Low-cost storage of fresh sweet potatoes in Uganda: lessons from participatory and on-station approaches to technology choice and adaptive testing

Andy J. Hall and Andrew D. Devereau

The authors are with the Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK. Correspondence should be addressed to Dr Andy Hall, c/o SEPP, ICRISAT, Patancheru, 502 324, Andhra Pradesh, India. Tel: +91 40 3296161. Fax: +91 40 3241239. E-mail a.hall@cgiar.org.

Studies were undertaken to identify and test low-cost storage technology for fresh sweet potatoes and subsequently to apply this technology in the northern region of Uganda. In this region the emergence of cassava mosaic disease has made the technology relevant to the rural food system due to the need to extend the availability of sweet potatoes. The studies used a combination of on-station and on-farm trials to test the technical feasibility and social compatibility of low-cost storage technologies. The performance of the storage methods and the process by which technical options were chosen, developed and tested are discussed. It was found that, although the on-station trials provided broad guidelines for technology development, specific requirements needed to be devised in conjunction with farmers. The use of parallel on-station and on-farm trials, although partially contradictory, saved much time and hastened the technology-validation process.

Andy Hall is a science policy specialist. He joined NRI in June 1995 and has been based for the last three years in the Socio-economics and Policy Programme at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) in India. He previously worked as an Associated Professional Officer with the Overseas Development Administration (ODA), now the Department for International Development (DFID) of the UK Government, based at the National Post-Harvest Programme, Kawanda Agricultural Research Institute, Uganda. His interests include rural development, participatory research, post-harvest research strategy development and agricultural science and technology policy analysis in the context of public/private sector relationships. Andrew Devereau is a storage engineer. He joined NRI in 1988. He is a lecturer on aspects of physical factors within grain storage. His work has included the investigation of heating and deterioration during large-scale cereal storage, the provision of training and support to grain quality inspection laboratories, the development of low-cost storage and disinfestation techniques for sweet potatoes and cowpeas respectively, and the development of techniques for monitoring insect pest development. His current research interests centre on improving techniques for developing cowpea, maize and sorghum varieties that are resistant to post-harvest insect pests.

Sweet potato (*Ipomoea batatas* L.) is a major food staple in Uganda. Estimates suggest that 170,000 ha of the crop are cultivated annually, producing around 1.4 million tonnes. The crop acts as either a staple or co-staple, in conjunction with *matooke* (an east African highland cooking banana) or cassava, in many of the country's regions, depending on the prevailing agroclimatic conditions. In production terms it is the third most important staple after cassava at 5.0 million tonnes per annum, and *matooke* at 4.0 million tonnes per annum.[1] It is produced and consumed predominantly on-farm. Specialist commercial production takes place in those regions with market access, mainly serving the low-income markets of the capital, Kampala. The crop thus acts as a major food security measure for both the rural and the urban poor.

In much of the country, storage and processing or preservation of sweet potatoes is not practised. In these regions, which are characterized by more reliable and well distributed rainfall, farm households can maintain a supply of fresh roots for much of the year by a process of almost continuous cultivation and piecemeal harvesting.[2] However in the drier northern districts of Uganda, a traditional method of sweet potato processing and storage is practised in which sweet potato is chipped or crushed and dried.[3]

Study background

Sweet potato is inherently perishable with a very limited shelf-life.[4] The lack of post-harvest technology to address this issue is seen as a major constraint to both food security and the wider contribution of this crop to livelihoods through market channels.[5] Because of this, speculative technology identification and on-station testing were undertaken before diagnostic survey work had started in the present trials. We use the term speculative because, at this point, fresh storage of sweet potatoes had not been identified as an actual constraint within rural food systems.

The range of options for low-cost storage was identified through a literature survey.[6] This review indicated that storage technologies had been developed and practised by farmers in many countries of the tropics. A summary of the different methods practised, and of the period of storage in other tropical countries, is presented in Table 1. Although attempts by researchers to replicate some of these storage methods had produced mixed results, the experiences in both Malawi[7] and Papua New Guinea[8] were more promising, with storage being routinely practised in climatic conditions similar to those in Uganda.

There were three main types of storage structure described: covered underground pits; covered overground mounds or clamps; and wooden boxes designed for use inside a building. Many were subject to variation, eg the level of ventilation, or the pre-storage treatment of the roots with wood ash. It was also clear that the sweet potato variety could have an influence on storage. On-station trials were therefore devised to examine these factors and hence to test the technical feasibility of the storage technologies identified.

At the same time, surveys were being conducted within rural communities in Uganda using participatory needs assessment techniques. These were designed to identify and analyse post-harvest constraints associated with sweet potato and thus assist with the targeting of the technology.

Initial development

On-station trials

Initial on-station trials were conducted between March and May 1994 at Kawanda Agricultural Research Station, close to Kampala. Sweet potatoes of a variety known locally as *New Kawoogo* were used. Three

Table 1. Methods of low-cost sweet potato storage used in the tropics.

Country	Storage method	Temp and relative humidity	Loss (%)	Storage period	Major cause of loss, or comments	Reference
Barbados	Clamp	–	30	3.5 months	12% rot, 18% evaporation	1
	Pit	–	20	4 months	Evaporation	2
Trinidad	Clamp	–	15	2 months	Loss dependent on variety	3
	Sacks	–	17–47	1–3 months	Loss dependent on variety	4
	Clamp	–	26.4	2 months		5
	Cardboard carton on soil	–	29.2	2 months		6
	Rack covered in grass	–	34.9	2 months		7
Rhodesia (now Zimbabwe)	Drum/wood ash	–	c. 0	4 months	1 or 2 in 50 lbs	8
Papua NG	Clamp	14.2–28.6°C	15.2–25.3%	40–50 days	Physiological	9
Bangladesh	House floor, bench, roof hung	24–35°C, 70–90%	20–25	2–4 months	Physiological, sprouting	10
	In-house basket/cured	27–34°C, 75–85%	19.3	1 month	Physiological, sprouting	11
Malawi	Wood ash/lime in pit	–	Usually high	2 months	Rot	12
	Wood ash in drum in-house	–	–	5 months	'Without loss'	13
	Pit	–	–	3–4 months		14
	Pit	–	16.8%	6½ months	Rotting, 5 kg per pit	15
India	Clamp	–	50–70%	2		16
Caribbean	Bag on a concrete floor in a shed	–	–	6–8 weeks	Best methods tested	17
	Clamp/pit	–	–	6–8 weeks	Best methods tested	18

Source: F.J. Proctor, J.P. Goodliffe and D.G. Coursey, 'Post-harvest losses of vegetables and their control in the tropics', in C.R.W. Spedding, ed, *Vegetable Productivity*, MacMillan Publishing Ltd, London, 1981.
1. G.P. Keleny, 'Sweet potato storage', *Papua and New Guinea Agricultural Journal*, Vol 17, No 3, 1965, pp 102–108; **2.** J.C. Bouwkamp, *Sweet Potato Products: A Natural Resource for the Tropics*, CRC Press, 1985; **3.** Anon, 'The storage of foodstuffs in the colonial empire', *East African Agricultural Journal*, Vol 5, 1940, pp 446–459; **4.** G.B. Kennard, 'Sweet potato variety experiments at the Imperial College of Tropical Agriculture, 1927–43', *Tropical Agriculture*, Vol 21, No 4, 1944, pp 69–77; **5.** *Ibid*; **6.** Kennard, *op cit*, Ref 4; **7.** Kennard, *op cit*, Ref 4; **8.** W.B. Blyth, 'Storing sweet potatoes', *East African Agricultural Journal*, October 1943, p 101; **9.** Keleny, *op cit*, Ref 1; **10.** P.D. Jenkins, 'Losses in sweet potatoes (*Ipomoea batatas*) stored under traditional conditions in Bangladesh', *Tropical Science*, Vol 24, No 1, 1982, pp 17–28; **11.** *Ibid*; **12.** Anon, 'The storage of sweet potatoes', *Nyasaland Agricultural Quarterly Journal*, Vol 8, No 2, 1949, pp 37–40; **13.** *Ibid*; **14.** J.A. Woolfe, *Sweet Potato: An Untapped Food Resource*, Cambridge University Press, 1992; **15.** *Ibid*; **16.** Woolfe, *op cit*, Ref 14; **17.** H.J. Gooding and J.S. Campbell, 'The improvement of sweet-potato storage by cultural and chemical means', *Empire Journal of Experimental Agriculture*, Vol 32, No 125, 1964, pp 65–75; **18.** *Ibid*.

storage methods — pits, clamps and indoor box stores — were tested. For the pits and clamps, the effects of ventilation and ash treatment were also investigated, while for the indoor boxes the effect of ventilation alone was investigated. Three replications of each treatment were used, each holding approximately 100 kg. The literature indicated that an initial period of curing aids the storage of sweet potatoes. This is achieved in commercial stores in the USA by subjecting them to a temperature of 27–29.5°C and relative humidity (rh) of 85–90% for 4–7 days before storing at 13–16°C and 85–90% rh.[9] No specific curing period was undertaken in these trials because the ambient temperature was between 17.6 and 27.6°C throughout storage.[10]

After eight weeks, the roots were assessed for weight loss and consumer acceptability. The results showed that pit and clamp stores without wood ash treatment or ventilation were the most successful, with weight losses of approximately 4% (wet basis) over the eight-week period.[11]

Technology targeting

A series of diagnostic needs assessment surveys[12] was undertaken in eight sweet potato-growing districts in Uganda. In the majority of these districts it was found that the sweet potato was important to the integrity of the rural food system, but that storage of fresh roots would be irrelevant as other fresh crops were available when fresh sweet potatoes were not. However, the findings of the surveys in northern Uganda suggested that low-cost storage technology could be valuable as a food security measure.

In northern Uganda the farming system is characterized by predominantly subsistence production of food crops. The key post-harvest constraints are access to food and the restricted scope for income generation due to poor market access and limited opportunities for adding value. The critical points in the food availability calendar, as described by farmers in the Soroti district of northern Uganda, are presented in Table 2. It was found that, originally, sweet potato acted as a co-staple with cassava, and to a lesser extent with sorghum and millet. Sweet potatoes were sliced or crushed, then dried and stored from the start of the four-month long dry season in late November or early December, until locally grown cassava was available approximately three months later. The dried roots were important as a source of food during this period when it was too dry for the majority of local farmers to grow sweet potatoes or other crops.

In recent years this system has been jeopardized due to the virtual disappearance of cassava in many of the northern districts of the country as a result of the spread of cassava mosaic disease (CMD). As a consequence, farmers have adapted their practice by extending dried sweet potato storage to six months, to provide food from the beginning of the dry season until fresh sweet potatoes are widely available again in June. However, farmers indicated that insect infestation of the dried roots reached unacceptable levels during this extended storage period, and also that they had a preference for fresh rather than dried roots. Furthermore it was observed that the price of fresh sweet potato increased dramatically with the onset of the dry season, from Ush 4,500 (US$4.5) per bag (100–120 kg) at the beginning, to Ush 15,000 (US$15) three months later,[13] the latter roots being from farms in wet areas still able to produce sweet potatoes during the dry season. Storage of fresh sweet potatoes therefore offered the possibility of taking advantage of these price rises.

The option of testing the storage of fresh sweet potatoes was suggested to farmers. They indicated that they thought this would be useful and agreed to participate, pledging some of their resources to the effort.

The identification of a clearly articulated need for storage technology in Soroti district was important as it provided a geographic focus for the trials. This formed the context in which the technology would need to perform, defining the physical parameters in conjunction with the preferences and agendas of target beneficiaries. It needed to be low-cost and aimed at those farmers who were predominantly subsistence producers but who were also, to a limited extent, relying on cash sales of the crop, particularly distress sales.

Further development

Rationale

The next step was to test the technology in the prevailing climate of the target area and in the farming and food systems in which farmers were operating. The approach adopted was to undertake parallel on-station trials and on-farm adaptive testing. This was done because the period when storage was needed was very season-specific (November/December to April/May), and trials and testing could therefore only take place once per year. In addition, while on-station trials were needed to investigate the storage of locally grown varieties and the effect of the local climate, it was felt that the technology was sufficiently robust to begin adaptive testing with farmers without waiting one more year. The on-farm work tested the technical success of fresh storage and addressed social and economic

Table 2. Food consumption patterns[a] in Soroti district.

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fresh sweet potato						7	7	29	28	18	7	3
Dry sweet potato (sliced)	7	13	27	45	8						2	5
Dry sweet potato (crushed)	17	16	8	4	1	1	2	4	7	9	13	18
Cassava consumption before CMD[b]												
Millet						26	53	21				
Food abundance								41	38	9	6	6
Food scarcity				17	15	68						

Source: PRA exercise with farmers in Achaboi village, Soroti district, 1994.
[a]Figures represent the percentage of annual consumption of each product in each month.
[b]Shading indicates the months in which cassava used to be consumed before the onset of cassava mosaic disease (CMD).

questions associated with the use of the technology. It also sought to use the input of farmers to modify the technology, where necessary, to meet the contingencies of local conditions, resources and skills.

The on-station trials were conducted at Serere Agricultural and Animal Research Institute, 25 miles from Soroti town. The on-farm testing was undertaken close to Soroti town with farmers who had originally been involved in the diagnostic needs assessment study. The work began in November 1994 during the period of sweet potato abundance immediately prior to the onset of the dry season.

On-station trials

The specific objectives of the on-station trials were:

(1) to evaluate the effectiveness of pit and clamp sweet potato storage technology in the prevailing climatic conditions;
(2) to compare storage performance between four local varieties of sweet potato in pit and clamp stores, and determine whether storage for three to four months was attainable.

The four local sweet potato varieties tested were *Osukut* (or *Tanzania*), *Ateseke*, *Odopelap* and *Ongada*. These were the most abundant varieties identified during the needs assessment survey of Soroti district. Approximately 100 kg of each variety was stored in both pit and clamp designs. Treatments were replicated three times. The trial started on 13 November 1994 and finished on 8 March 1995, a period of 16 weeks and 3 days.[14] The results showed the following:

(1) weight losses (wet basis) ranged from 17.5% for *Ateseke* to 31.9% for *Osukut*;
(2) weight losses were lower for pit stores than for clamp stores in all varieties;
(3) sprouting of the stored roots was more prevalent in clamp stores;
(4) rotting was lower for the variety, *Ateseke*.

The trial concluded that pit stores with *Ateseke* was the most effective combination.[15]

On-farm adaptive testing

An initial assumption was that the scale of the technology was most appropriate for individual household use.

The specific objectives of the on-farm trials were:

(1) to collaborate with the farmers to adapt the storage technology to suit their resources and needs;
(2) to evaluate the performance of the stores in the climatic and physical conditions of beneficiaries' farms;
(3) to monitor the experiences of farmers in order to judge the acceptability of the technology;
(4) to undertake a cost–benefit analysis of the technology to determine its impact on both food security and farm income;
(5) to test the assumption that the storage technology would allow farmers to take advantage of the dramatic dry season price rises.

One implicit objective of the on-farm work was to assess critically the process by which technology is adaptively tested and transferred to farmers.

The protocol adopted for the on-farm work was to convene a meeting of farmers and to ask them to choose individuals to test the technology at four different sites. This they did, selecting farmers who were well known and well liked. Although they were not the poorest, they were representative of the majority of farmers in terms of household circumstances.

After selection, one of the farmers became a 'node' for a group of farmers who wished to store their potatoes together. Groups also formed around the other farmers to assist with the construction of the stores. In this way a large number of people — up to 50 adults — were involved either directly or indirectly with the work.

A minimum amount of guidance was given to the farmers. They were told that the pits and clamps needed to be as follows:

(1) sheltered from the sun and the rain;
(2) protected from flooding in the event of heavy rain;
(3) lined with dry grass and sealed with soil;
(4) loaded with roots that had been graded to remove those that were small, damaged or insect-infested.

This was explained to them in such a way that emphasis was placed on the storage conditions that were needed, rather than simply providing a 'recipe' that had to be followed. Discussions were then held to highlight some important issues about which the farmers needed to make decisions, which included the following:

(1) which sweet potato varieties to store;
(2) how much to store (therefore the store size);
(3) how to make the stores;
(4) who was to construct the stores;
(5) which materials to use in construction;
(6) where to place the stores;
(7) how long to store for;
(8) what to use the sweet potatoes for after storage.

This allowed the farmers to adapt the stores to their own particular circumstances: the emphasis was on creating a situation in which farmers felt that the stores were their own responsibility and that they could make modifications as they wished. This was an attempt to move away from the common model in which farmers were reluctant to touch experiments undertaken by scientists in their villages.

In order to reduce the financial risk, the sweet potatoes were bought and then returned to the farmers for storage. It was emphasized to farmers that the potatoes were theirs and that they could do anything with them at any time they wished. In this way it was hoped that it was in the farmers' interests to become actively involved in the trials.

Adaptation of storage design. At the four storage sites (with four selected farmers, plus associates) farmers chose both pit and clamp stores, as they felt that they would like to test which was best. They chose the varieties *Osukut* and *Ateseke*, indicating that in addition to these being abundant and popular varieties, they both 'rotted' easily, *Osukut* in the ground, and *Ateseke* after it had been harvested. The logic

Box 1. Cost of store construction

Mr Max Epuro has a 3 acre farm and grows mainly sweet potatoes and sorghum. He is well liked by his fellow farmers and was chosen to test out the technology.

Max and his friends constructed a pit store that could take three bags of sweet potatoes and a clamp store that could take 2.5 bags. The round pit that he and his friends dug was 1.4 m deep by 0.9 m in diameter with a conical thatched roof. A similar roof was constructed to cover the clamp.

Max indicated that it took him and six friends one day to dig the pit. The grass he used for lining the pit, covering the clamp and for thatching the roofs was collected in half a day from public places. The roof was constructed by eight of his friends in around six hours. He used poles for the roof from an *agongo* tree, which is on his property. The flexible sticks for the roof came from the *akeroi* shrub and the fibres for tying came from the *abira* tree. Both of these species are swamp plants that Max collects from his own land.

Max indicated that had he needed to pay for the roofing materials, which would have cost Ush 6,000, in addition to the labour for construction, which would have been Ush 6,000. In fact his friends helped him because some of their sweet potatoes were going to be put into Max's store. Max had to buy local beer for all the people who had helped him.

Table 3. Summary of storage methods used by farmers.

	Type of store	Design of store	Variety stored	Source of sweet potatoes	Amount stored (bags)*
Farmer No 1	pit	conical	*Ateseke*	bought from friends, some from own field	3
	clamp	conical	*Ateseke*	bought from friends, some from own field	2.5
Farmer No 2	pit	conical	*Osukut*	own	2.5
	clamp	conical	*Osukut*	own	2.5
Farmer No 3	pit	square	*Osukut*	own	4
	clamp	square	*Osukut*	own	3
Farmer No 4	pit	square	*Ateseke*	bought from friends	4
	clamp	square	*Ateseke*	bought from friends	3

*1 bag is equivalent to 100–120 kg.

of their choice was that they wanted to improve the storage of the varieties that store the least well (*Osukut* is also the main cash crop variety).

At two of the sites, store designs were chosen that very closely resembled local buildings — round pits and clamps with conical thatched roofs. At the remaining two sites, designs were chosen that closely resembled those used on the research station — square pits and clamps with oblong 'pitched' roofs. All designs used local methods of construction and materials — wood, grass thatch, bark and banana fibres for lashings and fixings. None of the storage structures contained any plastic or metal components. The characteristics of the stores are summarized in Table 3.

Construction of the stores was undertaken by the farmers with assistance from the groups that had formed around them. They estimated that if they had hired someone to construct the stores, together with all the construction materials, it would have cost them Ush 20,000 (US$20). From their experience, they thought that the thatched roofs of the stores would last about two years without re-thatching, and the wooden framework could last beyond five years. The experience of one of the farmers is outlined in Box 1. Farmers indicated that they preferred the clamps as it was much easier to make a clamp than dig a pit, although it was more difficult to seal the clamps with dry soil.

Reactions of farmers. After the initial process of establishing the stores, the farmers were visited every two weeks to monitor their activities and gauge their reactions. After seven weeks they began to open the stores to examine the sweet potatoes. Their findings were not promising: the variety *Ateseke* in the pit stores had completely rotted (the opposite of the results found on-station — see later discussion). One of the farmers storing *Osukut* tried to sell some of the stored sweet potatoes after about eight weeks. He found that, although the potatoes had stored very well, he was unable to sell them as they did not have the pristine, 'just from the garden' look that buyers use to judge the freshness of sweet potatoes. In fact the price of sweet potatoes during the season of the trial was rather unusual. The rain, which normally stops in November, continued intermittently throughout the whole of the dry season. As a result, fresh sweet potato was more commonly available and, although the price increased, it did not reach the usual levels (see Figure 1).

As storage progressed, farmers started to remove small numbers of roots. At first they used these to test for taste, but later roots were removed to provide a rare meal of fresh sweet potatoes for their families. They indicated that the stored roots were rather sweeter than they would have been if they had just been harvested. In the main, this seemed to be liked, particularly by children. The interest of other members of the community increased as storage continued: one of the traditional leaders of the area constructed his own store after seeing the trials and kept sweet potatoes for two months.

Eventually the farmers decided that the potatoes should be unloaded from the stores. Those sweet potatoes that could not be consumed at once were sliced and dried for later consumption. *Ateseke* was stored for up to 19 weeks, while *Osukut* was stored for 18 weeks, both in clamps, the pit stores being opened slightly earlier. The findings of the farmers may be summarized as follows:

(1) clamps were more convenient to construct, but pits were also useful;

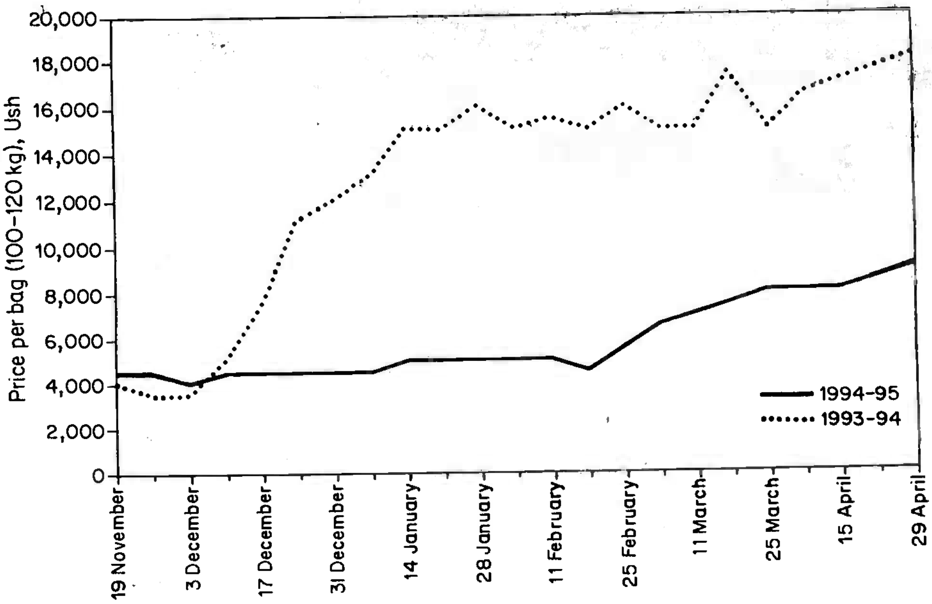

Figure 1. Comparison of sweet potato prices in local market during the on-farm trials (1994–95) and during the same period in the previous year.

(2) *Ateseke* should only be stored in clamps, but *Osukut* could be stored in either type of store;
(3) stored sweet potatoes were difficult to sell (this may be different in years when there are acute shortages of sweet potatoes);
(4) fresh sweet potatoes can be consumed 'piecemeal' from the stores throughout storage, which can last for up to 19 weeks;
(5) sweet potatoes are sweeter after storage;
(6) after storage the fresh sweet potatoes can be sliced, dried and stored for a further period;
(7) with the exception of *Ateseke* stored in pits, losses due to rotting in storage were very low.

A summary of on-farm storage results can be found in Table 4.

The cost of food security. As discussed earlier, the construction of storage structures was undertaken by the farmers themselves. However, for the sake of analysis, the farmers' estimates of the cost of construction of between Ush 15,000 and 20,000 may be used. Using an average value of Ush 17,500 discounted over the two years that the structures could last, this suggests a yearly cost of Ush 8,750. Additional costs include grading the harvested sweet potatoes (although this would have been done for roots harvested for sale anyway). The structures could store six bags of sweet potatoes, approximately 600 kg. Thus the additional cost of storing the sweet potato was approximately Ush 15 per kg (less than US$ 0.01 per kg).

There was clearly a problem in selling the stored roots during the period of the trial. However, in a season with greater scarcity, stored roots would probably have sold more easily, but at a discount compared with any available fresh roots. For the technology to break even, roots stored when the price was Ush 4,500 per bag would have to be able to sell at Ush 6,000, which is not inconceivable as it represents a discount of 60% on the usual dry season prices (Ush 15,000 per bag, see Figure 1).

The value of the technology for food security is more difficult to judge quantitatively. One way to do this is to estimate the value of the stored roots in terms of how long they can feed the average family. With a daily consumption rate of 10 kg, assuming a family of three adults and four children, with the adults

Table 4. Summary of on-farm storage results.

	Type of store	Design of store	Variety stored	Storage period/wks	End use	Comments
Farmer No 1	pit	conical	*Ateseke*	8	discarded	Inspection of the sweet potatoes revealed that they had started to rot
	clamp	conical	*Ateseke*	19	fresh and dried	Consumed fresh, piecemeal from week 12. Remaining roots dried at the end of week 19
Farmer No 2	pit	conical	*Osukut*	15	dried	Of 802 roots, 707 were good, 45 with some dry rot, and 52 were unusable
	clamp	conical	*Osukut*	18	fresh and dried	Consumed fresh during week 18, remaining roots dried
Farmer No 3	pit	square	*Osukut*	13	fresh and dried	Tried to sell but could not
	clamp	square	*Osukut*	16	fresh and dried	Consumed fresh up to week 16, remaining roots dried
Farmer No 4	pit	square	*Ateseke*	7	discarded	Inspection of the sweet potatoes revealed that they had started to rot
	clamp	square	*Ateseke*	16	fresh and dried	Consumed fresh up to week 16, remaining roots dried

Table 5. Cost and benefits associated with sweet potato storage.

1.	Cost of storage construction,[1] Ush (US$)	17,500 (17.50)
2.	Discounted annual cost,[2] Ush (US$)	8,750 (8.75)
3.	Total capacity of stores, kg	600
4.	Annual cost of storage, Ush/kg (US$/kg) (2÷3)	15 (>0.01)
5.	Daily consumption rate,[3] kg	10
6.	Daily cost of food security,[4] Ush/kg (US$/kg) (4×5)	150 (0.15)

[1]Farmers' estimations.
[2]Construction cost discounted over two years based on farmers' estimations of expected life of structures.
[3]Assumes a family of three adults and four children, the adults consuming 2 kg per day and children consuming 1 kg per day, see Ref 16.
[4]Not including the initial or subsequent value of the stored sweet potatoes.

consuming 2 kg per day and children consuming 1 kg per day,[16] an average rural family could survive on the 600 kg of stored roots for 60 days. Using the estimates of the cost of construction of the stores, this suggests that food security can be achieved for Ush 150 per day. The costs and benefits associated with storage are presented in Table 5.

In reality the value of the storage technology in terms of food security is dependent on the farmers' perceptions of the value of access to food in any given season. It is also modified by the farmers' recent experiences of years of food shortage — the more recent, the greater the perception of the value of food security measures. The ultimate test will be farmers' willingness to adopt and practise it without any external impetus from researchers or extension workers.

Comparison between on-station and on-farm results

The results from the on-farm and on-station work broadly concurred: pits and clamps were effective in storing varieties of sweet potato from Soroti district in the prevailing climatic conditions for approximately three months. However, more specific aspects of the results highlighted a contradiction between the two pieces of work. In the on-station work, *Ateseke* was found to be the best variety for storage in pits, whereas on-farm this combination led to a total loss of the stored sweet potatoes. Weight losses in the on-station trials, even for the most successful treatments, were relatively high in comparison with earlier work, with rotting and sprouting more common, but in on-farm trials the better stores were less prone to these problems.

There may be a number of reasons for these differences. One possibility is that farmers were more likely to have taken greater care when building and maintaining their few stores than was possible with the large on-station trials. This may have meant that problems with the rain that occurred during storage were more likely to occur in the on-station stores, possibly leading to the more widespread rotting and sprouting levels. However, the farmers may also have been so rigorous when sealing their pits, in comparison with the deliberately loose sealing of the on-station pits, that they promoted fermentation. There was certainly an indication of this when the pits were opened, and it may have been the reason for the poor pit storage of *Ateseke*.

One important conclusion that may be drawn from this is that the technology is susceptible to subtle differences in construction and choice of variety, ie the choices made by the farmers, and to variations in climate and store condition. This may mean that different groups of farmers may experience very different results, and that the technology may not be of benefit in all years — important factors if the technology is to be widely adopted. Another important conclusion is that on-station work can only at best give a rough approximation of the conditions encountered by farmers. The clear lesson is that it is much more useful to provide farmers with storage options to test in their own specific locations than to try to design generic technologies from apparently precise empirical evidence drawn from on-station trials. The ultimate test of this type of technology is whether it works — in the broadest sense of the word — for the farmer, and not whether it can demonstrate statistically significant differences from other treatments.

At the same time the value of the on-station work should not be underplayed. The initial phase of the on-station work provided sufficient confidence in the technology for it to be considered worthwhile for testing with farmers. Furthermore, the data collected by the on-station trials has value for subsequent up-stream research. For example, it provided evidence that varietal differences exist with respect to storage characteristics. Data collected during the entire storage period concerning the storage environment will be useful during subsequent research to understand the physiological processes that occur during storage.

Conclusions

The on-farm work described here is very much in the pilot phase. However, it has clearly demonstrated not only that sweet potatoes can be stored for up to three months in the dry season in Soroti district, but more importantly that this is a useful thing for farmers to do. While the technology was not able to allow farmers to achieve direct economic benefits from rising prices, it undoubtedly greatly improved their food security during the critical period towards the end of the dry season.

This technology is low cost and fills a need in the food system. With the decline of cassava production in the semi-arid zones of Uganda, this technology has the potential to provide an extremely valuable aid to food security in the small-scale farming sector. Accordingly, dissemination should be seen as a priority for food security intervention in these districts.

The lessons from the work carried out suggest that dissemination is best undertaken by allowing farmers to test the technology in their own environment. This should be done in as non-prescriptive a manner as possible — options should be provided rather than dictating a fixed recipe (technical details are described in an extension guide).[17] This can then be used as a mechanism to demonstrate the technology to a wider group of farmers. The importance of construction and choice of variety, and the influence of the climate on the economic success of the methods, are points that need to be highlighted.

The results of this work indicate that some varieties have better storage characteristics than others. This needs to be recognized by crop improvement programmes. These breeding and improvement programmes require strategic technical backstopping with research to understand the physiological and physiochemical bases for differences in the storability of sweet potatoes.

Perhaps the overriding message from this research is that the linked activities of diagnostic surveys, on-station trials and on-farm adaptive testing represent a powerful package of tools that have the potential to focus post-harvest technology on the poor. Without such approaches, the development of post-harvest technology may be concerned only with storage efficiency, and may not address the issue of whether technical change can contribute to the sustainability of the livelihoods of the rural poor.

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