**CROP POST HARVEST PROGRAMME**

# Maximising incomes from sweet potato production as a contribution to rural livelihoods

**R7498**

# PROJECT FINAL REPORT

**(1 December 1999 – 31 March 2003)**

Core Partners: Natural Resources Institute, United Kingdom;
Tanzania Food and Nutrition Centre, Tanzania; and
Lake Zone Agricultural Research and Development Institute, Tanzania

Managing Partner: Andrew Westby

Managing Partner's Institute: Natural Resources Institute

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# Project Final Report

## Section A Executive Summary

Sweet potato is a major staple food and income source in several regions of Tanzania and elsewhere in East Africa. Perishability and problems with in-ground storage mean that the crop is seasonal and with consequent peaks and troughs in prices. This project aimed to maximise economic returns for poor farmers through the development and validation of appropriate storage innovations. Storage was investigated on-station and on-farm.

The design factor with most pronounced effect on sweetpotato storage on-station was lining with dried grass. Roots obtained from lined stores had lower estimated market values, higher levels of shriveling and weevil infestation. After 12 weeks, weight losses of roots in all stores was high, and the acceptability decreased. Very good sensory properties were obtained up to four weeks of storage. Storage should only be carried out using good quality roots. Store type (pit or clamp) or ventilation did not have a consistent effect on shelf-life and suggests that any combination of these designs could be used. Some ventilation is necessary to avoid build up of high levels of carbon dioxide, but high ventilation reduces humidity. Cultivar had a relatively small impact on storage with polista and SPN/O cultivars leading to slightly improved shelf life. These cultivars also had significantly lower oxygen and higher volatile sulphur compounds at 8 weeks of storage. This indicates possible differences between the cultivars with respect to curing and wound healing.

Research in collaboration with farmers for storing fresh sweetpotato for up to 16 weeks (in 2001 and 2002) has indicated that the approach can work well. Results confirmed that both pit and clamp stores are equally good, which enables farmers to choose the most appropriate design for their situation. Stores worked well provided that good quality, undamaged fresh roots were selected for placing in the stores and that they were located in the shade under a tree and such that rain water could not enter. Dehalming roots up to 14 days before harvest improved the success of stores. Success of stores varied between locations and between years. The variation in success between years appears to be related to the condition of the roots. The way that the stored roots were evaluated had an impact on the analysis of the results. Grading of roots into marketable, for home use or below grade appeared to offer a more sensitive way of measuring the outcome as opposed to scoring randomly selected roots for specific type of defect. On-farm sensory evaluation indicated that the stored roots were acceptable and that the store design and dehalming had no effect on taste. Interviews with farmers suggested that they were more willing to takes risks with the storage technology if they grew a wide portfolio of crops for cash and home consumption. Most were keen to store their roots and some had already begun to do so during this research. While most farmers were only prepared to accept low risks (8/18), other where prepared to take a high risk (5/18). A concern, however, was that the stored roots were generally lighter than fresh roots and this might hinder acceptance by consumers. Considering the type of store, farmers expressed no preference overall, the type of store preferred depending on their individual circumstances. Most farmers (11/14) were keen to dehalm the plant canopy prior to harvest to harden the roots as they could see the advantages in root quality. The research endeavoured to estimate how profitable the storage technology might be if the farmers sold the stored roots to traders or directly to consumers at local markets, but farmers were concerned about revealing commercially sensitive information. However, farmers group meetings suggested the stores could be used both for income and food security.

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## Section B Background

B.1 Administrative data

| | |
|---|---|
| NRIL Contract Number: ZB0205 | Managing Partner(s)/Institution(s):<br>Andrew Westby<br>Keith Tomlins<br>Natural Resources Institute |
| DFID Contract Number: R7498 | Partner institution(s)<br><br>Tanzania Food and Nutrition Centre<br>Lake Zone Agricultural Research Institute |
| Project Title:<br><br>Maximising incomes from sweet potato production as a contribution to rural livelihoods | Target Institution(s)<br><br>Tanzania Food and Nutrition Centre<br>Lake Zone Agricultural Research Institute<br>Extension services in the relevant zones through on the ground activities.<br>Local NGOs and church groups as identified in activities<br>Southern Africa Regional Root Crops Network (Dr Kapinga was a member of the steering committee)<br>CIP and IITA (Post-Harvest Project) for wider dissemination. Dr Kapinga became a CIP Regional Scientist in the course of the project. |
| Research Programme: Crop Post-Harvest | Start Date: 1 December 1999<br>End Date: 31 March 2003 |
| Thematic area:<br><br>Forest-Agriculture Interface | Budget (i.e. Total Cost):<br><br>£212,969 |

## Section C Identification and design stage

### *Poverty focus*

***How did the project aim to contribute to poverty reduction?***

The project aimed to maximise economic returns to smallholder farmers through the development and validation of appropriate storage and handling innovations that enable farmers to have choice over how they manage their sweet potato crop post-harvest in order to optimise incomes.

***Was it enabling, inclusive or focussed (see definitions below[1])?***

The project could largely be described as being **focussed** since it addressed an issue what mainly affected smallholder, poor, farmers. Sweet potato is largely a poor farmer crop and it is for this reason that we considered it to be focussed research.

***What aspects of poverty were targeted, and for which groups?***

The aspect of poverty targeted was the issue of limited financial returns from agricultural production. The aim was to develop for small holder farmers a means of storing their sweet potato and marketing out of season. Sweet potato is a seasonal crop and all of the production has to be harvested at one time to prevent damage from sweet potato weevil (*Cylas* spp.). Storage provides the opportunity to market the crop out of season and also, from a food security perspective, to consume fresh roots further into the dry season.

***Please describe the importance of the livelihood constraint(s) that the project sought to address and specify how and why this was identified.***

Livelihood problems or opportunities addressed by the project include that sweet potato has major role in the food security of poor households in rural area, where it is a traditional crop for subsistence farmers (especially in the Lake and Eastern Zones). It is now increasingly being marketed to urban areas where poor consumers need energy rich food at low price. The importance of sweet potato is thus changing from a subsistence food crop to a cash crop. This situation has stimulated both men and women to become involved in sweet potato marketing.

The 'new' sweet potato farmers depend on incomes from the crop as a main part of the livelihood strategies. Specific constraints to sweet potato marketing for farmers are detailed below.

- Short shelf life and storage losses reduce the amount of marketable roots resulting in reduced income. Losses also reduce food security for rural consumers as it limits the availability of the crop throughout the year.

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[1] **Enabling**: addresses an issue that under-pins pro-poor economic growth or other policies for poverty reduction which leads to social, environmental and economic benefits for poor people
**Inclusive**: addresses an issue that affects both rich and poor, but from which the poor will benefit equally
**Focussed**: addresses an issue that directly affects the rights, interests and needs of poor people primarily

- Fluctuation of prices between high and low season of supply. During the high season of supply, prices of sweet potatoes are low while during the low supply season they are high. Lack of appropriate storage techniques and the susceptibility of roots to weevil damage prevent the farmers from holding the crop from high season of supply to the low season.

The project focuses on the above problems, but in addition the following problems exist and will need to be addressed as a part of future initiatives. This project provides some valuable results to contribute to future work on these issues.

- Farmers have little bargaining power at the market because they are not organised. Potentially the formation of farmer marketing groups (associations) could increase marketing efficiency of the farmers.
- Poor access to markets is caused due to the high transaction costs caused by the lack of information on prices, demand, quality and other physical factors such as transport problems. This leads to erratic supply of sweet potatoes in the market. Consequently, farmers often get poor returns from their crop due to asymmetric market information.
- Vitamin A deficiency is a problem of public health significance in Tanzania. It is estimated that Vitamin A deficiency affects 1.36 million people of whom 1.33 million are children under the age of 6. There is potential for orange fleshed sweet potatoes to contribute to overcoming this deficiency. Currently, there is limited availability and awareness of orange fleshed sweet potatoes in the country. If orange fleshed varieties are to become important then there needs to be market demand and promotion of the concept of orange-fleshed sweet potato.

It is proposed that an appropriate form of on-farm fresh-root storage will be used to enable farmers to market their produce at times outside the main harvest period and so gain higher returns from their crops. In warmer areas of the country, storage is uncommon, and when practised, it is only short term (ca. 1 month). Researchers at ARTI Ukiriguru have indicated that farmers are keen to store but lack knowledge on the relative merits of such storage technology. Flexible systems are required that enable farmers to market their crops either when they need income or when market prices are most favourable. Data from project R6508 (Table 1) indicate the potential for delayed market entry of the product. Although the primary intervention that we propose to evaluate is on-farm storage, this needs to be seen within the wider context of improvements to handling and crop management having impacts on quality and thus increasing value.

**Table 1. Seasonal changes in the quality, quality and price of Sweet potato entering Mwaloni market, Mwanza, Tanzania.**

| **Month** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Quantity** | + | ++ | +++ | +++++ | ++++++ | ++++++++ | +++++++++++ | +++ | ++ | + | + | +++++ |
| **Quality** | + | ++ | +++ | ++++ | +++++ | +++++++ | +++++++ | + | | | ++++++ | +++++++ |
| **Price** | ++++ | ++++ | +++ | ++ | + | ++ | ++ | + | + | + | ++++++ | ++++ |

Notes: Number of pluses indicate changes in variables from month to month as perceived by two key sweet potato traders. Pluses for quantity and quality give rough indications of relative values. For prices however, each plus represents approximately Tsh 1,000.

**How and to what extent did the project understand and work with different groups of end users? Describe the design for adoption of project outputs by the user partners?**

The project worked extensively in its second phase with farmers and traders of sweet potato. The project did not intend specifically to differentiate between different groups of end users – although, for example, in the Lake Zone there were diiferences between the farmers at Sengerema and at Ukerewe. These differences were explored in the project using statistical techniques.

We have evidence that some of the farmers with which we worked continued to sue the storage technologies for their own use. The extent of this was not specifically follow-up upon after the completion of the project activities.

***Institutional design***
***Describe the process of forming the coalition partnership from the design stage and its evolution during the project?***

The project coalition partnership has been established over a long period of collaboration on a range of research and technology transfer projects. The relationship between NRI and TFNC dates back ca. 1990 when Dr Nicholas Mlingi was supervised for his PhD studies. The relationship was strengthened in the early-mid 1990s with the implementation of the DFID Regional Africa Project on Non-Grain Starch Staples and research activities under the DFID Food Science and Crop Utilisation Research Programme. These collaborations continued with the commencement of the Crop Post-Harvest Programme. It was under the CPHP that collaborative work started on sweet potato. The origins of the work reported in this Report started from project R6508 in which the lead researcher from TFNC gained his PhD from Sokoine University of Agriculture under the supervision of Professor Andrew Westby of NRI.

The relationship between NRI and LZARDI pre-dates the Crop Post-Harvest Programme and originates with the DFID regional Africa project on non-grain starch staples. The relationship strengthened through a range of CPHP research projects supported by the Crop Post-Harvest Programme. The leader of the national root and tuber crops programme was based at Ukiriguru and NRI provided support to the national programme including participation in annual planning and review meetings.

The major change in the implementation of the project was the Principal Researcher, Dr Regina Kapinga, at the LZARDI Ukiriguru became the Director of Research and Promotoion in the Commission for Science and Technology and her role taken over by Mrs Theresia Ngendello.

***Is there an explicit institutional hypothesis? If yes, is it trying to attack a failure or inadequacy in a mechanism?***

The project pre-dates the national innovation systems approach championed by the CPHP.

***What other institutional factors were seen as being important?***

As can be seen above the above partners have developed a collaborative research partnership over a 10-12 year period. Within are elements of support and capacity building. This capacity building extends to supporting scientists to make progress in their career – for example Dr Regina Kapinga who took on a major national role in research coordination and went on to become a regional CIP scientist and Dr Gabriel Ndunguru who gained his PhD through collaboration with NRI.

## Section D Implementation process

***How was participation maintained among the different stakeholders (the Managing Partner(s) and the Core other Partners and, where relevant, user communities) in the research process?***

The major partners in the research remained unchanged.

***What were the major changes that took place during the implementation period. For each one, explain why they came about and how well did the project manage them?***

The major change in personnel was the departure of Dr Regina Kapinga to the Commission for Science and Technology based in Dar es Salaam. This removed an experienced members of the project team from Tanzania. LZARDI make Mrs Thersesia Ngendello available to lead on behalf of their organisation. NRI supported this transition process and excellent working relationships were developed with Mrs Ngendello.

Participation in the project on a technical level was mainly confined to the project partners since we were developing research outputs on station in the first phase on the work. In the second phase – where technologies were tested on farm – LZARDI and TFNC took the lead in working with farmers.

The project partners coped with these project-related changes.

The project partners found the **implementation** of the Partnerships for Innovation by the CPHP a significant distraction in the latter part of the project with the uncertainties and stresses that this put on institutional relationships – specifically with respect to the role of UK partners in the new approach. The series of events that took place severely strained relationship.

**What were the strengths and weaknesses of your monitoring system? How did you use the Information provided by your monitoring system?**

We did not have a monitoring system in place – other the logframe.

**What organisations were involved at the end of the project? Were there changes to the coalition (joining/leaving) during the project? If yes, why?**

The organisations involved at the end of the project were:

Natural Resources Institute
Tanzania Food and Nutrition Centre
Lake Zone Agricultural Research Institute
Marketing Development Bureau, Dar es Salaam.

Marketing Development Bureau left the project partnership because the scientist concerned died.

***Include a complete list of organisations involved, directly or indirectly, in the project and describe their relationships and contributions.***

| Organisation | Relationship | Contribution |
|---|---|---|
| Natural Resources Institute | Project leader | Project management and coordination, Project technical and economic inputs. |
| Tanzania Food and Nutrition Centre | Sub-contracted partner | Coordination of work in Lake Zone, Technical inputs to project |
| Lake Zone Agricultural Research and Development Institute. | Sub-contracted partner | Coordination of work in Eastern Region, technical inputs to project. |
| Marketing Development Bureau, Dar es Salaam | Affiliate to TFNC | Support to marketing studies. |

## How will(have) project outputs affect(ed) the institutional setting?

***How will the technical outputs of the project (if successful and if adopted) change the organisations and the relationships between them and in what way? Refer to the project's technical hypothesis.***

The project outputs were not specifically designed to change the institutional setting at all. All of the outputs were technical in nature. The technical hypothesis of the project was: Sweet potato storage and handling systems could be optimised to improve incomes for sweet potato producers. The project was not specifically intended to change or modify the institutional setting.

# Section E Research Activities

This section should include a description of all the research activities (research studies, surveys etc.) conducted to achieve the outputs of the project analysed against the milestones set for the implementation period.

Information on any facilities, expertise and special resources used to implement the project should also be included.

## Introduction

The project was designed to deliver three outputs. These were:

1. Systems developed that will increase the incomes of poor farmers and other participants in marketing of fresh sweet potato
2. Systems for improved storage or handling validated, and benefits quantified, on a case study basis.
3. Appropriate dissemination literature prepared and disseminated to identified target institutions and uptake pathways.

This report on activities is designed around these outputs.

## Summary of baseline study.

The baseline study is reported in the document authored by Ndunguru *et al.* 2000.

*Materials and methods*

Areas covered during the survey include, Lake, Eastern and Southern Highlands Zones. The survey covered both villages and selected markets as shown in table 1. People contacted included farmers, traders, shopkeepers and food vendors. Informal interviews were conducted among the key players. In the villages groups of between 8 to 15 farmers were formed and the interview lasted for about one and half hours. All the groups comprised of both women and men. Individual traders were interviewed in each respective market in order to allow them attend their customers at the same time. In the markets, hips of sweet potato tubers were taken and weighed in order to standardise their sales on a kilo basis.

*Main findings*

Production of sweet potatoes in all Zones is done by subsistence farmers. All men and women take part in the production process of the crop. The average yield of sweet potatoes per hectare is 2.7 tones. Farmers grow several varieties of sweet potatoes for both sale and home consumption. However, the most preferred varieties are polista, sinia and SPN/o. In the subsistence economy of the farmers, sweet potatoes rank second to other crops such as maize and cassava.

In ground storage of sweet potatoes is normally practised in all the areas surveyed except in the Southern Highlands where the tubers are stored after harvesting. Storage of harvested sweet potatoes is done only in Mbeya region using pits called “Ndali Pits”. Although the farmers in Mbeya can store the crop for up to five months, only the local varieties are suitable for storage. Processed and dried sweet potatoes are successfully stored in Shinyanga region.

**Table 1: The areas covered by the baseline survey**

| ZONE | REGION | DISTRICT | NAME OF VILLAGE | HOUSE HOLDS | POPULATION | AVG FARM SIZE | Markets |
|---|---|---|---|---|---|---|---|
| LAKE | MWANZA | Ukerewe | Kakerege | 280 | 1400 | 3 | Nansio |
| | | | Busagami & Bunyoro (Ilangala) | 450 | 4500 | 3-4 | |
| | | Sengerema | Kafunzo (Kahunda) | 380 | 1900 | 3 | Sengerema Farmers Mwaloni |
| | | | Igaka | 270 | 1350 | 6 | |
| | SHINYANGA | Meatu | Bulyashi | 450 | 2250 | 10 | Mwanhuzi Nguzonane |
| | | Shinyanga Rural | Pandagichiza | 290 | 1450-1740 | 20 | |
| EASTERN | DSM | Temeke | Gezaulole (Kigamboni) | 600 | 3600 | 4 | Tandale Tandika Buguruni |
| | MOROGORO | Morogoro Rural | Mtumbatu | 895 | 4414 | 5 | Sabasaba Soko kuu |
| | | | Kyegea | 611 | 3390 | 4 | |
| SOUTHERN HIGH LANDS | MBEYA | Ileje | Kapelekesi, Kafule ward. | | | | |
| | | Mbeya Rural | Songwe village | | | | |

Source: Survey Data, Jan-August,2000.

The most important markets for sweet potatoes are Mwaloni in Mwanza , Nguzonane in Shinyanga, Sabasaba in Morogoro and Tandale in Dar es Salaam regions. Prices of sweet potatoes vary with season and market. Although traders of sweet potatoes obtain adequate profits by selling the crop in all the markets, Mwaloni, Nguzonane and Tandale markets are the most profitable. Price discounting is normally done when tubers are aged three days by reducing prices by between 16.6 to 50 percent. In the retail trade discounting is through the addition of adding additional sweet potatoes to "Heaps" thus bringing down the unit price. This can be done on a daily basis over say three days or so.

A few traders who operate individually without any organisational set-up (Association) to support them characterise the marketing of sweet potatoes.

Sweet potatoes farmers face problems such as pests, rodents and diseases and both farmers and traders have no access to credit facilities which result into reduced volume of business. Lack of standardisation of bag weight has led to under payment per unit consignment of sweet potatoes. Farmers face also the problem of lack of agricultural extension services for the crop.

Generally, farmers are willing to try the technology of sweet potato storage if they can be shown the financial benefits of adopting the techniques. Farmers are not willing to store sweet potatoes communally. They prefer to store sweet potato around the homestead where security can be maintained. However, communal marketing should be encouraged.

## Study of sweet potato prices and quality chacteristics.

To complement the on-station and on-farm studies of sweet potato storage a study of the market for sweet potato was carried out in the Lake Zone.

Three sweetpotato market traders in Mwanza were interviewed throughout the 2002 season. The sack price, heap price and weight, root quality and problems faced by traders were monitored. The results confirm that it would be best for farmers to store their roots during the month of June when roots are plentiful and the price is low. There is a clear advantage in delaying the sale of the stored roots until the after the month of August when the sack price doubles and the quality of fresh roots is poor. However, a constraint might be that market traders also report low profits when the price of the sacks are high, perhaps because roots quality is poor. However, the expected improved quality of the stored sweetpotato roots may overcome this disadvantage.

A constraint noted by traders was competing products such as rice during the months of May and June. For a stored sweetpotato product, other product may compete when sold after the month of August.

The market traders were able to maintain a steady profit from February until June even though the price of a sack decreased and the weight of a heap sold increased. This suggests that market traders are able to control other costs such as transportation. Other factors such as the sack weight might be important. For example, the sacks might be lighter during the low season and heaviest when roots are plentiful. These factors might be important when selling the stored sweetpotato product in the low season.

## Summary of on-station research activities

<u>Materials and Methods</u>

On-station trials were carried out with 36 stores in 2000 and 24 stores in 2001; each with a unique combination of design factors. Five different treatments were assessed: cultivar (Polista, Sinia B and SPN/0); ventilation where stores with extra ventilation contained six ventilation pipes, others two pipes; lining with dried grass (which was folded into bunches of 10 cm diameter and placed inside the pits or outside the clamps); store type using both pit and clamp types of store (round pits were dug in the soil of about 0.6 m in diameter and 0.6 m depth. clamps were built with the roots); and damage treatment that was carried out by rolling a sack of roots 10 times. This treatment simulates damage that occurs during handling and transport of roots which is known to cause 'skinning injury' and was only used in 2000.

Each store contained 70 to 100 kg roots of similar quality. Over a period of 18 weeks of storage, the physiological changes of the roots in the stores were monitored by measuring root weight, dry matter content, oxygen and carbon dioxide levels, relative humidity and temperature. The quality of the stored roots was assessed by "Estimated Market Value", sensory evaluation and external appearance, which included sprouting, shrivelling, rotting and weevil infestation.

During storage the conditions inside the stores were monitored (temperature, relative humidity (RH), oxygen and carbon dioxide). Temperature and relative humidity were determined using a probe (Hanna Instruments, Portugal), or Tiny Talk data loggers (Gemini, Chichester, UK) that were inserted into the store at least every week for 10 minutes. Gas samples were taken in duplicate at regular intervals (at least every week) from each store via tubing (Tygon 3603 (BDH), 3 mm). The measurements were made using a $CO_2$ meter and an $O_2$ meter (Anagas CD 98 and Oxycheck 2, David Bishop Ltd, UK).

Dataloggers (RS Components, UK) were used to monitor temperature (Tinytalk II; +/- 0.2°C); and humidity (Tinytalk II; +/- 4%). They were fitted inside a ventilated plastic pipe that was located at the centre of the roots in selected stores.

Physiological characteristics were recorded at 0, 2, 4, 8, 12, and 18 weeks when stores were opened and inspected. Weight loss was determined by taking ten randomly selected roots per store labelling them and recording their weights every time the stores were opened. In addition rotten roots were removed during opening of the stores, and their total weight was recorded as a percentage of initial weight of roots stored. Dry matter contents were determined for three roots per store using both cooked and uncooked roots. To determine dry matter contents roots were sliced and dried for 48 hours in an oven at 80°C.

Respiration rates were measured at 25°C. Single roots were weighed and placed in a 3 L jar. Air samples were removed at intervals from each jar through a rubber septum using an air-tight syringe. Levels of carbon dioxide and oxygen were measured by gas chromatography using a molecular sieve (to separate carbon dioxide from oxygen/nitrogen) and poropak column (to separate oxygen and nitrogen) and a thermal conductivity detector.

The quality of roots was assessed at 0, 2 , 4, 8, 12, and 18 weeks of storage. A sample of 20 randomly selected roots was used. To determine the “Estimated Market Value” the roots were divided into two heaps. Ten consumer panellists then estimated the value of the roots, in relation to standard heaps, consisting of roots bought on the market that day. All heaps of roots were weighed, and thus the price per kg was calculated for each heap of roots. For External Assessment all 20 randomly selected roots were scored by three scientists for breaks, cuts, skinning injury, shrivelling, rotting, weevil infestation and sprouting.

Sensory evaluation was carried out by a trained panel of 10 panellists. Equally sized pieces (3-5 cm) were boiled for approximately 20 minutes and until the texture assessed by a fork was considered correct for eating. Each panel member scored each store-sample for pre-determined important characteristics by placing a mark on a 10.5 cm line. Characteristics included: appearance, colour (inside and outside), taste, smell, sweetness, flouriness, texture, chewiness, stickiness and acceptability. Panellists were presented with three or four randomly selected samples labelled with a random number. Three sessions (morning, noon and afternoon) were conducted each day.

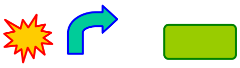
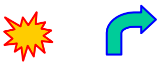
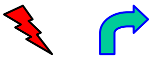
Statistical analyses were carried out using Genstat (Rothamsted, UK). Due to the incomplete design in 2000, the significance levels were calculated using type II and type III sums of squares. In year 2001 analysis was carried out using ANOVA. It only included only the main effects (store type, cultivar, ventilation and lining) because of the lack of replication.

Results of on-station studies

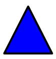
*Physiological changes*

Table 1 indicates which of the design factors had a significant effect ($P < 0.05$) upon physiological changes of the roots during the storage period.

**Table 1.** Store design factors that had a significant effect ($P < 0.05$) upon physiological changes of the roots during storage in on-station trials in the Lake Zone of Tanzania.

| **Physiological changes** | **Store design factors with significant effect** | **Design effects on physiological changes** |
|---|---|---|
| Weight loss |  | Lower weight loss when stores were not lined. Store type affected weight loss in week 8. |
| Dry matter cooked roots |  | Polista has the highest dry matter content when cooked ($P < 0.05$; 41-44% compared to 37-41% in other cultivars). Lower dry matter where there is no lining. |
| Dry matter uncooked roots |  | Polista has the highest dry matter content for fresh roots |
| Oxygen in store |  | Oxygen levels were higher in stores with extra ventilation and grass lining. Stores with cultivar Sinia B showed low levels of oxygen |
| $CO_2$ in store |  | $CO_2$ levels were lower in stores with extra ventilation and with grass lining. Stores with cultivar Sinia B showed high levels of $CO_2$. |
| Temperature |  | Temperature was about 3 degrees higher in stores with damaged roots in first 2 weeks ($P<0.01$). Increased ventilation reduced the temperature |
| Relative Humidity |  | The relative humidity was higher in stores with little ventilation (2 pipes 80-95%) than in stores with increased ventilation (6 pipes; 70-80%) |
| Respiration rate |  | Higher rate of respiration for Polista (73.8 ml $CO_2$/Kg/h) compared to SPN/0 and Sinia B (45.5 and 43.9. ml $CO_2$/Kg/h). Polista could be more prone to anaerobiosis in sealed store. |

Symbols indicate the store design factor that affected storage

 Clamp/pit  Ventilation  Damage

 Cultivar  Lining with grass

The average weight losses for stored roots were up to 4% (2 weeks), 7% (4 weeks) 15% (8 weeks) and 28% after 12 weeks (Figure 1). Lining the stores had an inconsistent effect on weight loss. Weight losses were reduced in year 2000 when stores were lined. Significant effects were observed in weeks 4, 8 and 12, while in year 2001 the lining treatment significantly increased weight loss during the whole storage period ($p< 0.05$). Dry matter content was measured for both the fresh and cooked roots sampled during storage. The pattern for both was similar. Cultivar, and to a lesser extent lining, were the factors that influenced dry matter content (Figure 1). Polista had the highest dry matter content when cooked ($P < 0.05$; 41 to 44% compared to 37 to 41% of the other cultivars and for fresh roots. In unlined stores the dry matter content was significantly lower in week 12 ($P < 0.05$).

The $CO_2$ concentration in the stores varied between 0.1% and a maximum of 13%. It increased during storage and the increase was greatest in stores that were not lined or ventilated. For lined stores (Figure 2) $CO_2$ levels increased from an average of 1.6% in the first four weeks of storage to 3.3% in the last four weeks, while unlined stores the increase was from 2.3% to 5.3%. Stores containing the cultivar Sinia B showed higher levels of $CO_2$.

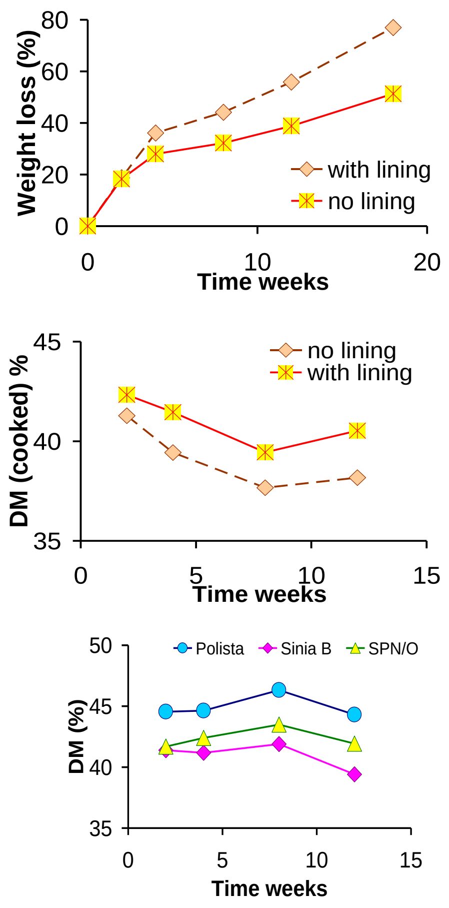



**Figure 1.** Changes in weight loss and dry matter (DM) of sweetpotatoes stored in pits and clamps in the Lake Zone of Tanzania. Figures show effect of lining of stores with grass and variety of sweetpotato.

The oxygen concentration in the stores varied between 15 and 21%. Overall, it followed an inverse response to $CO_2$ and the significant differences with respect to lining and ventilation were similar. Cultivar differences up to week 8 were noted where the concentration was least for Sinia B cultivar and highest for Polista.

The temperature (Figure 2) was about 3°C degrees higher in stores with damaged roots in the first two weeks of storage ($P<0.01$). This may be due to the higher metabolic activities of roots within the stores. The higher respiratory activity among the roots may have been due to wounding or even to rotting. Later during the storage period the temperature in stores with damaged roots was similar to other stores. Stores with cultivar SPN/0 recorded a lower temperature for the first four weeks of storage than the cultivars Polista and Sinia B. Ventilation only affected the temperature significantly after one week of storage, where two pipes ventilation resulted in higher temperatures than use of six ventilation pipes.

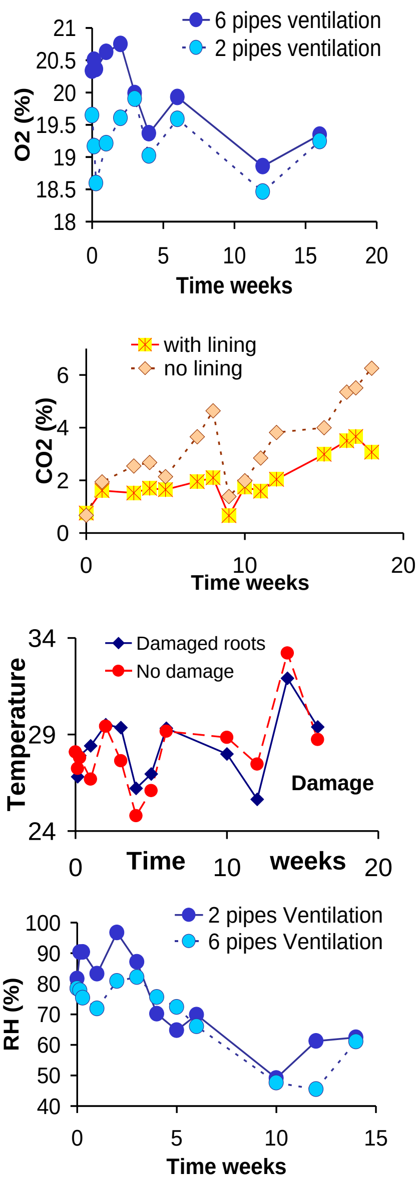



**Figure 2.** Changes in environmental conditions with pit and clamp stoes of sweetpotato during storage in the Lake Zone of Tanzania. Figures show effect of ventilation, lining and damage on selected environmental conditions (oxygen level, carbon dioxide level, temperature and relative humidity).

The relative humidity (Figure 2) was higher in stores with two pipes ventilation (80-95%) than in stores with six pipes ventilation (70-80%). This was highly significant after 1, 2, 7 and 14 days. After three weeks the humidity in the stores with two pipes dropped to under 80%.

Respiration experiments indicated that Polista had a significantly higher rate of respiration (73.8 ml $CO_2$/Kg/h) than SPN/0 and Sinia B (45.5 and 43.9. ml $CO_2$/Kg/h), with no significant difference between the latter two cultivars. It would be predicted that Polista is less suitable for long-term storage than the other two cultivars. It would be expected that Polista would be more prone to anaerobiosis within a sealed store (Rees 2002). This is, however, inconsistent with the $O_2$ and $CO_2$ measurements in the stores where Sinia B had the highest levels of $CO_2$.

**Quality changes**

Table 2 indicates which of the design factors had a significant effect ($P < 0.05$) upon quality aspects of the roots during the storage period.

The estimated market value was mostly affected by cultivar ($P = 0.009$). SPN/0 had the highest value per kg and was between 60 and 50 TSh/kg (exchange rate: US$1.0 = 775 TSh). This is in agreement with the findings of Rwiza *et al.* (2000) who found that the consumers have a preference for SPN/0. Sinia B was valued lowest per kg, During storage the estimated market value declined for all roots and was much steeper for damaged than for undamaged roots. The damaged roots were valued at 35.8, 25.9 and 20.9 TSh/kg for 2, 4 and 8 weeks respectively, while the undamaged roots were valued at 51.3, 43.8 and 31.2. Roots kept in pits were valued higher than roots kept in clamp stores and after eight weeks the estimated market value for roots from clamps was a third lower than of pit stored roots (20.8 and 31.8 Tsh/kg).

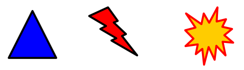
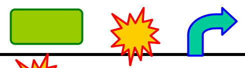
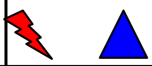
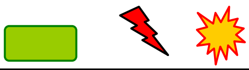
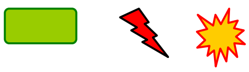
Roots in clamp stores were also more susceptible to rotting (Figure 3). Statistical analysis revealed that two factors significantly affected rotting: damage and type of store. Pit storage resulted on average in 11% rotten roots after four weeks and 25% after 12 weeks, while clamp storage resulted on average in 28% rotten after four weeks and 35% after 12 weeks. Damage affected rotting and 27% of the damaged roots were rotten after four weeks while 35% were rotten after 12 weeks. Of the undamaged roots 12% were rotten after four weeks and 35% after 12 weeks. Data for estimated market value and rotting were only analysed for the year 2000.

Sprouting, assessed during the external assessment of 20 randomly selected roots, started to appear after two weeks. Many of the stores showed significant sprouting, sometimes even large green patches of green leaves could be seen outside of the stores. Susceptibility to sprouting was significantly affected by cultivar ($p < 0.005$ in week 4) and Sinia B was most susceptible for it (Figure 3). Reduced sprouting occurred when stores were lined with dried grass. Pits had a higher rate of sprouting than clamps. There was an inverse relationship between the level of sprouting and the level of rotting (Figure 4) where rotting roots reduced the occurrence of sprouts.

The levels of shrivelling, expressed as a score during external evaluation, were significantly higher for roots from stores lined with dried grass (Figure 3). The trend for shrivelling had very low occurrences up until week 12 after which shrivelling and rots dramatically increased, the greatest increase being in the lined stores (Figure 3). The levels of shrivelling increased during storage for all stores. Store design did not have a consistent effect on the level of shrivelling. Slightly more shrivelling was observed with grass lining, and ventilation had a slight effect in the first eight weeks. Polista was overall slightly more susceptible to shrivelling than the other varieties.

There was significantly more deep weevil (*Cylas* spp.) infestation in stores with dried grass lining at 8, 12 and 18 weeks ($p < 0.05$). Sweetpotato weevil also increased more in the lined stores but this increase occurred from week 4 onwards whereas for unlined stores, the increase was delayed until after week 12 (Figure 3).

**Table 2.** Design factors with a significant effect (P < 0.05) upon quality aspects of sweetpotato roots during the storage period in on-station trials in the Lake Zone of Tanzania.

| Quality Aspects | Store Design factors with significant effect | Design effect on Quality Aspects |
|---|---|---|
| Estimated Market Value |  | Higher Estimated Market value for undamaged roots after 2-8 weeks storage. Roots from lined stores and clamps had a lower Estimated Market Value |
| Sprouting |  | Most sprouts in stores with no lining, low ventilation, pits. The cultivar Sinia B had significant more sprouting. |
| Shrivelling |  | The levels of shrivelling, expressed as a score during external evaluation, were significantly higher for roots from stores lined with dried grass. |
| Rotting |  | Roots in clamps had a higher percentage rotted roots then roots from pits. Also stores of which the roots had a damage treatment had higher levels of rotting. |
| Deep weevils |  | There was significantly more deep weevil (*Cylas* spp.) infestation in stores with dried grass lining. |
| SE (Sensory Evaluation) Smell, taste acceptability |  | Cultivar, damage and lining had significant negative effects on smell, taste and acceptability, especially after 2 and 4 weeks. |
| SE: Appearance, Colour (inside and outside) |  | Cultivar had significant effect on colour and appearance, with SPN/0 kept the best appearance during storage. Damage and lining affected the attributes in week 2 to 4. |
| SE: Sweetness and flouriness |  | Sweetness increased for the cultivars SPN/0 and Polista during the first weeks of storage. Sinia B was much less sweet. |
| SE: Texture, chewiness and stickiness |  | Cultivar had a significant effect on texture and chewiness. Damage resulted in lower texture in week 0, 2 and 4. Lining reduced chewiness of roots in the first 2 weeks. |

Taste, smell and acceptability were affected by cultivar, damage and lining especially after 2 and 4 weeks of storage. Cultivar had a highly significant effect after 4 weeks ($p < 0.005$). Taste scores increased for SPN/0 since harvesting from 72 to 73.4 while it had decreased for Sinia B from 65 to 50.7. For Polista a slight decrease in scores was noted from 69 to 67.6. A similar pattern was observed for smell. Root damage affected taste, smell and acceptability at 0 ($p < 0.05$) and 2 weeks ($p < 0.01$) and damaged roots scored lower for all sensory tests. Grass lining had a significant negative effect on these sensory characteristics at 2 and 4 weeks.

Cultivar had significant effect on the inside and outside colour and appearance of the roots, with SPN/0 keeping the best appearance during storage (Figure 5). Undamaged roots gave a significant higher score for these characteristics immediately after harvesting ($p < 0.001$) and in week 8 ($p < 0.05$). Lining reduced the scores from appearance and colour significantly ($p < 0.01$) in week 2 (Figure 5).

Cultivar had significant effects on the sweetness and flouriness of the roots (Figure 5). This was significant at four weeks for flouriness ($p < 0.05$) and sweetness ($p < 0.005$). Both SPN/0 and Polista developed these tastes well during storage: a small reduction in sweetness after two weeks, increasing to scores higher than at harvesting time at four weeks. For Sinia B these characteristics did not develop so much during storage.

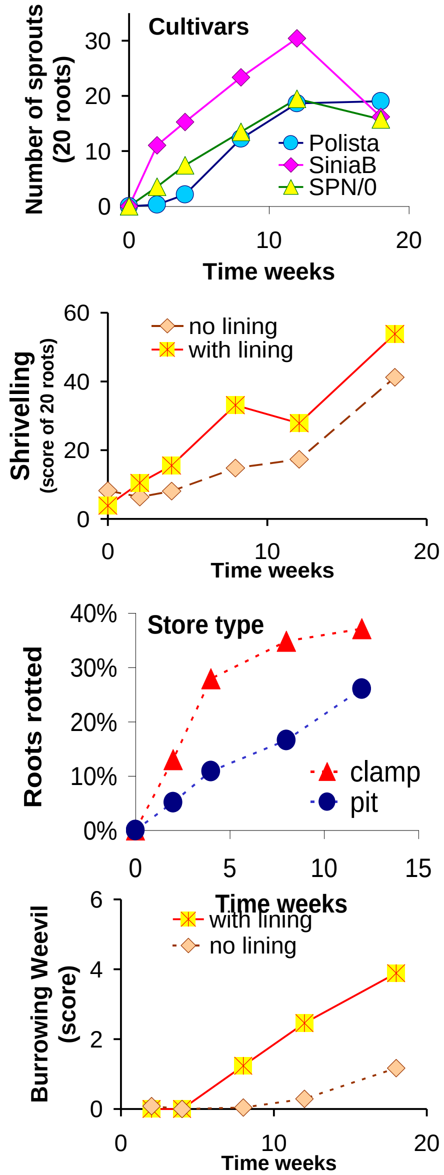



**Figure 3.** Changes in quality of sweetpotato roots in pit and clamp stores in the Lake Zone of Tanzania. Figures show effect of variety, lining and store type on sprouts, shrivelling, rotting and burrowing weevil.

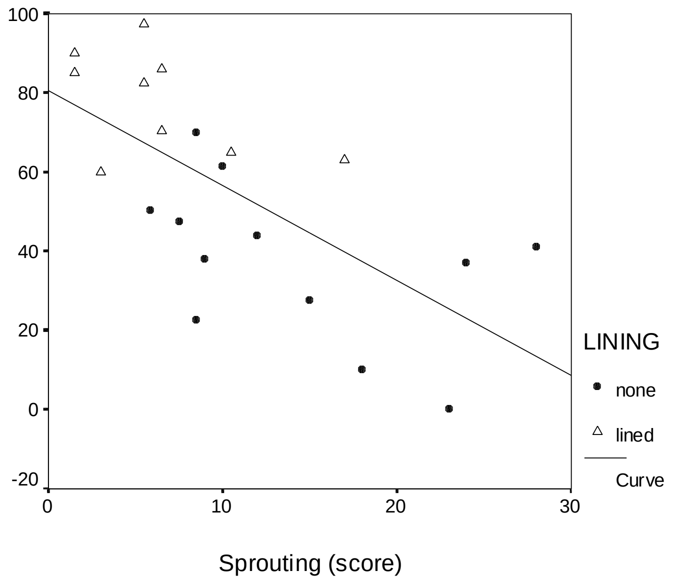



**Figure 4 .** Relationship between rots and sprouting in sweetpotato stored in pits and clamps with and without grass linings in the Lake Zone of Tanzania.

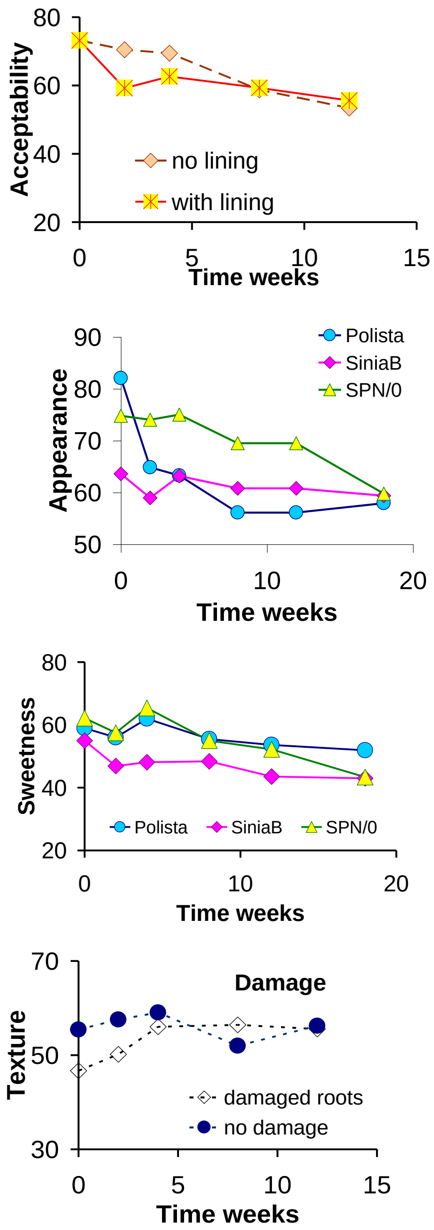



**Figure 5.** Changes in selected sensory properties of sweetpotatoes stored in pits and clamps in the Lake Zone of Tanzania. Figures show effect of lining, variety and damage on sensory properties over time.

Stickiness, texture and chewiness tended to increase during storage. Stickiness was not affected by any of the design factors. Cultivar had a significant effect on texture and chewiness in weeks 2, 4 and 8. The scores for texture and chewiness of Polista decreased during storage, while it increased for SPN/0.

Damage resulted in lower texture and chewiness scores in weeks 2 and 4 (Figure 5). Lining reduced chewiness of roots after two weeks.

***Discussion of on-station studies:Lake Zone***

In order to determine the best strategy for storage it is important to determine which characteristic is most important for root quality. Previous work has indicated that weight loss is very significant in determining the shelf life of roots (Rees 2003b). Van Oirschot *et al.* (2000b) estimated that a rough guidance to saleability of roots is that with up to 20% weight loss sweetpotato roots are still saleable. When the level of weight loss was 35% or greater they will become increasingly unmarketable. The weight losses recorded here, suggests that after 12 weeks, when weight losses are up to 12% roots can still be marketed. The estimated market value of the roots may decrease substantially during storage, and the value was less than 50% after 8 weeks storage. Thereafter the values were too low and missing data meant that the statistical analysis was not possible. Of the stores containing the most marketable roots, most contained undamaged roots and were from pit stores.

The results suggest that weight loss can be limited by not lining the stores. As weight loss is also affected by relative humidity it can be argued that reduced ventilation would lead to increased relative humidity, leading to reduced weight loss.

Ventilation seems especially important during the first two weeks of storage. This would appear to prevent too large an increase in temperature and build up of carbon dioxide, which would lead to anaerobic respiration. Later ventilation should be reduced, as it may reduce the relative humidity and increase water loss from the roots and lead to shriveling.

The temperatures measured and the RH should be high enough for wound healing to take place (van Oirschot *et al.* 2002). However, old wounds of damaged roots have a higher rate of water loss then the native periderm (van Oirschot *et al.* 2000a). Therefore it is recommended to keep damage as low as possible.

The dry matter content of roots is an important quality characteristics for sweet potato in East Africa, and has resulted in specific breeding programmes (Rees *et al.* 2003a). High dry matter after storage may however indicate desiccation. This may have been the case in the lined stores with dried grass that had an average DM of % in comparison with unlined stores. Lining may have contributed to lower RH, and therefore increased rate of water loss and reduced levels of wound healing, which resulted in higher levels of desiccation.

High respiration levels of carbon dioxide in the stores and high weight loss for the roots indicated deterioration during storage. This was most strongly associated with damaged roots as opposed to good quality ones. Although a high dry matter content is a plus, it may also indicate water loss of the roots and shriveling. Good roots sprouted often and this indicates that the roots in the store are healthy. However, an excess of sprouting may not be desirable, but more research would be required to determine this.

Sprouting was in general an indication of good quality roots. Figure 4 illustrates the significant ($P=0.001$, $R=-0.670$) inverse correlation between rotten roots and sprouting. This illustrates the practical visual importance of sprouting in the stores because this indicates healthy roots as opposed to rotten/shrivelled ones. The points in the figure are identified as either coming from a lined or unlined store and also shows that roots are healthier in unlined stores.

A related study monitored the effect of store type (pit or clamp), shade (shaded under a tree or located in direct sunlight) and pre-treatment with chemical fungicide on sweetpotato storage. Locating the stores in the shade under a tree improved market value. Store type was found to be not important (Tomlins and Ndunguru 2001). On farm studies revealed that farmers liked pits because of safety and clamps because they were easier to build.

Sweetpotato is consumed as a food source and so the sensory properties of the produce is very important. These studies have shown that good quality roots can still be obtained after storage.

Conclusions from on-station experiments in the Lake Zone

The design factor with most pronounced effect on sweetpotato storage was lining with dried grass. Roots obtained from lined stores had a lower estimated market values, higher levels of shriveling and weevil infestation. Lining also increased oxygen levels and reduced carbon dioxide levels.

After 12 weeks, weight losses of roots in all stores was high, and the acceptability decreased. Very good sensory properties were obtained up to four weeks of storage. Cultivar differences for storage success exist and both SPN/0 and Polista can be used. Storage should only be carried out using good quality roots.

Store type (pit or clamp) or ventilation did not have a consistent effect on shelf-life and suggests that any combination of these designs can be used. Some ventilation is necessary for gas exchange and to avoid build up of high levels of carbon dioxide, but high ventilation reduces the humidity. Roots in clamps more frequently showed rotting in the trials on station, but in subsequent on-farm trials they were as successful as pits.

Cultivar had a relatively small impact on storage with polista and SPN/O cultivars leading to slightly improved shelf life. These cultivars also had significantly lower oxygen and higher volatile sulphur compounds at the 8 weeks of storage. This indicates possible differences between the cultivars with respect to curing and wound healing.

## On-station studies in the Eastern Zone

Off season studies were conducted in the Eastern Zone, but this was largely the test research hypotheses. An example of this is the stud by Tomlins *et al.* 2001

This study monitored the effect of store design (pit or clamp), shade (shaded under a tree or located in direct sunlight) and pre-treatment with fungicide on store temperature and the gaseous (oxygen, carbon dioxide and volatile sulphur compounds) and the quantity of marketable roots. A pre-chemical treatment was also evaluated to determine if this would reduce rots.

Materials and methods

Sweet potato roots (SPN/0) were harvested at Gezaulole in December 2001.
A total of 20 stores were constructed at TFNC (Mikocheni) in Dar es Salaam and were monitored over a 6 week period. The treatments investigated were:

- Influence of shading (located in the shade under a tree or exposed to direct sunlight) from the sun
- Effect of store design (pit or clamp)
- Pre-treatment of the roots with a fungicide (Bayleton 25 WP). Roots were dipped in a solution (1.5g per litre) for 10 to 15 sec.

Results

During storage, the concentration of carbon dioxide and volatile sulphur compounds increased while the concentration of oxygen steadily decreased. The store design (pit or clamp) had the greatest impact on oxygen and carbon dioxide concentrations. The pit store had the highest carbon dioxide and lowest oxygen levels respectively. While carbon dioxide and oxygen levels were most influenced by store design, the store design had no significant effect on the yield of marketable or rotten roots. The concentration of carbon dioxide increased rapidly during the first week of storage before rapidly declining. It is suggested that this is related to increased respiration brought about by handling stress wound healing.

The volatile sulphur compounds (VSCs )detected were most influenced by the influence of shading and to a lesser extent by the store design. This pattern was similar to the quantities of marketable roots found with the stores exposed to the sun having more rotten roots and a higher corresponding levels of VSCs detected. During storage, the levels of VSCs fluctuated with decreases at one and a half weeks and at five weeks. This was similar to the pattern recorded for the temperature in the stores. This suggests that detection of VSC is also affected by store temperature.

The location of the stores under shade or in the sun had the greatest effect on the success of the stores with respect to marketable roots. The store design or chemical treatment had no effect on the yield of marketable roots. The VSC detector appears to be useful at indicating the presence of rots in a store but it affected by store temperature.

## Summary of on-farm-research activities in the Lake Zone

The major on-farm research activities were conducted in the Lake Zone of Tanzania in the main harvesting season – low season studies were not possible because of the low levels of the sweet potato harvest at this time of year. It just was not practical to store sweet potatoes.

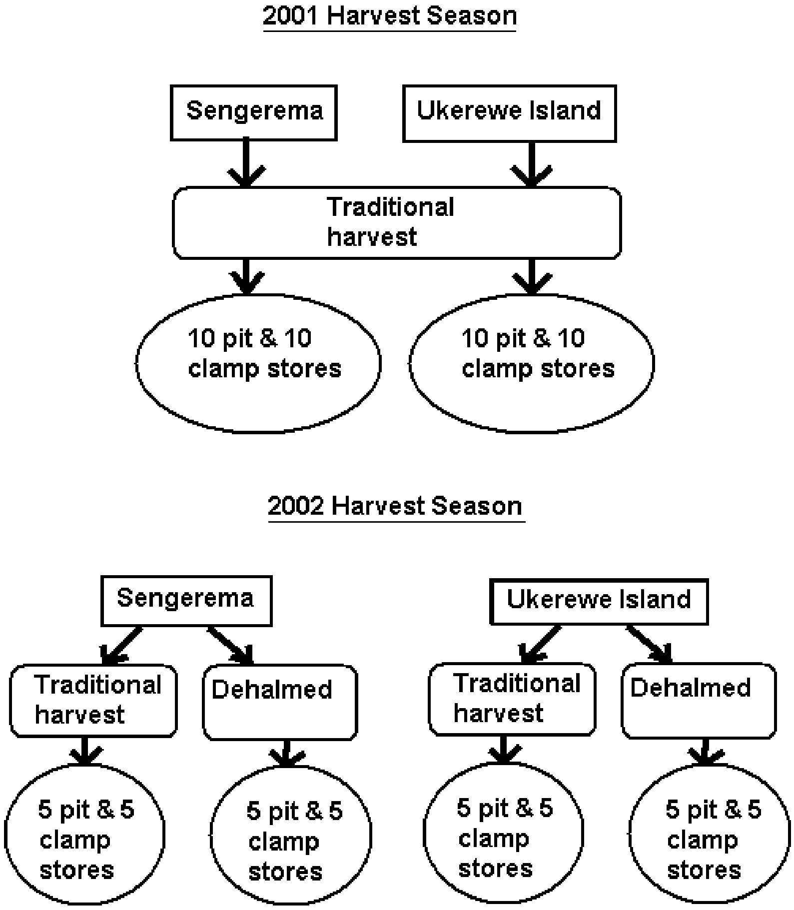
The season in Dar es Salaam – which was at a slightly different time to the season in the Lake Zone was used to develop and test research hypotheses. The most coherent story however comes from the Lake Zone.

This section of the report summarises investigations about how on-station research findings were transferred for use by rural farmers and how the techniques were adapted using local knowledge of the materials and environment. Farmers actively participated in the research by providing feedback of their views and their local knowledge. It also reports on many issues involved with storing sweetpotato that can only be evaluated by taking the technology away from the research station environment into the working situation.

Materials and Methods

The experimental approach over a two year period (2001 and 2002) is illustrated in Figure 6.

**Figure 6**: Experimental approach for storage trials during the years 2001 and 2002




*Farmer selection*
Farmers (20) from two districts (10 at Sengerema and 10 at Ukerewe) in the Lake Zone of Tanzania participated in the on-farm study over two harvest seasons (May to June in 2001 and 2002). At each farm, two stores (one pit and one clamp) were constructed.

*Sweetpotato roots and harvesting*
Commercially grown sweetpotato roots (Polista cultivar) were used in this study.

In the 2001 harvest season, all roots were harvested in the traditional manner. In the 2002 season, half the roots were harvested in the traditional manner whilst the remaining half were harvested after the root canopy had been dehalmed 14 days prior to harvest (Bonte and Wright 1993; Tomlins *et al*., 2002). This was to harden the roots by pre-curing them prior to harvest. After harvest, roots were carefully handled to avoid damage (Tomlins *et al*., 2000, Ndunguru *et al*., 2001) and protected from the sun to avoid scorching

*Storage of fresh sweetpotato roots in simple, low cost stores*
Two types of low cost store were evaluated. These were the pit and clamp store types (van Oirchot *et al*., 2003). Each store was filled with 90 kg freshly harvested

roots that had been sorted and graded to remove diseased and undersized (less than 150mm in length) roots.

In the 2001 season, all stored were filled with roots that had been harvested in the traditional manner. In the 2002 season, half the stores were filled with roots that had been harvested in the normal manner and the remaining filled with roots from plants that had been dehalmed.

Quality was assessed (Tomlins *et al*., 2000) using 40 randomly selected roots. Roots were scored for shrivelling, breaks and skinning injury using a 0 to 5 scale (0 = none; 5 = severe); the maximum possible score being 200. Cuts were scored as 0 = none, 1 = minor and 2 = major.

Roots were stored for 16 weeks. On emptying the stores, 40 roots were randomly sampled for root quality assessment. Then, the roots were sorted and graded into three categories, which were weighed:
1. Suitable for sale at the market. Roots are free of disease, rots and greater than 10cm in length;
2. Suitable for home consumption only. Roots have some disease and or rots or are less than 10cm in length. These roots had a short shelf life, but the sound parts of the root could be used for home cooking;
3. Suitable for animal fodder only or discarded: Roots had extensive disease damage or were rotten roots and so were assumed to have a minimal shelf life.

*Farmer perceptions about the storage technology*
To assess the suitability and effectiveness of the storage approaches, farmers were interviewed and asked a number of questions regarding the storage technology and how it complemented their livelihood strategies. This included whether the stores would make a contribution to overall income, problems in selling the stored roots, level of risk or losses the farmer is prepared to accept, effect on farmers livelihoods if all the roots stored went rotten, problems experienced when dehalming, which type of store was preferred, farmer assessment of the root quality in each store and estimate of the farm gate value of the roots recovered from the stores.

*Assessment of the cooked sweetpotato roots by farmers*
Four marketable roots from each store were selected at random and cooked by the farmers. The farmers scored (1 = very good, 2 = good, 3 = medium, 4 = bad and 5 = very bad) the roots on a five point scale for appearance, sweetness, flouriness and acceptability.

*Seasonal variation in sweetpotato market price*
To monitor seasonal variations in price and quality, sweetpotatoes were purchased at two weekly intervals from local markets in Mwanza, Tanzania from March to October 2002.

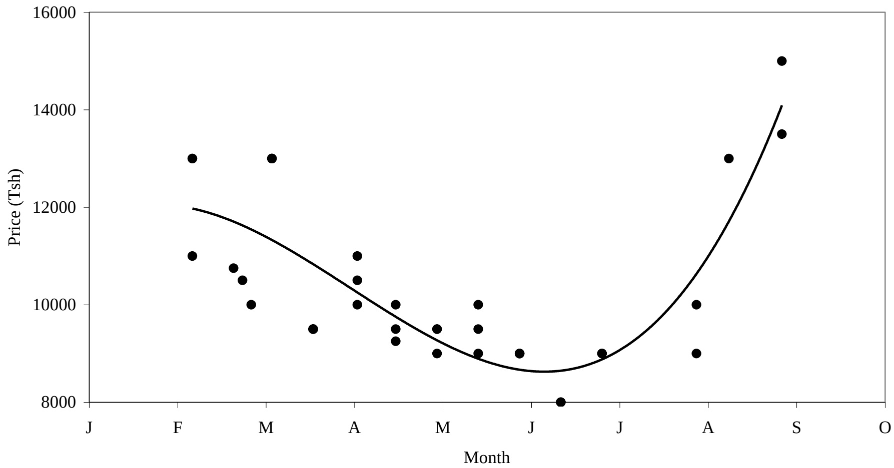
*Data analysis*
Data were analysed using Anova and Principal Component Analysis (PCA).

<u>Results and Discussion</u>

*Seasonal variation in market value*
Traders purchased fresh sweetpotato roots in sacks that weighed between 100 and 150kg. The variation in sack price as purchased by market traders is indicated in figure 7 and the number of sacks purchased in figure 3. Figure 2 shows that the market value of a sack of sweetpotatoes was lowest in the months of June and July

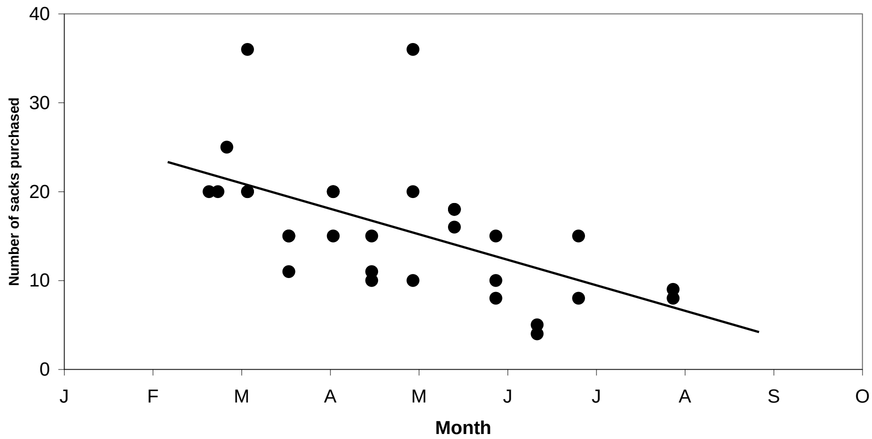
after which the price rapidly increases to double the value. Figure 3 shows that the increase in price after July is associated with the decline in availability of sweetpotatoes at the markets. These results compare favourably with those reported by Ndunguru (2000) and illustrates the potential benefit of the simple storage technology whereby roots purchased at low cost in the main season and can be sold for a high price in the low season.

**Figure 7:** Price per sack paid by market traders in the Lake Zone of Tanzania in 2002




*Where £1 = Tanzania shilling 1,316. The quadratic curve fitted to the data is to illustrate the trend in market price.*

**Figure 8:** Quantity of sacks of sweetpotatoes purchased by market traders each month during the 2002 season




Traders were interviewed regarding the prices they paid to farmers for sacks of sweetpotato in the 2002 season (Table 3). The prices paid follow similar trends for the market value.

**Table 3:** Traders farm-gate prices for the main and low season

| | Main season | | Low season | |
|---|---|---|---|---|
| **Trader** | **Period** | **Buying prices** | **Period** | **Buying prices** |
| **1** | Jan-Aug | 3500-5000 | Sept-Dec | 6000-10000 |
| **2** | Jan-Aug | 3500-5000 | Sept-Dec | 6000-10000 |
| **3** | Jan-Aug | 5000-7000 | Sept-Dec | 8000-9000 |
| **4** | March-Jun | 3500-5000 | Oct-Nov | 6000-10000 |
| **5** | May-Aug | 3000-5000 | Sept-April | 8000-11000 |
| **6** | May-Aug | 3000-5000 | Sept-April | 8000-11000 |
| **7** | Jan-Aug | 3,500 | Sept-Dec | 5,000 |
| **Mean** | | **4385** | | **8308** |

*Evaluation of on-farm storage trials*

Studies by Van Oirschot *et al*. (2003) to investigate factors that influence the storage of fresh roots at a research station in Tanzania has demonstrated that the most important factors influencing storability of roots were root quality, not lining the stores with grass and sweetpotato cultivar. The study was more comprehensive than earlier studies in that the temperature and humidity and gas (oxygen and carbon dioxide) were measured. Other factors, such as store design and ventilation, did not affect storability. A separate trial evaluated whether fungicides (thiobendizole) might improve the storability of sweetpotato. This trial found no effect and so roots in this study were not treated. This finding is similar to that reported elsewhere (Jenkins 1982).

The storage trails were carried out over two harvest seasons being the years 2001 and 2002. They involved only one sweetpotato cultivar (Polista) because this was the commercially grown one and included both pit and clamp store type. It should be noted that, although the store design had been shown in the on-station research to not be an important factor, it was incorporated into the on-farm research so that farmers could choose a store design that was more appropriate to their situation. The research was carried out in collaboration with the farmers who provided inputs of local knowledge and expertise. The first trial in 2001 enabled farmers to give their initial impressions and feedback. The second trial in 2002 enabled the feedback and suggestions to be included in the evaluation.

*Initial on-farm storage trial in 2001 harvest season*

Stores were constructed on the farmers land and monitored by both the farmers and the research team. After the stores had been emptied, the roots were evaluated for quality criteria such as breaks, cuts, shrivelling, skinning, rots, skin weevil, burrowing weevil and sprouting (Table 4). Analysis of the results (ANOVA) indicated that the store type did not influence root quality, but the district where the roots were grown did. Roots recovered from stores at Ukerewe were of better quality than those from Sengerema having fewer broken, shrivelled and rotten roots along with less sprouting and major weevil damage (*Cylas. spp*). The fact that the type of store did not influence stored root quality was expected because of previous on-station research (Van Oirschot *et al*., 2003). However, the design of the store might influence the farmers ability to adopt the approach.

The farmers mentioned that other factors not included in the initial design might affect storability. This included whether the store was shaded by a tree and if rainwater could flood the store. Neither shading or rain water damage significantly influenced the stored root quality.

Considering the farmer's own perception of root quality, there was a significant difference with respect to rainwater damage that the farmers had witnessed (ANOVA; P = 0.047). Roots from stores with perceived rainwater damage were given lower scored for quality (2.0) compared to those from stored that were not affected with rainwater (3.3). It is not clear why the farmers score for stored root quality differed from the scoring system used by the researchers.

**Table 4: External root quality of stored roots (unsorted)**

| Location | Breaks | Cuts | Shrivelling | Skinning | Rotting | Skin Weevil | Burrowing weevil | Sprouts |
|---|---|---|---|---|---|---|---|---|
| **District** | | | | | | | | |
| Ukerewe | 0.02 | 0.15 | 1.09 | 0.17 | 1.51 | 0.52 | 0.01 | 1.75 |
| Sengerema | 0.13 | 0.26 | 0.50 | 0.66 | 0.50 | 0.78 | 0.10 | 1.30 |
| *Probability* | *0.004** | *0.558* | *0.052** | *<0.001** | *0.029** | *0.075* | *0.040** | *0.027** |
| | | | | | | | | |
| **Store type** | | | | | | | | |
| Clamp | 0.06 | 0.33 | 0.61 | 0.46 | 0.73 | 0.76 | 0.07 | 1.44 |
| Pit | 0.07 | 0.09 | 0.92 | 0.43 | 1.24 | 0.51 | 0.04 | 1.56 |
| *Probability* | *0.739* | *0.219* | *0.238* | *0.739* | *0.266* | *0.065* | *0.527* | *0.637* |

*Effect of storage on sweetpotato grade (marketable, home use, animal feed)*

The roots were sorted and graded into three categories being those suitable for sale at local markets, for home use or for other uses (animal feed or discarded). The percent marketable and rotten roots, as a percentage of the initial fresh root weight, significantly differed between the districts, but not with the type of store (pit or clamp) as indicated in Table 5. Stores in Sengerema has a higher proportion of marketable and rotten roots but fewer roots for home consumption. The difference with respect to the district probably reflects a combination of differences in the initial quality of the fresh roots at harvest, positioning of the stores, soil type and climate.

The farmers mentioned that other factors not included in the initial design affect storability. This included whether the store was shaded by a tree and if rainwater could flood the store. Considering shading by trees, while many stores were completely shaded by trees, some were only partially shaded while others were not shaded at all. Table 6 shows that stores shaded under trees retained up to 26% more marketable roots than those that were not shaded. Likewise, stores that were not shaded contained 30% more rotten roots. There was no significant difference with respect to roots for home consumption. Rain water did not influence the stored root quality.

**Table 5: Comparison of stores after roots had been graded into different use categories.**

| | Percent roots recovered (relative to fresh weight) | | |
|---|---|---|---|
| **Location** | **Marketable roots** | **Home consumption** | **Rotten / animal feed** |
| **District** | | | |
| Ukerewe | 45.0 | 21.5 | 6.7 |
| Sengerema | 52.7 | 17.2 | 33.5 |
| *Probability* | *0.365* | *0.438* | *0.004** |
| | | | |
| **Store type** | | | |
| Clamp | 50.9 | 18.2 | 16.0 |
| Pit | 46.8 | 20.5 | 24.2 |
| *Probability* | *0.622* | *0.692* | *0.344* |

**Table 6: Comparison of stores with respect to shade.**

| | **Percent roots recovered (relative to fresh weight)** | | |
|---|---|---|---|
| **Location** | **Marketable roots** | **Home consumption** | **Rotten / animal feed** |
| Fully shaded | 57.9 | 16.9 | 12.7 |
| Part shaded | 38.1 | 22.6 | 14.6 |
| Unshaded | 31.6 | 13.1 | 42.2 |
| *Probability* | *0.015** | *0.260* | *0.034** |

*Sensory evaluation of stored roots in the 2001 season*

Farmers cooked and assessed the sensory *qualities* of the stored roots for appearance, sweetness, flouriness and acceptability. As well as assisting the study in evaluating the stored roots in rural locations, this also helped the farmers to evaluate the storage technology. The farmers found no difference in the sensory properties of the stored roots. The lack of significant differences in general reflects the variability of the testing from farmer to farmer and the fact that only good roots from each store were selected for testing.

***Second on-farm storage trial in the 2002 season to evaluate the improvements identified in the 2001 season***

As a result of the trial in 2001, the trial in 2002 was modified to include lessons learned from the farmers. For example, the recovery of marketable roots from the stores could be improved by locating the stores underneath trees and in places where rainwater could not flood the stores. While the influence of rainwater flooding was not statistically significant, it nonetheless appeared to reduce the recovery of marketable roots in one or two cases. Additionally, curing of the fresh roots prior to inserting into the stores was considered to be an advantage. However, discussions with the farmers suggested that post-harvest curing was not practical because of issues of theft and keeping the roots away from animals. Therefore, pre-harvest curing by dehalming the plant canopy 14 days before harvest was included as a new treatment.

*Effect of dehalming on root quality of fresh roots immediately after harvest*

Earlier studies (Bonte and Wright 1993; Tomlins *et al*., 2002) have demonstrated that dehalming reduced subsequent post-harvest damage to sweetpotato roots. This study found similar results where the roots from dehalmed plants had significantly reduced skinning injury (P=0.002) which declined from a mean score of 29 to 18. Hence, while post-harvest curing appears unsuccessful in tropical sweetpotato storage (Thompson 1970; Jenkins 1982; Ray *et al*., 1994; Hall and Devereau 2000), this study suggests that dehalming offers advantages.

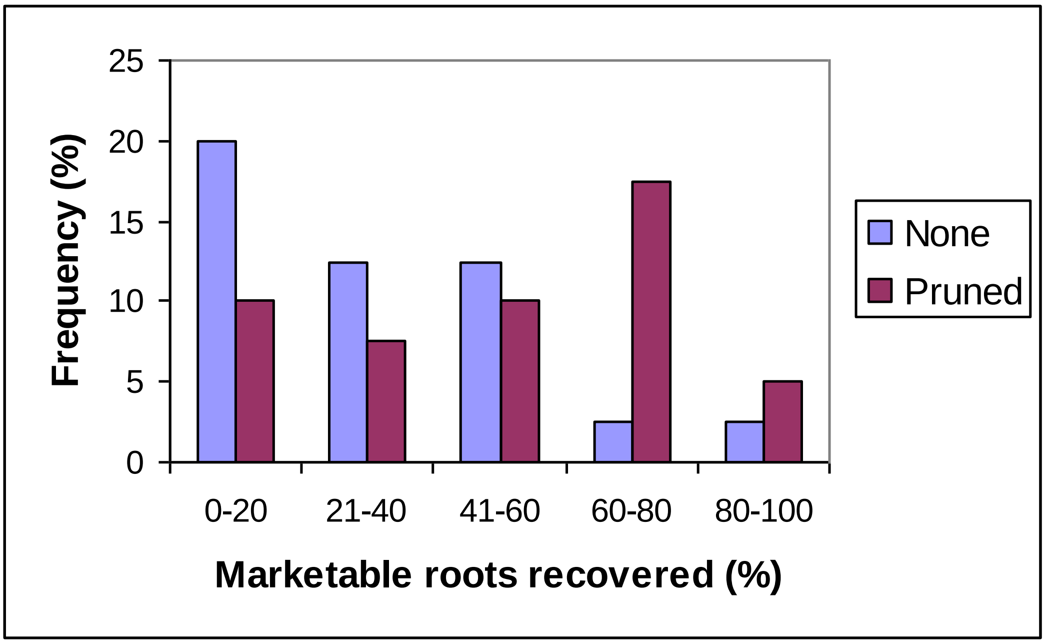
*Effect of dehalming, store type and district on root quality after storing for 16 weeks*

Store design and dehalming had no significant effect on cuts, breaks, shrivelling, skinning, rots, weevil and sprouting scores. However the effect of dehalming treatment on fewer rots was almost significant (P=0.084).

*Effect of dehalming on the recovery of marketable roots*

Dehalming significantly increased the recovery of marketable stored roots (P = 0.020) from a mean recovery of 29% to 41%. When plants were not dehalmed, most stored contained less and 60% of marketable roots (Figure 9). With dehalming, a high proportion of stores (18%) had between 60 and 80% of marketable roots.

**Figure 9: Marketable roots recovered by category and per cent of stores**




The treatments had no effect on the recovery of rotten roots (11%) and those used for home consumption (19%) or on the estimated farmer price or the farmers assessment of root quality or their estimate of the farm gate price.

*Sensory evaluation of roots harvested in 2002 season*
The store design or dehalming did not influence the sensory properties of the sweetpotato when cooked.

**Comparison of roots stored in 2001 and 2002**

*Comparison of fresh root quality in stores*
The quality of fresh roots significantly differed with respect to skinning injury with respect to year of storage (ANOVA; P<0.001) and district where stored (P = 0.003). Considering the year, the skinning injury was less in 2001 compared to 2002 with mean scores of 0.44 and 1.15 respectively. Considering the district, roots from Sengerema (0.86) had more skinning injury than those from Ukerewe (0.50).

*Comparison of marketable roots in stores*
The recovery of marketable roots (excluding dehalmed roots) was significantly (ANOVA; P=0.009) less in 2002 than in 2001 being 30% and 49% respectively while the proportion of rotten roots increased (P=027) from 14% to 20%. Changes in weight loss between the seasons was nearly significant (P=0.061) increasing from 22.5% in 2001 to 33.3% in 2002.

The reduction in the recovery of marketable roots and corresponding increasing in rotten roots and weight loss was surprising because the stores in the second year (2002) were all shaded under trees and situated such that rainwater would not affect the stores. The improvements had been anticipated to improve the recovery of marketable roots. However, the roots stored in 2002 had a higher occurrence of skinning injury and this suggests that the quality of the roots placed in the store is an important factor.

**Analysis of rural farmer perceptions of the storage approach (there looks to be too many sob-headings here)**

Part of the research was to investigate the perceptions of the rural farmers to the low cost storage technology. A total of 20 farmers were interviewed at Ukerewe and Sengerema. This was considered very important because while an approach may appear to offer optimum results and advantages, other factors may also influence the uptake of the technology.

*Comparison of districts where the farmers grew sweetpotato*

Farmers at Sengerema grew a wider portfolio of crops than their counterparts at Ukerewe. At Ukerewe, cash crops were predominantly rice and cassava and to a lesser extent banana, whereas in Sengerema it was rice followed by maize, sweetpotato, cotton and cassava. At Sengerema, access to the main market at Mwanza was by road, but access was hindered during the rainy season when roads sometimes became impassable. At Ukerewe Island, access to Mwanza was by water across Lake Victoria either my paying ferry or by canoe.

*Assessment of the quantity of roots that farmers would wish to store and potential impact on their incomes*

Most farmers said that if the technology was very successful that they would each be prepared to store up to 900kg of fresh roots and that it was anticipated that this would have a large impact on their incomes. When selling the roots, about half of the farmers felt that the roots that had been stored might be difficult to sell because customers will not be familiar with them.

*Problems on livelihoods due to delay in selling roots*

Of the 15 farmers who responded, 11 said the delay in income from selling the roots would not cause problems but four said the delay in income would influence family needs such as food, clothes and school fees.

*Risks to livelihoods and food security acceptable to the farmers*

It was explained to farmers that it was expected that some losses will be incurred when using the storage technology and that in a bad year some stores might yield no good roots. Of the 18 farmers who responded, 8 were prepared to accept a low risk, 5 a medium risk and 5 a high risk.

When asked what would happen if all the roots in the store went rotten, of the 16 who responded ten said minimal impact because they had other crops while six said they would have less food and less income.

*Which type of store (pit or clamp) was preferred?*

There was no difference in preference between the stores with 11 farmers preferring the pit and eight the clamp. Farmers said they liked the pit because the roots were protected from animals and thieves and the roof was easier to build requiring less material. The clamp was liked because it was easier to empty the stores.

*Dehalming the sweetpotato canopy*

Fourteen farmers responded to questions about the dehalming activity. Of these 11 did not encounter problems dehalming the crop while three did. The advantages of dehalming were that pruned leaves could be used to fertilise the field or as feed for livestock, the dehalmed crop was easier to harvest and the roots had less skinning injury, weevil and rotting. Disadvantages mentioned was increased labour costs.

*Would they use the storage technology again?*

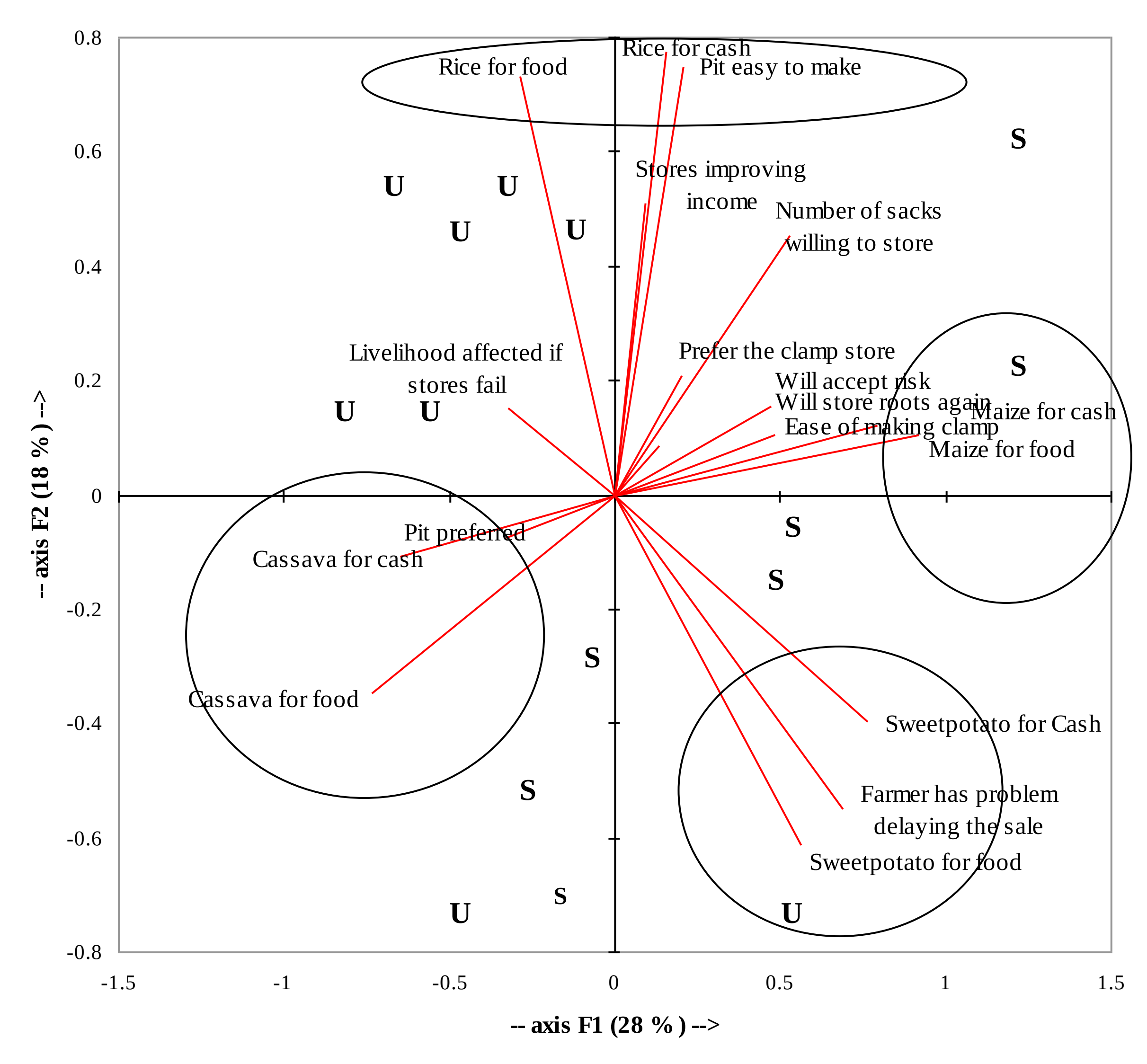
The majority (15 out of 18) said they would moderately to very willing to try the stores again.

*Summary of farmer perceptions of the storage approach*

The results of the farmer interviews were summarised by principal component analysis (PCA). This analysis, however, only included answers that could be translated into numerical responses. Also, some questions (for example number of sacks sold each month and whether dehalming was useful) could not be used because there were too few replies from the farmers. The PCA plot, accounting for 46% of the variability, is shown in Figure 9.

The PCA plot has circles and ellipses which are included to assist interpretation only. The circle in the bottom left-hand quadrant shows the relative position of farmers who predominantly used sweetpotato for cash and food. Also in the same direction are the concerns that these farmers have in delaying the sale of sweetpotato by storing them. In the bottom right-hand quadrant are farmers who grown cassava for both food and cash. At the top are farmers who grow rice for food and cash and at the right are farmers who grown maize for cash and food. Considering the attitudes towards storing sweetpotato, those growing rice are most associated with storing sweetpotato to improve income and those growing maize and rice are likely to store more roots and accept risk of the stores failing. The plot, however, is not completely consistent because the response 'livelihoods affected if stores fail' is not associated with 'farmer has a problem delaying the sale of the stored roots'. Considering the relationship of these responses to the farmers, those from Ukerewe (labelled U) are predominantly in the top-right hand quadrant confirming that they do not grow sweetpotato as a cash or food crop but instead grow rice and cassava. However, since sweetpotato is widely grown in Ukerewe, this implies that the selection of the farmers was not representative. The farmers from Sengerema (labelled with an S) tend to be in the right hand side of the plot and are associated with sweetpotato.

**Figure 10:** PCA summarising the relationship between the responses to questions at interview and location of the farm




*Where: U = farmer from Ukerewe and S = farmer from Sengerema*

*__Profitability of storage technologies__*

The research team attempted to gain an understanding of the profitability of the storage technology by interviewing the farmers to gain information about the farm gate prices of sacks of sweetpotato, cost of materials and transportation. However, the figures obtained were not consistent. An overview of the analyses is given in a separate section as this was a specific activity of project.

During subsequent visits, some farmers mentioned that they had increased the selling and transportation prices and reduced the buying prices because the research project had purchased roots from the farmers in order to carry out the experimental research. They were concerned that they were giving away commercially sensitive information regarding their livelihoods.

Therefore, an alternative approach was to hold farmer's group meetings to discuss the general approach. At these meetings, farmers said that the storage technology was useful for both income by selling stored roots at the local markets and for food security at home. An issue concerning selling the roots at the markets was that many of the roots weighed less than freshly harvested roots and that consumer's were not familiar with the stored roots. At this meeting, many of the farmers mentioned that they had already constructed their own sweetpotato stores in addition to the experimental stores.

Conclusion

Research in collaboration with farmers for storing fresh sweetpotato for up to 16 weeks (in the years 2001 and 2002) has indicated that the approach can work well in a variety of ways. The results confirm that both the pit and clamp store designs are equally good at storing roots enabling farmers to choose the most appropriate design for their situation. Stores worked well provided that good quality, undamaged fresh roots were selected for placing in the stores and that stores were located in the shade under a tree and such that rain water could not flood the store. Other factors improving the success of the stores included dehalming the roots up to 14 days before harvest.

The success of stores also varied between locations and between years. The variation in success between years appears to be related to the condition of the roots; in the second year (2002) roots available were generally in poorer condition and suggest seasonal variations.

The way that the stored roots were evaluated had an impact on the analysis of the results. Grading of roots into marketable, for home use or below grade appeared to offer a more sensitive way of measuring the outcome as opposed to scoring randomly selected roots for specific type of defect (breaks, cuts, shrivelling, rots and weevil damage). It is speculated that the grading is more sensitive because it includes more than one of the specific defects used in the scoring system.

On-farm sensory evaluation indicated that the stored roots were acceptable and that the store design and dehalming had no effect.

Interviews with farmers suggested that farmers were more willing to takes risks with the storage technology if they grew a wide portfolio of crops for cash and home consumption. Considering the approach to storing, most were keen to store their roots and some had already begun to do so during this research. While most farmers were only prepared to accept low risks (8 out of 18), some where prepared to take a high risk (5 out of 18). A concern, however, was that the stored roots were generally lighter in weight than fresh roots and this might hinder acceptance by consumers. Considering the type of store, farmers expressed no preference overall, the type of store preferred depending on their individual circumstances. Most farmers (11 out of 14) were keen to dehalm the plant canopy prior to harvest to harden the roots as they could see the advantages in root quality.

The research endeavoured to estimate how profitable the storage technology might be if the farmers sold the stored roots to traders or directly to consumers at local markets but rural farmers were concerned about revealing commercially sensitive information. However, farmers group meetings suggested the stores could be used both for income and food security.

**On-farm studies in the Eastern Zone.**

Initial studies in the Eastern Zone were not successful (Tomlins *et al.* 2001). The influence of store design (pit, clamp and cellar) and inspection of the stores during storage was evaluated at a commercial farm near Dar es Salaam, Tanzania during the low harvest season. The loss in market value as assessed by commercial traders of 30% and 46% after 2 and 4 weeks storage respectively was unacceptable. The sweetness and acceptability of the cooked roots also declined when assessed by a sensory panel. The quality of roots deteriorated with an increase in weight loss (13 to 32%), weevil infestation, sprouting, skinning injury and broken roots. The study, however, was carried out during the hottest months in Tanzania when the ambient temperature was around 33$^{o}$C.

The design of the store and whether the store was inspected or not, had an influence on the internal temperature, gas composition (carbon dioxide and oxygen) and volatile sulphur compounds which indicate rotting. The temperature of the pit and clamp stores increased steadily to reach a maximum of about 43$^{o}$C after 7 to 8 weeks of storage. The ventilated cellar stores showed either no increase or a very slight increase in temperature. Improving the ventilation of the pit and clamp stores would reduce the store temperature but would be at the expense of increased weight loss. Considering the carbon dioxide concentration, it increased in the pit and cellar stores that were inspected to reach a peak after 9 weeks. The increase in concentration in the stores that were not inspected did not start to increase until after 6 weeks after which the increase was sudden and rapid. This implies that the respiration of roots in the stores that were not inspected was less possibly because the roots were not damaged when disturbed if inspected. The high concentrations of carbon dioxide (20%) suggest that the ventilation of the pit and cellar stores needs to be increased. The oxygen profiles were the inverse of the carbon dioxide.

Although not successful in their own right, these studies fed into the on-station and on-farm studies conducted in the Lake Zone.

**Profitability of storage technologies and comparison with the 2001 harvest season**

Traders farmgate prices for sacks of sweetpotato are given for the main and low harvest seasons in Table X. In the main harvest season from January to August, the prices given by the seven traders varied between Tsh3000 and Tsh7,000 with a mean of Tsh4385. In the low season, sack prices varied between Tsh6,000 and Tsh11,000 with a mean of Tsh8,308. This represents approximately a doubling of the sack value which is within the range identified by an earlier CPHP project (R6508) where a three-fold difference was recorded and a baseline study in 1999/00 (Ndunguru *et al*. 2000) suggested a smaller 10% increase. However, it appears that there is variability from one year to another.

**Table 3: Traders farmgate prices for the main and low season**

| | **Main season** | | **Low season** | |
|---|---|---|---|---|
| **Trader** | **Period** | **Buying prices** | **Period** | **Buying prices** |
| **1** | Jan-Aug | 3500-5000 | Sept-Dec | 6000-10000 |
| **2** | Jan-Aug | 3500-5000 | Sept-Dec | 6000-10000 |
| **3** | Jan-Aug | 5000-7000 | Sept-Dec | 8000-9000 |
| **4** | March-Jun | 3500-5000 | Oct-Nov | 6000-10000 |
| **5** | May-Aug | 3000-5000 | Sept-April | 8000-11000 |
| **6** | May-Aug | 3000-5000 | Sept-April | 8000-11000 |
| **7** | Jan-Aug | 3,500 | Sept-Dec | 5,000 |
| **Mean** | | **4385** | | **8308** |

Considering the 2002 season where there were 20 stores with pruned roots and 20 with unpruned roots, the mean recovery of marketable roots was 31% and 48% respectively. In the 2001 season the mean marketable root recovery was higher at 46%. Table 4 shows the percent profit for each season for different ratios between the low season when prices are anticipated to be high and the main season when the stores are set. The worst case is a ratio of 1 where prices have not risen. In all cases, the farmer would make a loss assuming the mean recovery of marketable roots above. If the price rises three fold (as observed in the earlier project), the farmer would see an increase in the value of their roots by 37% (unpruned roots) in 2001, a loss of 9% (unpruned roots) in 2002 and an increase of 43% for pruned roots in 2002.

**Table 4: Increase in value (%) of recovered roots for different ratios between the low season when prices are high and the main season when prices are low.**

| | | **Ratio of low season price to main season price** | | | | | |
|---|---|---|---|---|---|---|---|
| | **Year** | **1.0** | **2.0** | **2.5** | **3.0** | **3.5** | **4.0** |
| **not pruned** | **2001** | -54 | -9 | 14 | 37 | 60 | 83 |
| **not pruned** | **2002** | -70 | -39 | -24 | -9 | 6 | 21 |
| **pruned** | **2002** | -52 | -4 | 19 | 43 | 67 | 91 |

This suggests that pruning the roots before setting the store would increase the likelihood for the farmer to make a profit and in a bad year, all stores would lose money. However, this is the worst case scenario because farmers are more likely to reduce risks by consuming the roots earlier if prices are unlikely to rise.

## Dissemination of research results

Dissemination of the outputs of the project have been on two levels.

At the practical level the uptake of the storage technologies is being handled by a CPHP Coalition Project. The technical outputs from the research were summaried in a brochure which is attached to this report. This summaries in simple language the main outcomes from the technical research. Copies of this leaflet has been made and it has been made available through the project partners.

**Building a Clamp Store**

a) Create a small mound of soil 10 cm high and 1 m wide.

b) Pile 50 to 100 kg roots starting from the centre and working your way out towards the edge.

c) Cover roots with 10 to 20 cm soil.

d) Build a roof using branches and dried grass or leaves to protect from rain and animals.

e) Add a drainage channel around the store to divert rainwater.

SHADE

*Clamp store*

*Farmer building a clamp store*

Farmers said the **pit** store offered more security from animals, can be reused, but was harder to make. The **clamp** store was easier to build but required more material to make the roof.

**Can I line the store with dried grass?**

No, lining the stores with dried grass **reduced** the length of time you can store the roots.

**How long will the roots last in the store?**

Roots can last for up to 4 months. We recommend **inspecting** the root every two weeks. If the roots start to rot, empty the store.

**How do stored roots compare with roots freshly harvested in the low season?**

Roots harvested in the low season are expensive and of poor quality. Stored roots should be of better quality. They may, however, be lighter and taste a little sweeter.

This technology was developed by:

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**Lake Zone Agricultural Research and Development Institute (LZARDI)**, PO Box 1433, Mwanza, Tanzania. Email: ukiriguru@africaonline.co.tz Tel: +255 68 550214/5; Fax: +255 68 500676.

**Tanzania Food and Nutrition Centre (TFNC)**, PO Box 977, Dar es Salaam, Tanzania. Email: ndunguru@africaonline.co.tz, Tel: +255 22 2118137/9; Fax: +255 22 2116713, Internet: www.tanzania.go.tz

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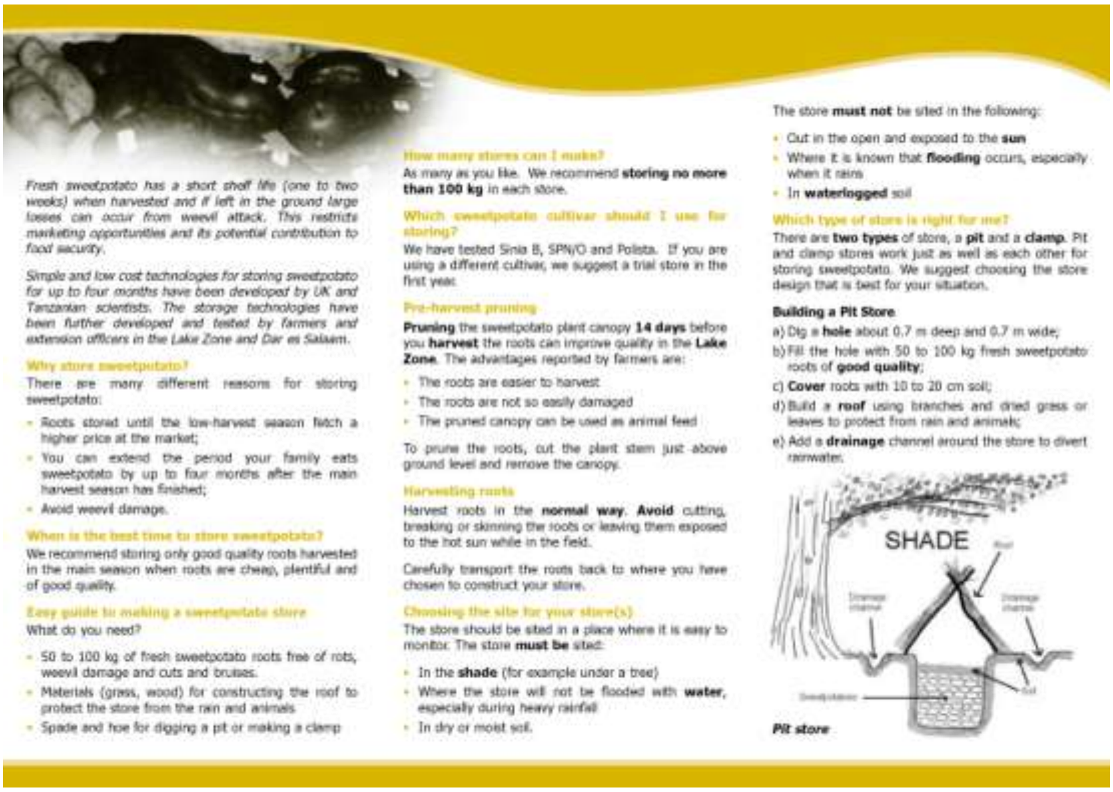
# Storing sweetpotato made *simple*

**Do-it-yourself simple and low-cost technologies for storing fresh sweetpotato for up to four months after harvest**



*Fresh sweetpotato has a short shelf life (one to two weeks) when harvested and if left in the ground large losses can occur from weevil attack. This restricts marketing opportunities and its potential contribution to food security.*

*Simple and low cost technologies for storing sweetpotato for up to four months have been developed by UK and Tanzanian scientists. The storage technologies have been further developed and tested by farmers and extension officers in the Lake Zone and Dar es Salaam.*

**Why store sweetpotato?**

There are many different reasons for storing sweetpotato:

- Roots stored until the low-harvest season fetch a higher price at the market;
- You can extend the period your family eats sweetpotato by up to four months after the main harvest season has finished;
- Avoid weevil damage.

**When is the best time to store sweetpotato?**

We recommend storing only good quality roots harvested in the main season when roots are cheap, plentiful and of good quality.

**Easy guide to making a sweetpotato store**

What do you need?

- 50 to 100 kg of fresh sweetpotato roots free of rots, weevil damage and cuts and bruises.
- Materials (grass, wood) for constructing the roof to protect the store from the rain and animals
- Spade and hoe for digging a pit or making a clamp

**How many stores can I make?**

As many as you like. We recommend **storing no more than 100 kg** in each store.

**Which sweetpotato cultivar should I use for storing?**

We have tested Sinia B, SPN/O and Polista. If you are using a different cultivar, we suggest a trial store in the first year.

**Pre-harvest pruning**

**Pruning** the sweetpotato plant canopy **14 days** before you **harvest** the roots can improve quality in the **Lake Zone**. The advantages reported by farmers are:

- The roots are easier to harvest
- The roots are not so easily damaged
- The pruned canopy can be used as animal feed

To prune the roots, cut the plant stem just above ground level and remove the canopy.

**Harvesting roots**

Harvest roots in the **normal way**. **Avoid** cutting, breaking or skinning the roots or leaving them exposed to the hot sun while in the field.

Carefully transport the roots back to where you have chosen to construct your store.

**Choosing the site for your store(s)**

The store should be sited in a place where it is easy to monitor. The store **must be** sited:

- In the **shade** (for example under a tree)
- Where the store will not be flooded with **water**, especially during heavy rainfall
- In dry or moist soil.

The store **must not** be sited in the following:

- Out in the open and exposed to the **sun**
- Where it is known that **flooding** occurs, especially when it rains
- In **waterlogged** soil

**Which type of store is right for me?**

There are **two types** of store, a **pit** and a **clamp**. Pit and clamp stores work just as well as each other for storing sweetpotato. We suggest choosing the store design that is best for your situation.

**Building a Pit Store**

a) Dig a **hole** about 0.7 m deep and 0.7 m wide;

b) Fill the hole with 50 to 100 kg fresh sweetpotato roots of **good quality**;

c) **Cover** roots with 10 to 20 cm soil;

d) Build a **roof** using branches and dried grass or leaves to protect from rain and animals;

e) Add a **drainage** channel around the store to divert rainwater.

SHADE

*Pit store*

Anon. (2003) Storing sweetpotato made simple. Dissemination Leaflet. Natural Resources Institute, Tanzania Food and Nutrition Centre and Lake Zone Agricultural Research and Development Institute. 2pp.

Project outputs have also been disseminated at a scientific level.

The on-station studies have been presented at the triennial symposium of the International Society for Tropical Root Crops as follows:

van Oirshot, Q.E.A , Ngendello, T., Amour, R., Rwiza, E., Rees, D., Tomlins, K.I., Jeffries, D., Burnett, D. and Westby, A. (2002) Preliminary observations on the potential for long-term storage of fresh sweetpotatoes under tropical conditions. p.341-344. In: *Proceedings of theTwelfth Symposium of The International Society for Tropical Root Crops: Potential of Root Crops for Food and Industrial Resources,* Ed. M. Nakatani and K. Komaki. ISTRC

van Oirschot, ., Ngendello, T., Rwiza, E., Amour, R., Tomlins, K., Rees, D. and Westby, A. (2003) The potential for storage of fresh sweetpotato under tropical conditions: evaluation of physiological changes and quality aspects. Presented at the Thirteen Sympsoium of the International Society for Tropical Root Crops, November 2003, Arusha, Tanzania. 18 pages in manuscript.

The on-farm studies will be submitted to the Journal of the Science of Food and Agriculture and a manuscript was available for submission in late 2004. The details of this are as follows:

Tomlins, K. I., Ndunguru, G.T,., Kimenya, F., Ngendello, T., Rwiza, E, Amour, R., Van Oirschot, Q. and Westby, A. (2005) Evaluation of appropriate methods for storing fresh sweetpotato roots. To be submitted to the Journal of the Science of Food and Agriculture. 19 pages in manuscript.

Elements of the work appeared in the book:

Rees, D., van Oirschot, Q. and Kapinga, R. (eds) (2003) Sweet potato post-harvest assessment: experiences from East Africa. Chatham: Natural Resources Institute. ISBN 0 8594 548 2.

The following have also been published:

van Oirschot, Q. (2002) [With credit given to other project partners] Reaching the full potential of sweet potatoes in East Africa. www.new-agri.co.uk/02-6/focuson/focuson5.html

Tomlins, K.I., Ndunguru, G.T., Rwiza, E. and Westby, A. (2002) Influence of pre-harvest pruning and mechanical injury on the quality and shelf life of sweet potato (*Ipomoea batata* (L.) Lam) in East Africa. *Journal of Horticultural Science and Biotechnology* **77**, 399-403.

At a more strategic level the outputs of the project have been included in the following invited/keynote conference papers that have helped to shape international investments in root and tuber

Westby, A. (2004) Linking farmers to markets with HarvestPlus focus commodities in Africa. Keynote invited paper presented at the Harvest Plus Challenge Programme Meeting on “Reaching End Users”, May 2004, IPGRI, Rome.

Westby, A., Van Oirschot, Q., Tomlins, K., Ndunguru, G., Ngendello, T., Kapinga, R., Sanni, L. and Oyewole, O. (2003) Root and tuber crop post-harvest systems: lessons learned and future Interventions to contribute to food security and poverty alleviation. Invited thematic paper presented at the 13th triennial Symposium of the International Society for Tropical Root Crops, 8-15 November 2003, Arusha, Tanzania. http://www.istrcsymp-tz.org/ISTRC%20Presentation4.pdf

Westby, A. Van Oirschot, Q., Tomlins, K. Ndunguru, G., Ngendello, T., Sanni, L., Pessey, D. and Oyewole O. (2004) Bridging the gap between post-harvest technology development and commercialization of root and tuber crops in Africa. Invited thematic paper at the ISTRC-Africa Branch Triennial Symposium, 31 October – 5 November 2004, Mombasa, Kenya.

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## Section F Project effectiveness

This section of the evaluation report uses the rating criteria for the purpose and your outputs previously used in your annual reports.

| | Rating |
|---|---|
| Project Goal | X |
| Project Purpose | 3 |
| Project Outputs 1. Systems developed that will increase the incomes of poor farmers and other participants in marketing of fresh sweet potato | 1 |
| 2. Systems for improved storage or handling validated, and benefits quantified, on a case study basis. | 1 |
| …………………3 Appropriate dissemination literature prepared and disseminated to identified target institutions and uptake pathways. | 1 |

1= completely achieved
2= largely achieved
3= partially achieved
4= achieved only to a very limited extent
X= too early to judge the extent of achievement (avoid using this rating for purpose and outputs)

**Outputs**

*What were the research outputs achieved by the project as defined by the value of their respective OVIs? Were all the anticipated outputs achieved and if not what were the reasons? Your assessment of outputs should be presented as tables or graphs rather than lengthy writing, and provided in as quantitative a form as far as is possible.*

| **Output** | **OVIs** | **Achievement of OVI** | **Reasons why not achieved if not fully achieved.** |
|---|---|---|---|
| 1.Systems developed that will increase the incomes of poor farmers and other participants in marketing of fresh sweet potato | 1.1Characterision of system and collection of base line data completed by March 2000 | Achieved. Report Ndunguru et al. (2000) prepared | Completed |
| | 1.2 Technology identified by end of August 2001 as a consequence of on-station trials. | Technological options identified through on station studies | Completed |
| | 1.3 Modifications make to technology as a consequence of on-farm by December 2002. | Modifications made to techniques and validated on station | Completed |
| | 1.4 Preliminary assessment of the impact on the livelihoods of producers and consumers undertaken by March 2003 | Undertaken and reported in on-farm studies. | Completed |
| 2. Systems for improved storage or handling validated, and benefits quantified, on a case study basis. | 2.1 Systems technically validated by December 2003. | Completed in the Lake Zone of Tanzania | Completed |
| | 2.2 Benefits quantified by December 2003. | Variables in assessing potential profitability of storage assessed. | Completed |
| 3.Appropriate dissemination literature prepared and disseminated to identified target institutions and uptake pathways. | 3.1 Initial planning workshop held by October 1999 | Workshop took place | Completed |
| | 3.2 Dissemination materials prepared by 31 January 2003 | Materials prepared as detailed in activities section of this report. | Completed. |

All of the project outputs were achieved, although a number of the dissemination outputs came after the end of the project.

Although not reflected in the OVIs, it was initially planned to undertake both high season and low season storage. In the event, only low season storage was possible.

For projects aimed at developing a device, material or process, and considering the status of the assumptions that link the outputs to the purpose, please specify:

a. What further market studies need to be done?

None specifically are essential.

b. How the outputs have been made available to intended users?

See report on activities in section above.

c. What further stages will be needed to develop, test and establish manufacture of a product by the relevant partners?

(i) The next stage is to further develop and promote the research outputs and include them within a production and marketing system.

(ii) International plans to promote orange fleshed sweet potato offers a new focus and emphasis for this work and this needs to be followed up.

d. How and by whom, will the further stages be carried out and paid for?

(i) above is dealt with by a CPHP project that is detailed in Annex II

(ii) above will be dealt with by VITAA and the HarvestPlus Challenge Programme. VITAA submitted a concept note the CPHP in September 2004, but this was rejected. HarvestPlus has developed a plan which is summarised in Annex II.

e. Have they developed plans to undertake this work? If yes, what are they? If not, why?

These are all detailed in Annex 2 and will not be repeated here.

**Purpose**

Based on the values of your purpose level OVIs, to what extent was the purpose achieved? In other words, to what degree have partners/other users adopted the research outputs or have the results of the research been validated as potentially effective at farmer/processor/trader level?

The purpose of the project was that "Poor people benefit from new knowledge applied to food commodity systems in forest-agriculture interface areas

The project outputs have been achieved. Systems developed on station and modified on farm that will potentially increase the incomes of poor farmers and other participants in marketing of fresh sweet potato. On farm studies have been undertaken to validate the innovations and benefits have been quantified on a case study basis. A number of dissemination outputs have been produced – including a workshop for key stakeholders in April 2002 and a dissemination leaflet. Further scientific publications will be submitted from the work, but these have not yet been completed.

The outputs of the work were taken up by a "partnerships for innovation project" – see Annex II and also used in the formulation of the work programme for the HarvestPlus Challenge Programme.

At the time of the preparation of this proposal the CPHP was in the process of revising its purpose and goal level OVIs. The following were believed to be the current ones at the time:

1.1 By 2005, improve storage techniques or systems for fresh or processed products validated, capable of extending shelf life.
1.2 By 2003, better handling systems validated which increase value of poor people's crops.
1.3 By 2002, more efficient and cost-effective methods of small-scale processing validated.
1.4 By 2003, constraints reduced within existing marketing systems used by the poor.
1.5 By 2002, new market opportunities validated, capable of increasing value of commodities produced by the poor.

This project makes a significant contribution to OVIs 1.1 and 1.2 because it has involved the developed and validation on a case study basis of improved storage techniques for sweet potato that allow off season marketing. There is also a contribution to OVI 1.2 because of the use of pre-harvest pruning – which could be classed as a handling technique – as a means of improving the storability of roots.

**Goal**
What is the expected contribution of outputs to Project Goal?

The goal of the project was that

"Poor people benefit from new knowledge applied to food commodity systems in forest-agriculture interface areas"

The project has developed and validated techniques for the handling and storage of in selected locations in the Lake Zone of Tanzania technologies. The performance of storage has been improved through the project activities and there is not a much clearer understanding of the factors that effect storage.

Within the forest agriculture interface sweet potato are an important part of the cropping systems in several East African Countries, but principally in Uganda, Tanzania, Kenya, Burundi, Rwanda and Mozambique. Sweet potato has recently received increased attention in the region, specifically as a consequence of the VITAA and HarvestPlus Challenge Programme that are promoting orange fleshed sweet potato as a means of combating vitamin A deficiency. The outputs of this project have the potential to make a significant contribution to these initiatives.

Wider dissemination and promotion of the project outputs should ensure that poor people can benefit from this new knowledge in the storage of sweet potato in forest agriculture interface systems.

## Section G – Uptake and Impact

***Organisational Uptake*** (max 100 words)

*What do you know about the uptake of research outputs by other intermediary institutions or projects (local, national, regional or international)? What uptake by which institutions/projects where? Give details and information sources (Who?What?Howmany?Where?)*

Two significant means of uptake have occurred. A "Partnerships for Innovation Project" supported by the CPHP has taken up the outputs of this project in Tanzania and I believe that some of the outputs were used in the "partnerships for innovation" project in Uganda. There is also reasonable scientist level knowledge about this research in East Africa, but it is not clear the extent to which the outputs have been used beyond these two initiatives. It is not something that was specifically monitored. Take up by these two projects means dissemination in two zones of Tanzania and also in Uganda.

Secondly, the outputs have been promoted within the HarvestPlus Challenge Programme. The project leader presented the findings of the project at a HarvestPlus Challenge Programme Meeting in Rome in May 2004 and these outputs have been incorporated in the "Reaching End Users" work plan. Field work on this should start in 2005 with NRI as a core international partners. The Programme of work on sweet potato will be lead by CIP. Similarly the value of the outputs are recognised by the VITAA Coalition – but lack of funding is restricting direct take up through VITAA at present.

***End user uptake*** (max 100 words)

*What do you know about the uptake of research outputs by end-users? Which end-users, how many and where? Give details and information sources*

Our on-farm project work indicated that a number of the partner farmers with whom the project work took up some of the technologies. This could not have numbered more than 20. If end users are defined as research and technology transfer organisations then both LZARDI Ukiriguru and TFNC have taken up the project outputs and disseminating them in a follow-on project in "coalition" mode.

***Knowledge*** (max 100 words)

*What do you know about the impact of the project on the stock of knowledge? What is the new knowledge? How significant is it? What is the evidence for this judgement?*

The new knowledge generated by this project relates to technologies for the storage of sweet potato. Attempts are being made to publish to findings of the research. On-station studies have so far been presented at two posters at the ISTRC triennial symposia in Japan and Tanzania. The meeting in Tanzania was a very effective means of reaching East African Scientists. The on-farm studies have been written up and will be submitted to the Journal of the Science of Food and Agriculture provided such adaptive on-farm work is acceptable to such a journal. It is still too early to judge the scientific uptake of this new knowledge.

***Institutional*** (max 100 words)

*What do you know about the impact on institutional capacity? What impact on which institutions and where? What change did it make to the organisations (more on intermediate organisations). Give details and information sources.*

As a technology generation project, our institutional basis was limited. From NRI's perspective one of our staff members was able to register for a PhD degree using part of the outputs from this project, the previous project and the follow-on project. From LZARDI and TFNC's perspective the project further built up technical and management skills in carrying outfit field work and developing staff resources.

***Policy*** (max 100 words)
*What do you know about any impact on policy, law or regulations? What impact and where? Give details and information sources*

Not aware of any specific impact on policy of this technical research.

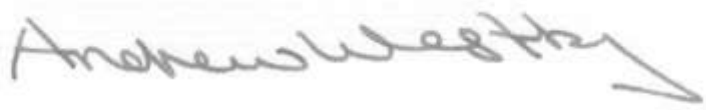
***Poverty and livelihoods*** (max 100 words)
*What do you know about any impact on poverty or poor people and livelihoods? What impact on how many people where? Give details and information sources.*

It was not expected that this research would have direct impact on poverty and livelihoods. The intention was to develop and validate a storage technology. We know that some of the farmers with whom the project worked have taken up the storage technology – exact numbers are not available.

***Environment*** (max 100 words)
*What do you know about any impact on the environment? What impact and where? Give details and information sources.*

Bearing in mind the nature of the outputs of this project. It would not be expected that there would be any major environmental impacts.

Signature



Andrew Westby

## ANNEXES

**I Copies of the stakeholder, gender, livelihoods and environmental form included with the concept note.**

This was not prepared for this specific project.

## II Project Logical Framework: The logical framework from the project memorandum was as reproduced below.

:

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumptions |
|---|---|---|---|
| **Goal** | | | |
| Poor people benefit from new knowledge applied to food commodity systems in forest-agriculture interface areas | To be completed by Programme Manager | To be completed by Programme Manager | To be completed by Programme Manager |
| **Purpose** | | | |
| Strategies developed and promoted which improve food security of poor households through increased availability and improved quality of root crop and horticultural foods and better access to markets. | To be completed by Programme Manager | To be completed by Programme Manager | To be completed by Programme Manager |
| **Outputs** | | | |
| 1. Systems developed that will increase the incomes of poor farmers and other participants in marketing of fresh sweet potato | 1.1Characterision of system and collection of base line data completed by March 2000<br>1.2 Technology identified by end of August 2001 as a consequence of on-station trials.<br>1.3 Modifications make to technology as a consequence of on-farm by December 2002.<br>1.4 Preliminary assessment of the impact on the livelihoods of producers and consumers undertaken by March 2003. | Project technical reports and publications | Economic benefits and other benefits are sufficient for adoption.<br>New constraints not generated that can internalised with project<br>Normal environmental and market conditions exist whilst project is being implemented. |
| 2. Systems for improved storage or handling validated, and benefits quantified, on a case study basis. | 2.1 Systems technically validated by December 2003.<br>2.2 Benefits quantified by December 2003. | Project technical reports and publications | Successful delivery of output 1<br>Normal environmental and market conditions exist whilst project is being implemented. |
| 3. Appropriate dissemination literature prepared and disseminated to identified target institutions and uptake pathways. | 3.1 Initial planning workshop held by October 1999<br>3.2 Dissemination materials prepared by 31 January 2003. | Project technical reports and publications | Successful delivery of outputs 1 and 2 |

| Activities | Inputs | Means of Verification | Important Assumptions |
|---|---|---|---|
| 1.1 Characterise system and collect base-line information<br>1.2 Preliminary economic assessment of cost-benefit to farmers, traders and consumers assessed.<br>1.3 Undertake assessment of technology on-station<br>1.4 Undertake on-farm assessments of the technology<br>1.5 Develop and validate improved handling procedures.<br>1.6 Preliminary assessment of the impact on the livelihoods of producers and consumers | £212,838 (without VAT) | Project quarterly reports. | |
| 2.1 Validate storage and handling procedures on farm.<br>2.2 Collect quantifiable data on benefits of new storage approach and implications for the production and marketing system. | | | |
| 3.1 Confirm uptake pathways with stakeholders in the system<br>3.2 Prepare appropriate dissemination materials | | | |

## III Partner (user) organisations workplan for adopting project outputs

The coalition of partners that developed and implemented this proposal because a recognised coalition under the "innovations partnerships" initiative launched by the Crop Post-Harvest Programme. As part of this new approach, the coalition developed a new proposal that was supported The work plan of which is taken forward below.

In addition, the partners in the proposal have been key players in developing the VITAA initiative and specifically the sweet potato component of the HarvestPlus Challenge Programme.

**CPHP Project WorkPlan**

| | |
|---|---|
| ***Project Title*** | Enhancing the livelihoods of the rural and urban poor through improved market access for sweet potato. |
| ***Managing Partner(s)*** *(registered offices):* | Dr Gabriel T Ndunguru<br>Tanzania Food and Nutrition Centre,<br>P.O. Box 977, Dar es Salaam, Tanzania |
| **Outputs of new project** | 1. Characterization of market systems for sweet potato in Dar es Salaam, Morogoro and Mwanza updated and current demand confirmed |
| | 2. Institutional arrangement/ partnership that effectively and sustainably improve access to post-harvest knowledge and market innovations developed |
| | 3. Promotional and dissemination strategies for uptake of technologies through the partnership developed and implemented effectively |
| **Activities of new project** | 1.1 Preliminary planning workshop to discuss strategies for implementing the project and formalize institutional arrangements in carrying out the project |
| | 1.2 Assemble information from previous CPHP projects and elsewhere. |
| | 1.3 Update characterization of market systems of sweet potatoes in Dar es Salaam, Morogoro and Mwanza and confirm current demand. |
| | 2.1 Assess current knowledge, attitude and practices on sweet potato handling, storage and marketing by stakeholders (KAP study). |
| | 2.2 Facilitate formation of farmers and traders groups and groups to participate in validation studies. |

| | |
|---|---|
| | 2.3 Establish an effective and sustainable coalition partnership. |
| | 2.4 Workshop to discuss and prioritise interventions based on the market studies, KAP studies and validation exercises. |
| | 2.5 Conduct case study of the project to document success factors produced in the project |
| | 2.6 Synthesise information on the lessons learned from the coalition based approach in a workshop and disseminate findings |
| | 3.1 Select suitable technologies for storage, handling and marketing of sweet potatoes, adapt and validate them |
| | 3.2 Make economic assessment of cost-benefit to farmers, traders and consumers of technologies in specific locations. |
| | 3.3. Compare and evaluate the consumer preference of OFSP with those currently available in the markets |
| | 3.4 Produce plan for promotional strategy |
| | 3.5 Prepare dissemination materials based on the plan |
| | 3.6 Disseminate technologies, monitor uptake and feedback to dissemination approach. |
| | 3.7 Prepare dissemination materials to more widely promote project outputs – e.g. for VITAA, through SARRNET, Africare etc. |

# Confidential

Work programme of the HarvestPlus Challenge Programme activities on sweetpotato (Not for publication, replication or citation)

Extract

"

**3. Product Market studies, processing and development:**

The major objective is to promote the consumption and income generating potential of OFSP through development of appropriate post-harvest and marketing strategies in the targeted countries. Since countries are at different stages country specific programmes will be developed and implemented. Baseline studies to determine the target population for post-harvest interventions and to define the specific interventions will be undertaken. Handling technologies to ensure year round availability and incomes from high quality produce will be developed and verified at farm level. Other activities will include: the development of flour and chip processing systems to the meet identified market demands; to develop and promote sweet potato recipes to support the use of OFSP; to undertake promotional activities for the specific technologies and also for the concept of OFSP consumption; to undertake specific research activities to provide underpinning knowledge on the effect of post harvest operation on nutritional content.

Both TOT and follow up practical trainings will be organized for identified rural processors and women groups. Motorized sweetpotato chippers will be purchased for the rural processors. Additional funds will be used to produce localized manuals on different products. Critical research areas under this component include studies on:

Storage techniques for sweet potato; background research topics on nutritional implications of post-harvest operations; bio-availability of carotene (in collaboration with the HP nutritional group); sensory studies on different varieties for different types of consumers; development of approaches to quality control that may be then adapted to specific countries; Iron/zinc levels in fresh and processed products. These will be tendered out to institutions such as Natural Resources Institute( NRI) capable of handling these component The whole component is estimated to cost **US $955,000**

## IV Copies of diaries, coalition meeting reports etc

Specific diaries and coalition meeting reports were not maintained since this project started prior to the coalition project approach.

## V Feedback on the process from Partners(s) and users (where appropriate)

Feedback was collected from farmers as a part of carrying out the project and this is documented.

## VI Tabulated description of disseminated outputs (format from green book)

***The following outputs were reported in the PCSS.***

Anon. (2003) Storing sweetpotato made simple. Dissemination Leaflet. Natural Resources Institute, Tanzania Food and Nutrition Centre and Lake Zone Agricultural Research and Development Institute. 2pp.

Jeremiah, S.C. (2002) Overview of root and tubers research activities in Tanzania. In: Proceedings of Post-Harvest Workshop LZARDI-Ukiriguru, Mwanza 29 April 2002 Edited by Q.E.A. van Oirschot, H. Ngazi and T. Ngendello. LZARDI Ukiriguru, Mwanza.

Kapinga, R.E., Rees, D., Westby, A., Ndunguru, G.T., Rwiza, E., Tomlins, K.I., Stathers, T, Jeremiah, S. and Mbilinyi, L. (2002) Increasing the contribution of sweetpotato to sustainable rural livelihoods in Tanzania. P. 285-291. In: *Proceedings of theTwelfth Symposium of The International Society for Tropical Root Crops: Potential of Root Crops for Food and Industrial Resources,Tsukuba, Japan 10-16 September 2000* Ed. M. Nakatani and K. Komaki. ISTRC.

Kulembeka H P (2003-In Press). Introducing orange-fleshed sweet potato varieties in the Lake zone of Tanzania. In: Cassava and Sweetpotato after Harvesting. Editors: Ngazi, H., Joram F., Placid J., Ngendello, T. and Van Oirschot, Q. Proceedings of a Workshop held at the Lake Zone Agricultural Research and Development Institute, Ukiriguru, Mwanza Tanzania, 29 April 2002.

Ndunguru G.T. (2003-In Press) Handling of sweetpotato during marketing. In: Cassava and Sweetpotato after Harvesting. Editors: Ngazi, H., Joram F., Placid J., Ngendello, T. and Van Oirschot, Q. Proceedings of a Workshop held at the Lake Zone Agricultural Research and Development Institute, Ukiriguru, Mwanza Tanzania, 29 April 2002.

Ngazi, H., Joram, F., Placid, J., Ngendello, T. and Van Oirschot, Q. (2003 – in Press). Cassava and Sweetpotato after Harvesting. Proceedings of a Workshop held at the Lake Zone Agricultural Research and Development Institute, Ukiriguru, Mwanza Tanzania, 29 April 2002, 105 pages.

Ngendello T. (2003-In Press) Potential for long term storage of fresh sweet potato. In: Cassava and Sweetpotato after Harvesting. Editors: Ngazi, H., Joram F., Placid J., Ngendello, T. and Van Oirschot, Q. Proceedings of a Workshop held at the Lake Zone Agricultural Research and Development Institute, Ukiriguru, Mwanza Tanzania, 29 April 2002.

Rwiza E. (2003-In Press) Sweetpotato damage and implications for shelf-life In: Cassava and Sweetpotato after Harvesting. Editors: Ngazi, H., Joram F., Placid J., Ngendello, T. and Van Oirschot, Q. Proceedings of a Workshop held at the Lake Zone Agricultural Research and Development Institute, Ukiriguru, Mwanza Tanzania, 29 April 2002.

Tomlins, K., Ndunguru, G.T., Rwiza, E. and Westby, A. (2002) Improved handling of sweetpotato in Tanzania, East Africa P. 149. In: *Proceedings of theTwelfth Symposium of The International Society for Tropical Root Crops: Potential of Root Crops for Food and Industrial Resources,* Ed. M. Nakatani and K. Komaki. ISTRC.

Tomlins, K.I., Ndunguru, G.T., Rwiza, E. and Westby, A. (2002) Influence of pre-harvest pruning and mechanical injury on the quality and shelf life of sweet potato (*Ipomoea batata* (L.) Lam) in East Africa. *Journal of Horticultural Science and Biotechnology* **77**, 399-403.

van Oirschot, Q. (2002) [With credit given to other project partners] Reaching the full potential of sweet potatoes in East Africa. www.new-agri.co.uk/02-6/focuson/focuson5.html

van Oirshot, Q.E.A , Ngendello, T., Amour, R., Rwiza, E., Rees, D., Tomlins, K.I., Jeffries, D., Burnett, D. and Westby, A. (2002) Preliminary observations on the potential for long-term storage of fresh sweetpotatoes under tropical conditions. p.341-344. In: *Proceedings of theTwelfth Symposium of The International Society for Tropical Root Crops: Potential of Root Crops for Food and Industrial Resources,* Ed. M. Nakatani and K. Komaki. ISTRC

The following outputs from the work have also been produced since the PCSS:

Rees, D., van Oirschot, Q. and Kapinga, R. (eds) (2003) *Sweet potato post-harvest assessment: experiences from East Africa.* Chatham: Natural Resources Institute. ISBN 0 8594 548 2.

Tomlins, K. I., Ndunguru, G.T,., Kimenya, F., Ngendello, T., Rwiza, E, Amour, R., Van Oirschot, Q. and Westby, A. (2005) Evaluation of appropriate methods for storing fresh sweetpotato roots. To be submitted to the Journal of the Science of Food and Agriculture. 19 pages in manuscript.

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Westby, A., Van Oirschot, Q., Tomlins, K., Ndunguru, G., Ngendello, T., Kapinga, R., Sanni, L. and Oyewole, O. (2003) Root and tuber crop post-harvest systems: lessons learned and future Interventions to contribute to food security and poverty alleviation. Invited thematic paper presented at the 13th triennial Symposium of the International Society for Tropical Root Crops, 8-15 November 2003, Arusha, Tanzania. http://www.istrcsymp-tz.org/ISTRC%20Presentation4.pdf

Westby, A. Van Oirschot, Q., Tomlins, K. Ndunguru, G., Ngendello, T., Sanni, L., Pessey, D.,and Oyewole, O. (2004) Bridging the gap between post-harvest technology development and commercialization of root and tuber crops in Africa. Invited thematic paper at the ISTRC-Africa Branch Triennial Symposium, 31 October – 5 November 2004, Mombasa, Kenya.

## 5. Internal Reports:

Ndunguru, G., Mlingi, N., Mashamba, F., Oirschot, Q., Tomlins, K. and Westby, A. (2001) Baseline survey on the long term storage of sweet potato in Tanzania, Technical Report, Tanzania Food and Nutrition Centre, Tanzania 21pp.

Ndunguru, G., Tomlins, K., Ngendello, T., and Rwiza E. (2001) On-Farm Trials For Long Term Storage Of Sweet Potato In Lake Zone, Tanzania 7th June – 22nd June 2001. Project Report 16 Pages.

Tomlins, K. I., Ngendello, T., Rwiza, E, Van Oirschot, Q. and Westby, A.. (2002) On-farm sweetpotato storage trials in the Lake Zone of Tanzania: 2002 harvest season. Project Technical Report. pp. 11.

Tomlins, K. I., Ngendello, T., Rwiza, E, Van Oirschot, Q. and Westby, A. (2002) Survey of sweetpotato market prices and volumes traded in Mwanza during the 2002 season. Project Report 11pp.

Tomlins, K. T., Van Oirschot, Q., Ngendello, T., Rwiza, E., Amour, R., Ndunguru, G. T., Burnett D. and Westby, A. (2002) Long term storage of sweet potato in Tanzania (main season 2001) – on farm study, Technical Report, Chatham, Natural Resources Institute. 14 pp.

Tomlins, K.I, Ndunguru, G. T, Kimenya, F. L and Westby, A. (2002) Preliminary report on on-farm experimental trials on long-term sweet potato storage (Gezaulole, Kigamboni) in the 2002/2003 season. Technical Report, Tanzania Food and Nutrition Centre, Tanzania. 7pp.

Tomlins, K.I, Van Oirschot, Q., Ndunguru, G. T., Ngendello, T., Rwiza, E. and Westby, A. Report on on-farm experimental trials on long-term sweet potato storage in the Eastern Zone of Tanzania (Gezaulole, Kigamboni). Project Report 12 pages.

Van Oirschot Q.E.A., Tomlins, K.I., Ngendello, T., Amour, R., Rwiza, E., Rees, D., Jeffries, D. Burnett, D. and Westby, A. (2002). On Station Sweetpotato Storage Trials 2000; Testing: Cultivar, Lining, Store type, Ventilation and Damage, 70 pp. Chatham: Natural Resources Institute/LZARDI Ukiriguru.

***Other Dissemination of Results:***
A workshop was held 29 April 2002 in Mwanza, Tanzania for key stakeholders in sweet potato storage and marketing.

Westby, A. (2001) DFID/NRI post-harvest activities and links to SARRNET.
Presentation to the SARRNET Steering Committee Meeting, 15 May 2001. (Presentation included overview of this project).

Informal presentations of the outcomes from the project were made to coalition partners in the follow-on project – see item 8 below. Technical information was also made available to assist in the preparation of this project.

***Listing and reference to key data sets generated:***

The main datasets are the raw data from the on-farm and on-station studies of sweet potato storage. It is the project participants intention to make available in the public domain all of the data generated – either through making available project reports or through NRI's or the CPHP's web-site after due time has been given for the partners to publish their work either through international meetings or through peer reviewed journal articles.