2003

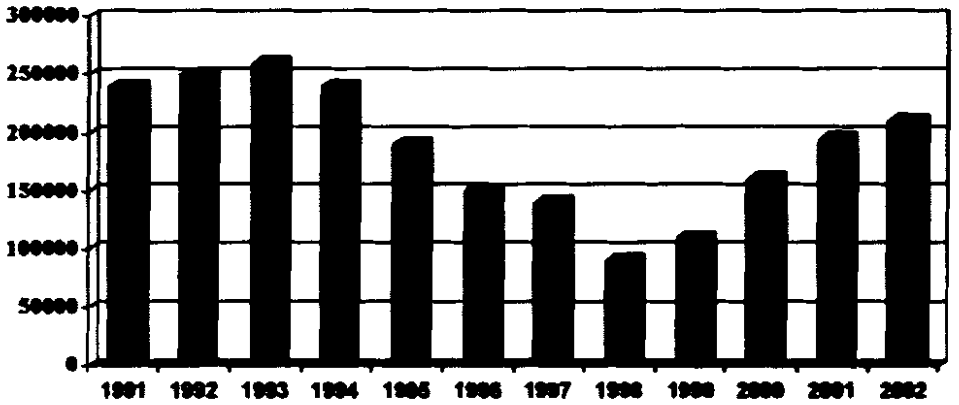
Year	Mini stems distributed	Area planted
1998	240,000	2.4
1999	771,000	7.7
2000	16,221,000	1,622
2001	709,8000	719
2002	420,9300	421
2003	6,246,669	625
Total	34,785,969	3,397

There are currently 19 improved clones selected through farmer participatory on farm evaluation (Table 36) which has been channeled through the multiplication and distribution system. All clones are resistant/tolerant to CMD including the virulent the Uganda virus strain (UgV). The table indicates that the tuberous root yield at farmer level ranged from 18.4 t/ha in SS4 to 51.1 t/ha in MH95/0183 t/ha. These yield levels are much above the pre-pandemic time (6 t/ha) and is expected to significantly impact on productivity per unit area and time in W. Kenya.

Table 36. Number of improved cassava clones currently being multiplied and distributed to farmers in W. Kenya.

Clones	CMD status	Cyanide potential	Maturity	Average yield at farm level tons/ha
SS4	Resistant/Tolerant	4.0	9-12	18.4
Migyera	Resistant/Tolerant	5.4	12-14	21.3
MM96/4466	Resistant/Tolerant	3.0	9-12	30.6
MM96/1871	Resistant/Tolerant	3.8	9-12	29.8
MM96/3868	Resistant/Tolerant	4.0	9-12	25.1
MM96/9308	Resistant/Tolerant	4.3	9-12	35.4
MM96/5280	Resistant/Tolerant	4.4	9-12	25.9
TME 14	Resistant/Tolerant	4.7	9-12	19.3
MH95/0183	Resistant/Tolerant	6.0	9-12	51.1
MM96/9362	Resistant/Tolerant	4.0	9-12	22.7
MM96/7151	Resistant/Tolerant	3.0	9-12	33.0
MM96/4684	Resistant/Tolerant	4.5	9-12	20.0
MM96/7688	Resistant/Tolerant	6.0	12-14	41.4
MM96/4884	Resistant/Tolerant	4.5	9-12	24.5
Unknown	Resistant/Tolerant	3.7	12-14	22.3

A general situation regarding hectares and productivity of cassava between 1991 and 2002 is that of encouragement. Fig.s 10 A and 10b indicate the serious decline (60%) observed between 1991 and 1998 of both production and area under cultivation in Western Kenya. There after both area under cassava and productivity have continued to show steady recovery up till 2003. It is estimated that total area under improved clones is 13,000 hectares which is equivalent to 38% restoration. Full recovery may come as early as 2004. Preliminary survey report indicates high rate of uptake of improved clones in the most CMD affected Western Province.



(a)

(b)

Fig. 10. Pre-pandemic, pandemic (a) and current area (b) under cassava and production levels in W. Kenya

In Rwanda multiplication activity started in about 1999 with 5 improved varieties I92/0057, TME14, MH95/0414, I92/00063 and Migyera introduced from Uganda and tested in collaboration with Istitut des Sciences Agronomiques du Rwanda (ISAR)

scientists. Initially the clones were planted in Kibungo (5 hectares) and Nyagatare (4.5 hectares) for in country observation and multiplication and distribution to farmers. Sprouting was affected by drought (65 to 85%), less than one percent mosaic incidence was reported but generally, the clones have shown remarkable resistance against the disease threat and are currently being distributed to farmers in collaboration with Agricultural Technology Development and Transfer Project (ATDT). Additional five clones (Table 37) selected through farmer participatory evaluation have been added.

Table 37. Status of clones under institutional multiplication

Clones	Locations	area (ha)	Status
TME14	Umutara,	0.35	0.35 ready for harvest 0.1 is 3 months old
	Rubona	0.35	Approx 1 month old
	Karama	3	Planting to start in September under irrigation
I92/0057	Umutara,	.38 + 0.2	0.38 ready for harvest 0.2 is 3 months old
	Rubona	0.33	One month under irrigation
	Karama	2.5	Planting to start in September under irrigation
MH95/0414	Umutara,	0.23 + 0.2	0.23 ready for cutting 0.2 is 3 months old
	Rubona	0.37	One month under irrigation
	Karama	2	Planting started in September under irrigation
I92/00063	Umutara,	0.2 + 0.1	0.2 ready for harvest 0.1 is 3 months old
	Rubona	0.4	One month under irrigation
	Karama	2.5	
MM96/3920	Rubona	0.12	One month under irrigation
MM96/4618	Rubona	0.1	One month under irrigation
MM96/1967	Rubona	0.1	One month under irrigation
M col 1413/6	Rubona	0.2	One month under irrigation
MM96/3280	rubona	0.12	One month under irrigation
MM96/5280	Karama	With farmers	

It is estimated that already 3.5 ha is under institutional multiplication out of which 1.2 is ready for cutting while the rest have just been planted. A total of about 10.5 hectares have been cleared at Karama for multiplication of I92/00063, MH95/0414, I92/0057, I92/0057 and TME14. The ISAR team is confident that they would deliver more than 10,000,000 cuttings estimated to benefit 200,000 households within a period of 8 months. In addition, using the augmented design in a farmer-participatory evaluation process is permitting rapid uptake of large numbers of these improved clones for immediate household multiplication, thus generating new hopes for the cassava sub-sector stakeholders in Rwanda.

8. Socio-economic, diffusion and adoption study of improved varieties

This theme seeks to conduct studies to update baseline information on production, processing, utilization and marketing, identify constraints and needs, disseminate technologies and develop monitoring systems and their validation, evaluate levels of adoption and impact of disseminated technologies

A study conducted to evaluate the diffusion and adoption patterns of improved varieties in six districts (Luwero, Masindi, Kumi, Soroti, Lira and Mpigi) revealed that the spread of improved varieties was inversely related to the diffusion of unimproved local cultivars because the improved varieties had resistance to mosaic diseases that limited the cassava production. In 1998, the rate of spread of local cultivars increased due to the poor tuber qualities of the early releases. Subsequent improvement of root quality attributes together with farmer participation in selection reversed this trend to significant increase from 1999 upwards. Farmer participation in selection increased household levels of multiplication and spread among farmers

The widespread diffusion and adoption of improved varieties in improving household food security in a number of districts in Uganda necessitated the assessment of the economic returns to investments. The internal rate of return (1990-96) to participatory interventions in development and transfer of technologies was estimated at 121% suggesting that the investments have been profitable. A favourable benefit-cost ratio of *c.*7.2 with a net present value (NPV) showing net surplus by 1994 was attained. This high profitability to investment was attributed to the massive responses to the CMD effects, testing and dissemination of improved varieties in collaboration with complementary organizations. Contributions of non-research institutions are essential and interdependent.

9. Capacity building/training

The effectiveness and efficiency in developing, adapting and disseminating improved agricultural technologies depends on the existence of a strong research base comprising personnel, infrastructure and financial resources. For constructive regional collaboration, national systems requirements need to be distinguished at their different stages of institutional development and strategies developed which will evolve and change as NARS grow in strength. The objective of this theme is to improve the efficiency and effectiveness of NARS through fostering partnership, linkages, human resource development and rendering technical assistance in defining planning, executing and controlling research and development agenda. Different categories of training programs were implemented, benefiting over 600 persons. A total of 435 farmers were trained in W. Kenya in preparation of planting material multiplication, disease identification and control and crop husbandry (Table 38).

Table 38. Number of stakeholders trained in preparation of cassava planting material multiplication, disease identification and control and agronomic practices.

District	Site	farmers		FEWs	number trained	NGOs/CBOs represented
		males	females			
1. Butere-Mumias	a) Matungu	23	4	4	31	-
	b) Khwisero	56	34	6	96	-
2. Busia	a) Nambale	34	56	3	93	3
	b) Funyula	13	3	2	18	1
3. Teso	a) Chakol	25	14	3	42	-
	b) Amagoro	36	9	2	47	4
4. Bungoma	a) Nalondo	12	3	-	15	-
	b) Bumula	26	4	1	31	-
5. Mt. Elgon	Cheptais	38	20	4	62	2
Total		263	127	25	435	

In addition, a total of 10 regional, in country and attachment training were conducted in which 197 NARS Scientists, Technicians, Extension, producers benefited (Table 39). The courses varied from multiplication and distribution of clean planting material to monitoring and impact assessment of root crop technologies that was jointly organised with ECAPAPA. The course was designed to introduce NARS researchers to the concept of impact assessment and sensitise researchers to the needs of other stakeholders in the research process. The workshop enabled participants to integrate impact assessment into the research agenda and demonstrate competence in the use of appropriate analytical tools to assess project impact. In country courses targeted technicians, producers and extension section of the Ministrie of Agriculture while the regional ones targeted more of scientists.

Table 39. Number, types and course contents of training workshops conducted by EARRNET between 1998/99 to 2003

Date	Course title and nature	Course content	Country	Numbers
1999	Identification and control of major diseases/pests and rapid multiplication of cassava (In country	Assist NARS technicians, extension, farmers develop skills in identification and control of major diseases and pests	DR Congo	19
1999	Agronomy, multiplication and distribution of cassava (In country)	Assist NARS technicians, extension, farmers develop skills in agronomy, multiplication and distribution of cassava	Kenya	22
1999	Improved cassava transformation technologies (In country)	Assist NARS technicians, extension, farmers develop skills in transformation of cassava to stable and marketable high grade product	Madagascar	25
1999	improved post harvest utilization (Incountry)	Enable farmers develop skills in transformation of cassava to stable and marketable high grade product to generate incomes	Kenya	25
2000	Report and proposal writing (Regional)	Assist NARS researchers develop skills in the preparation of research report and proposal writing with a view to promoting research the workshop strengthened participants' research planning and management skills through focused activities on report and proposal writing (Regional)	Kenya	25
2000	Monitoring and impact assessment of root crops technologies (Regional)	designed to introduce NARS researchers to the concept of impact assessment and sensitise researchers to the needs of other stakeholders in the research process (Regional)	Kenya	22
2000	Virus elimination and detection (Attachment)	Assist Scientist in charge of PQS better understand procedures in virus elimination and detection	South Africa	2
2000	Cassava mosaic virus disease monitoring and diagnostics (Regional)	Assist NARS scientists from east and central Africa learn skills in cassava mosaic virus disease monitoring and diagnostics	Uganda	11
2001	GIS Training Workshop (Regional)	Application of geographical information systems in agricultural research	Uganda	20
2003	Statistical Computing analysis with SAS (Regional)	Enable researchers update their skills in statistical data computing using SAS	Uganda	26
Total	**10**			**197**

10. Priority Settings

EARRNET is one of the ASERACA networks whose mandate is research for development on cassava and although in the past the main focus had been on biological research, emphasis shifted to post-harvest and market issues in the last five years. The current strategic vision of EARRNET focuses on "*Transforming cassava into a broad-based commercial commodity for sustained food security, poverty alleviation, and income generation through integrated regional production, utilization, marketing and trade*". In order to respond to this vision, the EARRNET priority setting exercise was conducted with stakeholders across the cassava sub-sector inclusive of representatives from traders, feed millers, farmers, NGOs, policy makers, Universities and NARS, with special technical inputs provided by ASARECA, ISNAR and IITA. The ASARECA NARIs' socio-economists actively participated in the various workshops and helped in providing the EARRNET's Priority Setting Committee with national data used in the compilation of necessary information for the exercise. The exercise that took place through a number workshops and meetings before the stakeholders meeting at ILRI, Nairobi. 23-28 followed the 7 steps proposed by ISNAR, which includes 1: Establishing the network committee for priority setting. 2: Review of the Research Domain. 3: Constraints and Opportunity Analysis. 4: Evaluation of Existing Results. Step 5: Defining Research Themes 6: Priority Setting of Research Themes 7: Recommendations for Implementation

Research domain: The major production systems, constraints, role of cassava in the agriculture economy within in ASARECA region were analyzed. Four important chains for cassava development in region were identified as food, flour, feed and starch. However, opportunities varied among different countries with the food and flour being the most lucrative in most countries.

***Constraints and opportunities analysis*:** A number of constraints were identified in the sub-sector analysis conducted across all member countries and confirmed with the involvement of several stakeholders. These were economic, technical, biological and institutional. All the constraints identified were ordered and structured in causal-effect relationships to better understand whether some constraints were the cause of, or were caused by, other constraints identified. The major constraints identified along the different intervention levels are indicated below;

Production Level Constraints: (Low productivity of available planting material; poor soils; poor agronomic practices; inefficient multiplication and delivery system of plating material)

Processing Constraints: (Poor processing technologies; lack of appropriate processing technologies for certain products targeting some niche markets such animal feeds; poor capital base among potential investors and existing processors limiting economies of scale; lack of grades and standards; poor quality raw material for processing; limited range of processed products)

Market Constraints: (Lack of market information; poor linkages between markets and producers; high costs of bulking and transportation; spoilage especially for fresh leaves, roots and dried chips; competition from grains in the food and animal feeds industry; lack of government or institutional support for market development; lack of formal standards and quality control; market opportunities in the industrial sector not fully developed)

Utilization Level Constraints: (Hydrogen cyanide levels; narrow range of processed products; negative attitude towards cassava by sections of population (poor man's crop))

Policy Constraints: (Lack of grades and standards; lack of policy support e.g. of mention of cassava in food or agriculture policy documents; limited national resources allocation for development of the sub-sector; lack of credit facilities for commercialization activities; low level of government priority for the crop)

A set of criteria were applied for pre-screening and ranking the constraints in order to put in perspective EARRNET's strategic contribution to ASARECA's consolidated conceptual framework. These included a) regional importance, b) contribution to agricultural productivity, c) contribution to social welfare, d) contribution to environmental quality, e) within EARRNET Management interest in terms of capacity, comparative advantage, mandate, f) contribution to capacity building, g) exhibits creativity, innovation, novelty and h) contribution to economic wealth. From these, the following were classified as the most important constraints affecting the cassava sub-sector

1. Low productivity of cassava based system
2. Narrow range of cassava based products
3. Inadequate information systems
4. Limited capacity (human, funds, infrastructure, equipment, etc)
5. Inadequate institutional linkages or services
6. Inappropriate storage methods
7. Inappropriate processing methods or services
8. Absence of supportive policy environment
9. Limited cassava trade (local, regional, international)
10. Poor R4D delivery systems
11. Shortage of planting material

The number of constraints put through the analysis was reduced to ten based on the EARRNET's steering committee decision that multiplication of planting material is an expensive but important undertaking for which bilateral funds should be sought for its implementation.

Evaluation of Existing Results: The status on research results as regards a comprehensive knowledge on how to maximize the cassava system in each EARRNET country was assessed as low. Understanding the full chain is important but the funds to do such work will depend on the human expertise available in each discipline in the member countries.

Defining research sub-themes: Ten research sub-themes were identified from the constraints and opportunities analyses, however due to the extent to which they were aggregated; a two step process was adopted to decipher the aggregation into a matrix of four chains x seven intervention point and ranked. Flour and feed processing, and food production were the most critical areas for focus. A total of thirty two activities were compiled from all the sub-theme/projects into a general set of activities and attempts made to apportion them according to their contribution to each of the 28 cells.

Prioritization of sub-themes: Based on the 28 operational cells, the weighted scoring method as proposed for ASARECA and its NPP were used to prioritize the sub-themes/projects. Seven cells were rated as having high priority, eleven of medium and ten of low priority. Careful analysis of the ranking however using additive model based on mean score by the stakeholders (a) along the market chain and (b) sub-sector and chain by sub-sector intervention points, confirmed EARRNET's initial prioritization in addressing production, processing and utilization and marketing within the food, flour and feed chains a shown in Tables 40 (a), (b) and (c), respectively.

Table 40. Additive model for priority setting

a) Market chain

Market chain	Mean additive score	Rank
FOOD	25.8	2
FEED	24.6	3
FLOUR	26.6	1
STARCH	17.6	4

b) Sub-sector intervention point

Sub-sector intervention points	Mean additive score	Rank
Production	93.3	2
Transport	69.0	7
Processing	100.5	1
Storage/ Loss reduction	81.3	5
Marketing and trade	88.8	3
Utilization forms	82.5	4
Consumer concerns	76.3	6

c) Chain x sub-sector intervention points

Column by column	FOOD	FEED	FLOUR	STARCH
Production	95.19	89.19	90.15	53.08
Transport	70.12	67.12	67.12	46.08
Processing	89.12	100.19	100.15	75.12
Storage/ Loss reduction	81.08	74.19	85.08	53.15
Marketing and trade	79.12	85.19	84.15	57.19
Utilization forms	76.12	79.08	80.19	56.19
Consumer concerns	78.15	66.12	79.15	57.04

EARRNET therefore developed the following consolidated projects as its portfolio

Title1	Improving Cassava Productivity for Greater Competitiveness
Title2	Value Addition to Cassava through Improved Processing and Product Diversification
Title3	Enhancing Private Enterprise Support for Increased Commercialization of Cassava
Title4	Development of a Cassava Information System
Title5	Enhancing Human Capacities for an Efficient Cassava Sub-Sector
Title6	Public-Private Sector Partnerships for Sustained Cassava Systems
Title7	Policy Interventions for a Market-Driven Cassava Sub-Sector
Title8	Strengthening Delivery and Adoption of Cassava Technologies
Title9	Promotion of Cassava Technologies for Better Nutrition and Health

Recommendation: The following recommendations were made towards implementation of the priority activities

Improving the legal framework: In order to encourage increased use of cassava in the industrial sector, there will have to be deliberate efforts to support contractual arrangements between producers (organized) and processors. This will require mechanisms entering into and enforcing contractual agreements. To achieve this there will be need for policy support on enforcement of regulations to build trust and equity in the market place and especially along the commodity chain. Development of grades and standards for various cassava products and mechanisms for their enforcement will increase the phase of cassava commercialization in the region. Grades and standards can be developed at national level and then extended to regional level for regionally traded products. To achieve this some form of institutional framework that brings together all the actors along the value chain will have to be established. This institutional body can then be charged with the development and implementation of the grades and standards. Initially the standards could just be those acceptable to the industry and consumers, but later assuming national recognition by the bureau of standards.

Investigate finance options to improve rural finance options, including loans to farmer associations and venture capital arrangements with specialist organizations, traders and processors. Credit facilities can greatly assist traders and processors to expand their economies of scale and hence increase demand for cassava products. Financing could also be explored for supporting farmers to purchase bulk inputs such as planting material and chips processing and drying technologies.

Ensure that Government policy supports access to improved transport via road, rail and that access to information is also improved in the rural areas, via radio, telephone and internet. Other measures would include reduction of number of road blocks and other forms of control that increase the cost of marketing.

Improved physical market infrastructure, in the major urban centres, to reduce transaction costs at the market level. This will also reduce losses incurred due to poor storage and trading conditions.

Support to the development of private sector support groups and work closely with private sector associations, such that these sectors can work in a more cohesive fashion and be in a position to lobby with Government and donors.

Support Import Substitution: Cassava utilization in the industrial sector could greatly increase through import substitution policies. Since all the countries in the region are net importers of wheat there should a policy lobby to require baking and confectionary industries to incorporate a percentage of cassava flour in their baking flour. Similarly use of cassava flour in animal feeds and in brewing industry should be encouraged.

Deliberate efforts should be made to promote diversification of cassava products through promotion of improved processing technologies. Cassava should also be given prominence in food and agriculture policies in the region.

Other specific policy measures include;

- Promote cassava for food security
- Make a deliberate attempt to promote improved processing technologies for cassava
- Revise punitive taxes that discourage cassava trade
- Promote market efficiency through provision of information

Environmental concerns

- reduce soil erosion, research on motivation and practices
- reduce pollution, especially in the production/processing for starch,
- prevent destruction of ecosystems, forests, shifting cultivation

Institutional support

- public/private sector partnerships essential, e.g., for herbicide resistance, response to plant nutrition practices, research infrastructure, training of scientists, farmers, organizations, cassava networks.
- Develop and support institutional links along the commodity chain to promote market efficiency
- Coordinate all cassava activities among various institutions in the country through establishment of a cassava working group

In conclusion, EARRNET has identified nine project areas whose aim is to commercialize the cassava sub-sector to assure food security, rural incomes and socio-economic growth. The focus will be development of growth along three prioritized chains (Food, Flour and Feed). Within each of the chain, priority areas for R4D have been identified and the necessary activities to achieve growth have also been determined. The main focus will be to strengthen the private sector, farmers groups and create linkages between processors and farmers in order to assure efficient market linkages.

EARRNET along with other development partners will also lobby for necessary policy changes/reforms to spur private sector growth and participation in the development of the sector. To achieve this EARRNET will work in partnership with private sector, NGOs, farmers groups, donors, national research systems and regional and international research centres.

Annex A. Synthesis report on the regional workshop on improving the cassava Sub-sector, Nairobi, April 8-12th 2002

Background

Cassava provides livelihood to farmers, processors and traders and has potential for food, feed and industrial applications. Cassava production in Africa is projected to grow at 2.9 percent per year, which will raise production to 114 million tons by 2005 and continue into the 2020 when the current African production will double as a result of both area and yield expansion. The bulk of the increase is expected from Democratic Republic of Congo, Ghana, Madagascar, Mozambique, Nigeria, Tanzania and Uganda. Demand for direct consumption is expected to reach 85 million tons in the year 2005 with a growth rate of 2.8 percent. The use of cassava for animal feed is expected to grow at an annual rate of 1.3 percent to the year 2005 largely due to expansion of livestock sectors and attempts to meet the rising demand for feed from domestic sources rather than imported feed grains. Though the potential for expansion as grain substitute is considerable, this would depend on the relationship between cassava prices vis-à-vis protein meals and feed grains and expansion of processing facilities to meet any potential growth in domestic and export markets. Other uses (starch, etc) of cassava in Africa are expected to rise at even higher rates: 5 percent in Benin, Ghana, Kenya, Zambia and Zimbabwe. With increasing demand for cassava following population growth, changes in food preferences and increase in industrial needs, sub-sector operators will be confronted with the challenge of increasing production, improving access to good quality cassava products and expanding markets, which will contribute to local, national and regional food security and socio-economic growth.

In Africa, cassava production is presently characterized by use of low inputs, rudimentary technology, large post-harvest losses and minimal processing. Associated with these are problems of unreliable supply, uneven quality of products, low producer prices and costly marketing structure. These factors contribute to near zero utilization of cassava in the industrial sector in the continent. While research advances have been made in addressing some of the most important production problems, policy and technological environment in which cassava development occurs is a limiting factor. Regional research networks (EARRNET, FOODNET, SARRNET) have introduced changes within their operational framework to enable them respond effectively to strategic plans and objectives of the sub-regional agricultural research organizations. The transition from production to market orientation enhances closer links among the sub-sector stakeholders in information exchange and sharing research and development tasks. The networks have also recognized that developing cassava into a commercially acceptable crop requires building human resource and institutional capacity at all levels of research, production, processing, marketing and utilization with the necessary policy and private/public sector support.

The workshop was called to discuss the findings and recommendations of a recently completed sub-sector analysis studies covering the six EARRNET network countries and three SARRNET network countries. Other presentations covering global cassava thematic issues were also presented. The workshop formed a forum for the private

sector, researchers, international NGOs and other development agencies to come together to discuss necessary steps to commercialize cassava and for the crop to contribute to food security, income generation and socio-economic growth.

The main objectives of the workshop were:

- Identify key areas of program interventions that would enable small-scale cassava farmers and processors to increase cassava production for food security, income generation and contribute to economic growth.

- Facilitate the exchange of lessons learned and best practices from other countries of the sub-region, to target development and transfer of technologies.

- Identify key partners (private and public sector institutions, farmers, agro-industries, NGOs, and other beneficiaries of the program) engaged or with potential in using cassava and cassava based products.

- Establish common approaches and methodologies for incorporating innovative interventions in each project activity that enhances food security, and income and employment generation.

- Establish institutional and procedural framework for enhancing cassava production, commercialization and contribution to food security in the region.

Expected output

The expected outputs from this meeting included:

- A long term development agenda for the cassava sub-sector
- Client focused research agenda developed and implemented at national and regional level.
- Increased use of cassava products in the industrial sector
- A well focused policy and technology environment that would ensure cassava plays its rightful role in food security and poverty alleviation among farmers, traders and small and medium scale processors.
- Critically identify, discuss and agree on demand and supply side interventions that are necessary for cassava development.
- A strategy for improving technology development and transfer processes
- Greater awareness on importance of cassava in food security and industrial applications among the private sector, policy makers and donor community.

Composition/origin of the participants

The workshop took place as scheduled at the ICRAF campus Nairobi, from April 8 – 12th 2002. There were 89 participants from; research institutions, public sector, private sector, NGOs, donors and the press from Kenya, Uganda, Tanzania, Rwanda, Burundi, DR

Congo, Madagascar, Malawi, South Africa, Zimbabwe, Zambia, Nigeria, Italy, USA etc attended the workshop.

Classification of papers

The presentations comprised key note addresses from donors, IITA and Network coordinators, reports of the sub-sector analysis synthesis, country reports, invited thematic papers, reports of commissioned studies looking at identified niche opportunities for the development of the sub-sector, private sector presentations on industrial application and papers on advances towards market-led research and development.

Key presentations

There were six key note presentations as outlined below.

1. Delivering the African agricultural development potential: the IITA vision
2. Enhanced regional capacity to achieve food security
3. The production to consumption systems analysis: switching from supply to demand driven research and development programs
4. Cassava transformation: Africa best kept secret
5. Global cassava development strategy
6. The shift from production to market-led cassava research and development in East, Central and Southern Africa.

These key presentations looked at methodologies and donor perspectives of the sub-sector not only at the regional level but also globally. The presentations also gave an insight on what certain donors were going to

The paper on enhanced regional food capacity to achieve food security was a synopsis of USAID's current mission objectives to achieve food security in the region. The strategy has three achievement indicators;

- Number of African Institutions with a shared vision; sound analysis; complementarity; capabilities in strategic planning and analysis;
- Growth in volume of intra-regional agricultural trade flows; and
- Decreased time to move goods across borders.

There are four intermediate results within thin this framework;

- Regional organizations strengthened
- Improved regional availability of appropriate technologies/ practices
- Increased networking and cooperation
- Selected policy, regulatory and procedural changes advocated by African partners.

REDSO's vision is that food security in the region can be enhance through agricultural trade.

These strategic results are in line with recommendations of the workshop which strongly advocated for need of cassava championship groups at national level which can then link up through existing or new networks. Improved production and processing technologies and the need to promote market efficiency was emphasized.

The production to consumption systems analysis paper provided methodological analysis of understanding and managing the development of the sub-sector. The paper also outlined the need to focus on the entire sub-sector, determine the policy and technology environment in which the sub-sector operates and how this affects the performance of the sub-sector. The paper also reiterated the need for identification of the stakeholders in the sub-sector and the need for their collaboration. Researchers and development agencies need to take into consideration the needs of the stakeholders in order to achieve high impact of research and development activities.

FAO presented a paper on the global cassava development strategy. This paper was important in that it set the stage in which the regional cassava development strategy needs to be modeled. It outlined the FAOs vision for cassava in Africa and globally.

The paper on cassava Africa's best kept secrete was a synopsis of the work done under COSCA studies and basically summarized the findings of the studies. The highlights were that cassava held a great potential in the development of the sub-sector in the region. Cassava's in food security, equity and income generation in the region was highlighted.

A paper was also presented showing the shift of the research work in cassava in the region towards a demand oriented approach. In this case, the private sector has become an important partner in shaping research agenda in the region. Examples of collaboration of research work with private sector in Malawi were presented.

Regional and national sub-sector analysis

The main objectives of the sub-sector studies were:

- Review and update available information on the sub-sector,
- Identify constraints, assess needs, determine areas of technological, institutional, organizational and policy opportunities too enhance food security, income generation and socio-economic growth and development of the sub-sector.
- Propose necessary research and development programmes and dissemination of end-user preferred market oriented technologies for equitable sub-sector,
- Highlight access, equity, sustainability and gender issues for technical options, assess costs and returns of technologies (existing and new) and the potential for increased cassava trade through increased production, commercialization and utilization.

The EARRNET sub-sector analysis was undertaken in six countries (Kenya, Uganda, Rwanda, Burundi, DRCongo and Madagascar). It looked at cassava only but used a more comprehensive approach in which all components of the sub-sector were studied and the links identified. Policy and technology environment affecting the performance of the sub-sector was also studied. Eight commissioned papers were also undertaken to look at particular niches that were identified after literature review and PRA assessment with stakeholders. The study focused more on identifying potential industrial use of cassava which could stimulate commercial production of the crop. The studies also looked at the food situation in each of the countries and identified ways in which cassava could be used for boosting food security. Increase cassava trade/sales into the manufacturing sector could also play an important role in fight against food insecurity.

The main cassava processed products in the region include; dried chips and flour (all countries), starch (Kenya and Madagascar), crisps (Kenya), animal feed Madagascar, Kenya), Chikwangue (DRC, Burundi) and baked products (Madagascar, Kenya, Rwanda, Uganda). Leaves are also processed for export in DRC. Processing technologies are poor and result in un-standardized products and of limited scale. The costs of production are also very high, resulting in uncompetitive products.

Cassava is a major calorie source among the population in EARRNET region. It is the main source of daily calorie intake in DRC, second in Madagascar (but main in the Southern region of Madagascar), third after banana and sweet potato in Burundi, third after maize and wheat in Kenya (but second in western and coastal Kenya), second after bananas in Uganda (but the main source of daily calorie intake in the eastern part if the country).

In Kenya cassava is grown in three main regions: Western, Central and Coastal region. According to FAO In 1999 it is estimated that 910,000 mt of cassava was produced under 98,000 ha. FAO data differ greatly with ministry of agriculture data. Even within the ministry data differs between that obtained from the crops division and that from provincial annual reports. Western Kenya produces over 60% of the cassava in the country. Cassava is largely a smallholder crop with over 80% of the surveyed households (312) cultivating less than 2 acres. Cassava is one of the most traded agriculture commodities in the country though on a small scale. Over 76% of the surveyed households sell part of their cassava produce. There is some limited industrial use of cassava (flour and starch). The potential to expand is great. Diseases, pests, poor processing technologies, inefficient marketing system and lack of policy support are some of the factors limiting development of the sub-sector. Potential industrial users of cassava starch are unsure of supply, product quality and stability of their products in the case of pharmaceuticals if they were to use cassava starch. Potential market for starch in Kenya is in the region of 25,000 tons/ an.

There was no evidence of cross border trade but there were allegations of cross border trade in small quantities along Kenya-Uganda border, Rwanda-Burundi border, Burundi-Tanzania border, Burundu-DRC border and Rwanda-DRC border. Most of the

commonly traded commodities across the borders were fresh tubers and dried chips. Trading of planting material was also reported.

In DRC where cassava is the main food staple it was reported that cassava export of processed cassava leaves to the European and American markets was on the increase. Support to this emerging trade was recommended as a priority as a follow-up activity in DRC. Support for domestic traders of fresh tubers, dried chips and fresh leaves is also required in terms of provision of market information and intelligence, improved transportation systems and improved processing, drying and packaging technologies for cassava chips.

In Madagascar the use of cassava in animal feeds, food industry, textile and manufacturing industry is being hampered by poor production, assembly, processing and market systems. The demand for cassava flour and starch within the manufacturing industry far outstrips supply. Though the industry is primed for use of cassava in manufacture of a number of products including feeds, biscuits, bread, textile, paper and timber products, supply and quality of the raw material has remained a main bottleneck. It was recommended that a consortium of private, NGOs, and public sector be formed to sort out the problems facing the cassava industry and its ability to service the industry. EARRNET should in a follow-up activity nurture this proposal and try to see how farmers and traders can be helped in order to meet the demands of the industry.

In Uganda annual demand for starch is estimated at 580 tons, of which all of it is imported from South Africa and Kenya. Pharmaceutical uses 53.6%, paperboard 32.5%, food processing 13.5% and commercial laundries 0.4% of the starch. The animal feeds industry has a potential of up to 18,750 tons of fresh tubers per annum. In the bread industry the potential is of up to 26,400 tons of fresh cassava roots.

The potential for cassava in Burundi and Rwanda lay more in addressing food security needs than an immediate focus for use of cassava in industrial sector. Burundi and Rwanda are currently facing food shortages according to FAO and WFP due to internal displacement of people. Focus should be one sanitary activities to ensure clean planting material reaches farmers. Multiplication and distribution of the material also needs to be stepped up.

The SARRNET paper looked more at the market chain of the cassava and sweet potatoes in three countries (Malawi, Tanzania and Zambia). It tried to trace the movement, seasonality, price changes and trade margins of the two crops. The purpose was to identify opportunities and constraints to increased market output of the two crops.

In Zambia the focus was on identifying the current levels of household processing of cassava for both own consumption as well as for sell, assess consumer perceptions of different forms of cassava sold locally and study the linkages between farmers and industrial processors. Study found that cassava is important for 40% of population and that it occupies 10% of farmed land. The study estimates that cassava production in Zambia is increasing. Women play a significant role in processing of cassava. Most

farmers grow cassava for both food as well as for income. Men form majority of the cassava traders. Majority of the farmers sold cassava in processed form (dried chips and flour) as opposed to fresh form.

Within the industrial sector, cassava flour is used in paper industry, timber industry, packaging industry and milling industry.

In Malawi it is estimated that cassava is a staple food for about 30% of the population and occupies 10% of the cultivated land.

Commissioned papers

There were eight commissioned papers designed to capture issues that were considered as requiring detailed analysis. The studies were conducted within EARRNET countries. These include:

A. Commercialization, multiplication and distribution of cassava planting material at the community level. It explored and recommended appropriate private/community sector led models for commercial multiplication and distribution of planting material.

B. Labor saving and appropriate cassava storage and processing technologies paper analyzed the available storage and processing technologies in terms of gender appropriateness, type of power used, cost, scale, types and quality consistencies of products made, availability of spares etc. and provided appropriate models for various processing and storage needs.

C. Presentation on cassava bulking at the village/community level for market designation in other areas explored and recommended a model for developing a core entrepreneurship in cassava bulk trading.

D. Policy reforms for promoting cassava as a commercial /food security crop, reviewed food policy and other policy instruments that may hinder the development of the cassava sub-sector in the country and made recommendations for appropriate policy reforms.

E. Use of cassava in animal feeds manufacturing analyzed the potential demand for cassava in the different (poultry, dairy, pigs etc.) feeds lines in Kenya and Madagascar and provided details of cost savings by substituting maize and wheat based feeds with cassava.

F. Industrial (food and non-food manufacturing) use of cassava starch explored the potential demand for cassava starch in a number of industries (textile, pharmacy, brewery, ply woods, packaging, battery making, glue and other adhesives etc.).

G. Marketing of cassava leaves focused on Kinshasa markets and export trade. It quantified the level of leaves traded, trade margins, gender participation and scale of trade to complement other available data on trade and also related these to level of consumption roots. The study also analyzed the implication of the leaves trade to household incomes.

H. Study on cassava in the food Systems looked at cassava within the food crops system and identified the competing crops in terms of production and utilization, crops that are complementary in the production system and in the utilization in relation to livestock production system and proposed areas in which the complementarities can be expanded.

The papers were able to identify certain opportunities for cassava to contribute to food security and also play a major role in industrial processing. The paper on potential use of cassava in animal feeds in Kenya showed that if all the maize used in animal feeds production in Kenya were to be substituted with cassava then we would require more cassava (500,000 mt /an.) in fresh tuber equivalent than actually produced in the country. It was also shown the potential within the starch industry also exists but currently there was no industry producing the cassava starch in the country. It was shown that some starch is actually imported. The potential industries that could use cassava starch included pharmaceutical, sausages, timber and paper industries. Other potential industries were in the confectionery in which cassava flour could substitute wheat flour for biscuits, cakes and bread.

In Madagascar cassava is already in use in animal feeds, confectionery and textile industries. However, the level of use is still low due to lack of regular supply of raw materials (dried cassava chips, starch and flour).

In the area of commercial production of planting material, it was evident that this will be a difficult task as most cassava farmers are used to either getting material from own farms or free from either other farmers or through NGOs. This was said to be the case in Kenya and Burundi. However, in Uganda it is said that some farmers have made some good money through multiplication and sale of planting material. For the commercialization to occur it was proposed that a serious campaign needs to be done to ensure profitable farming in cassava. This will trigger demand for improved planting material.

Thematic papers

Five thematic papers as outlined below were presented by invited experts in cassava sub-sector.

1. Cassava use in manufacture of animal feeds: Global perspective investigated the strategies for cost-effective cassava plant based feeds for livestock and fish production in Africa, Asia and Latin America countries.

2. Integrated plant protection and production systems

3. Commercially competitive and sustainable production systems provided an overview on the clientele objectives, cassava nutrient management and provided a strategy for sustainable productivity

4. End-user targeted germ plasm development

5. Marketing and agro-enterprise development

The thematic papers provided a global perspective of the cassava sub-sector and reported in recent gains in research in cassava that would be useful in guiding the development of the sub-sector in the region. The papers looked at the gains in germ-plasm development, production systems and markets and enterprise development for the sustainable sub-sector. Of particular importance was a paper highlighting formulation of cassava based feeds for different types of livestock and a comparative analysis of their effectiveness in relation to other feeds (mainly maize based feeds). These papers were able to demonstrate that cassava could effectively substitute maize in all animal feeds without affecting the performance of the animals.

In Africa only 6% of the cassava production is used in feeds, and mainly in traditional systems. There is however, a growing use of cassava in commercial feeds in some countries due to ban on maize. In Asia 8% is used domestically as animal feed, while 40% is exported to EU for feed market. In Latin America 33% of production is fed to animals mainly as chips.

Cost savings from use of cassava inlayers feeds instead of corn have been estimated at between 9.7 – 13.4%. A study looking at cost and performance of dairy cattle fed on either cassava supplement of maize supplement showed a cost reduction of 8.66% if cassava is used. Milk yield was however lower by 0.2kg/day on feeding cassava supplement. Butter content remained the same at 4.2%.

It was also demonstrated that depending on the production system in place, efficiency of processing and marketing of cassava chips, the savings to the feed millers using cassava instead of maize could be as much as 30 – 50%.

However, the question of whether our production systems were efficient enough to deliver at competitive prices kept on popping up.

Industrial Application of Cassava/ Private Sector Presentations

A number of presentations were made by the private sector from Malawi, South Africa, Tanzania, Uganda and Madagascar. The presentations were on production of cassava and cassava starch in South Africa, production and use of cassava flour in the industrial sector in Malawi and Madagascar, production and use of cassava in animal feeds in Tanzania and on problems and opportunities in cassava farming in Uganda.

The private sector was committal that cassava had a great opportunity in the industrial sector in the region, but then there were a number of factors that needed to be considered for cassava to play its rightful role in the industrial sector. The South Africa starch firm produces 22,000 tons of starch annually and plans to expand to 68,000 tons/ a. in the next three years. The domestic demand is estimated at 360,000 tons per annum. Corn starch production in the country is estimated at over 350,000 tons/a. In Kenya the demand is over 20,000 tons annually. In Madagascar, the private sector said they could not get enough starch in the county and have been forced to import it at very high cost. Uganda also has to import all its starch requirements. Although cassava starch in more superior to maize starch, its was in short supply in the region. The world demand for starch is estimated at 40 million mt/ a. of which North America uses 16 million mt/a.

The industry would like to see a well organized and more efficient cassava production system close to starch processing factories. The crop has to be produced under well organized production units, and at low cost (focus on high yielding, disease resistant varieties, harvesting must be done when dry matter content is highest). The crop management must also be improved so as to guarantee high yields. The South African firm has its own nucleus farm aimed at ensuring constant supply of roots, it contracts outgrowers for 40% of its requirements. In order to mitigate against irregular supplies its combined fresh roots production per annum is 40% above its factory requirements.

Post harvest technologies must also be vigorously promoted so as to improve the quality of cassava secondary products such as cassava chips that go into flour production.

Marketing systems must also be improved to ensure timely delivery of cassava to processing factories.

The problem of cassava supply to the industrial sector is underlined by the fact that all the industries manufacturing cassava starch or flour in large scale or using cassava for animal feeds have been forced to either have their own nucleus farms or organize and contract farmers to produce cassava on their behalf.

The private sector was committal that it would like to see a more efficient cassava sub-sector and in order to that it the private and public sector must begin to work together in order to solve the miriant of the problems affecting the sub-sector.

Private sector presentations focused on the opportunities of use of cassava various industries in Malawi, Tanzania, South Africa, Kenya, Madagascar, Mozambique and Uganda.

It was noted that high costs of production at farm level, processing, transportation were making cassava products highly uncompetitive in domestic and also international markets. In Brazil for example, it was noted that firm gate prices for fresh tubers were as low as US$25/ ton, while in most eastern and central Africa countries the roots fetch between US$ 100 – 200 per ton. Production costs need therefore to be brought down through a number of measures including increased in productivity.

Emerging Issues

Main constraints

The workshop presentations identified key problems in developing cassava sub-sector as ranging from biological, post-harvest, marketing, utilization and policy. The key problems affecting cassava production were summarized as poor multiplication and distribution of improved varieties. Despite availability of improved varieties which are resistant to most of the diseases and pests common in the region, national capacities to multiply and distribute the varieties remains limited. Poor agronomic practices due to lack of effective extension services coupled with use of poor planting material have contributed to low yields recorded in the region. The low yields make productions high and therefore result into highly priced roots.

In DRC, new strains of the cassava mosaic disease have also complicated the multiplication and distribution of existing varieties.

Post harvest constrains such as lack of appropriate processing and storage facilities were also mentioned as key constraining factors to development of the sub-sector. Though IITA has come-up with processing technologies that improve on the efficiency, quality and shelf life of the processed cassava chips or flour, these technologies are yet to be widely spread across the region.

Marketing of cassava is severely limited by lack of information, market intelligence, poor marketing and transport infrastructure and low quality processed products. The need to link up cassava production to processing/utilization was also emphasized during the workshop.

Lack of appropriate policy support for the sub-sector has also contributed to its low development despite its high potential. Most countries in the region lack policy guidelines for the development of the sub-sector, resource allocation therefore remains

unpredictable and sometimes very low or lacking. In countries where cassava has been promoted, it has been promoted as food for the poor and for marginal lands and therefore its potential as a commercial crop grossly overlooked.

Opportunities

Recommendations

The workshop identified a number of opportunities for cassava to contribute to food security, income generation and economic growth in the region. Though the opportunities were identified as largely country dependent it was clear that some opportunities were applicable across a number of countries.

Cassava for Animal Feeds:

The workshop identified the potential for use of cassava in the animal feeds industry. The potential exists in a number of countries and from the sub-sector analysis it was evident that cassava was already being used either in raw form or semi-processed and fed to animals in all countries with EARRNET, and also in Tanzania. The potential for industrial use of cassava in manufacture of animal feeds was specifically identified in Kenya, Madagascar, and to some extent in Uganda and Tanzania. The private sector is also planning to begin pilot trials in Malawi.

To achieve the use of cassava in the animal feeds industry, its was evident that the whole production, processing and marketing of cassava chips needed to be overhauled in order to assure regular and sufficient supplies of the raw material to the potential processing industries. The need for linking up all the components of the commodity chain is therefore important. To achieve this a first step of getting all stakeholders to work together for the common good was recommended.

Cassava Flour In The Food and Other Industries

The potential for use of cassava flour and starch in the timber and paper industry in the region was also identified. Currently there are two companies in Malawi that are already using cassava in the timber and paper making. Other countries with potential include Kenya, Uganda and Madagascar.

Cassava was also identified to have a great potential in the food manufacturing industry such as sauces, sausages, food thickeners, bevearages, and confectionery (bread and biscuits). Already a number of countries are using cassava in the manufacture of various food stuffs across the region. The scale is small and can be expanded.

In South Africa cassava starch is already being produced but cannot meet the domestic demand. In The East African region, the demand for cassava starch is also evident in a number of industries, but its availability is the problem. The industry is also concerned about its efficacy in the manufacturing of either pharmaceuticals or foods. Since there are no existing standards for use of cassava starch in either of these industries, there is

need for policy interventions as well as setting of standards and grades so as to ensure cassava flour and starch can easily be integrated in the manufacturing sector.

There were a number of cottage and micro-enterprise firms producing a wide range of cassava based products such as cakes, crisps, sausages etc that need support in terms of management training, marketing information, improved production and packaging and credit facilities to expand their scale of operations.

- *continued research and dissemination of improved technologies (varieties, processing and packaging technologies)
- *marketing intelligence studies to improve the efficiency of delivery of raw material to the processors.
- *establishment of a stakeholder consultative groups at national level to lobby for the sub-sector and coordinate production, processing and marketing of cassava products.
- *policy studies to provide an enabling environment for production, movement, processing and utilization of cassava products.

Formation of National Championship Groups

The workshop recommended that each country forms a cassava championship group with private sector leadership. This group will spearhead the development of the sub-sector with the assistance of other partners such as research networks, NARS, NGOs tc.sssss

Annex B. Characteristics of some cassava starches compared to corn starches (ABCD).

Sample	SS4	Migyera	mm96/1603	mm96/2358	mm96/2649	mm96/3152	mm96/4133	A	B	C	D
% weight loss at 70 (av.)	14.41	11.98	10.89	10.72	10.80	10.98	10.60	11.79	12.07	10.46	11.05
% weight loss at 100 (av.)	16.19	13.83	12.61	12.75	12.68	12.80	12.42	12.59	12.30	11.14	11.74
% weight loss at 130 (av.)	16.32	14.27	13.10	13.32	12.99	13.31	13.10	14.40	14.02	12.89	12.66
average % ash	0.33	0.38	0.30	0.10	0.32	0.21	0.35	0.52	0.43	0.25	0.41
% proteins (average)	0.18	0.17	0.18	0.15	0.17	0.09	0.17	0.17	0.17	0.26	0.24
swelling volume	4.50	4.75	4.00	4.75	3.75	4.25	5.00	2.75	5.00	3.38	4.25
swelling power	22.29	23.88	22.90	23.83	25.27	18.52	22.68	19.62	18.55	12.55	11.44
Average % solubility	17.70	20.10	23.40	18.47	18.50	17.84	19.17	15.99	18.37	15.05	12.81
Average pH (20% suspension in distilled water)	6.84	8.00	6.51	7.00	6.72	6.22	5.37	5.28	4.88	5.25	5.40
Average pH (10% dispersion in 10% ethanol)	6.95	8.10	6.80	7.31	6.60	7.15	5.43	5.42	4.98	5.35	5.48
Total titratable acidity (Average NaOH titre (ml))	0.30	0.30	0.30	0.40	0.20	0.35	0.55	0.90	1.00	0.40	0.40