Increasing the contribution of sweetpotato to sustainable rural livelihoods in Tanzania

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Abstract

Sweetpotato is a food security crop that is important for the livelihoods of many poor people. Recently the marketing of fresh roots and use as livestock feed have increased in importance in both urban and rural areas.

This paper summarises research efforts over the past six years aimed at increasing the contribution the crop makes to sustainable livelihoods. The paper focuses on post-harvest and marketing issues that affect the crop and the people who grow, trade and consume it. The major constraints identified were lack of knowledge concerning the acceptability of different varieties in the marketing chain, poor shelf-life of roots, losses in quality during handling, impact of weevils on market value, and the seasonality of production.

Varietal selection has to be needs driven. For farmers the main criteria were high yield, early maturity, disease and pest tolerance, sweetness, low-fibre content, root firmness, and extended in-ground storability. For traders and urban consumers, the main preference criteria were starchiness/flouriness, taste, cooking time, and colour of root flesh/skin. Extended shelf-life of fresh roots, root shape and size were also important. Factors most associated with fresh root storability were established as weight loss and rotting. These are influenced by cultivar, environmental factors and handling practices. Handling studies indicated that the most important type of damage, breakage, was caused by dropping. Skin damage, which affected shelf-life, was due to many (800-1,200) minor shocks caused by vibration during transport. Loss in value after 14 days storage was estimated at 60% with transport-induced damage. Improved packaging and use of pre-harvest pruning were shown to reduce damage from poor handling. Varietal differences in susceptibility to weevil damage have been assessed. Pronounced seasonality in production indicated the potential of storage as a means of increasing incomes and this is being investigated.

Introduction

Sweetpotato (*Ipomoea batatas* (L) Lam.) is a household food security crop for many Tanzanians and as such it makes a significant contribution towards their livelihoods. It is marketed and consumed in both urban and rural areas.

Table 1. Trends in sweetpotato production in Tanzania for the past ten years

Year	Area ('000ha)	Production ('000t)	Yield (t/ha)
1989	199	337	1.7
1990	307	996	3.2
1991	232	290	1.3
1992	198	257	1.3
1993	200	260	1.3
1994	205	234	1.1
1995	274	451	1.6
1996	271	420	1.5
1997	310	653	2.1
1998	250	403	1.6
1999	280	500	1.8
Average	248	436	1.7

Source: FAOSTAT agriculture data for Tanzania

The area under cultivation has varied over the past ten years with an average of 248,000 hectares (Table 1). The crop is found in the Lake, Western, Southern Highlands, Eastern and Northern zones (Figure 1). Yields however have been misrecorded and hence do not reflect the true production of the crop. This is due to agronomic practices such as piecemeal harvesting.

Although produced all year round in some locations, there are distinct production seasons that vary by location. This is reflected in varying market prices both in rural and urban markets (Ndunguru et al. 1998). With increasing urbanisation, sweetpotato together with other foods is becoming increasingly important in urban food systems (Kapinga et al. 1997a).

Although sweetpotato has a number of agronomic advantages which underpin its importance in agricultural systems, there are several issues that need to be addressed to increase the contribution that the crop makes to poor peoples' incomes and to food security.

Despite its importance in food systems, there is little

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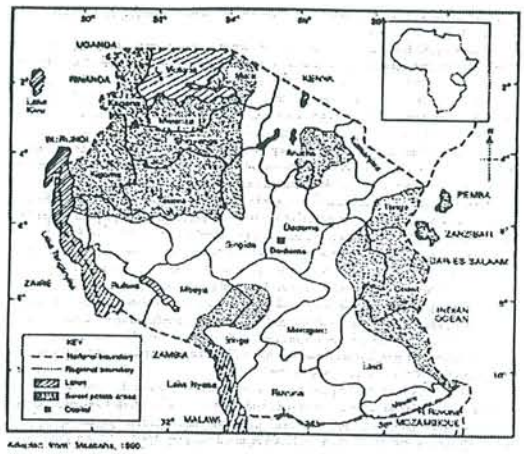

Fig. 1
Map of Tanzania showing the distribution of sweetpotato

information concerning the preferences of urban consumers for different sweetpotato varieties. This has occurred because in the past sweetpotato was consumed mainly in rural areas (Kapinga et al. 1995). The utilization of sweetpotato in urban areas was very limited, if not a secret, because it was considered to reflect the low-income status of consumers. The limited range of processed sweetpotato products available is also thought to contribute to its low status and weakens competition with other commodities.

In recent years, as urban populations have increased, there has been a tremendous positive change in attitude towards the crop. In urban areas, most consumers obtain sweetpotato roots from markets. Some consumers, however, supplement these by growing sweetpotato themselves.

Several needs assessment studies have been conducted in Tanzania to identify factors limiting increased sweetpotato production and utilization (NCU- FSR 1996; Kapinga et al. 1997a, b). The major constraints identified were: lack of knowledge concerning the acceptability of different varieties in the marketing chain; poor shelf-life of roots; losses in quality during handling; impact of weevils on market value; and the seasonality of production. This paper summarises some of the findings from several studies to address these constraints.

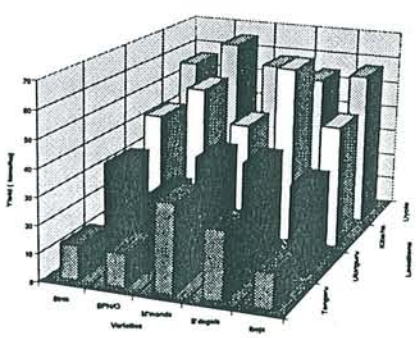

Fig. 2
Yield performance of sweetpotato in different agroecologies of Tanzania

Selecting varieties to meet needs of farmers, traders and consumers

Farmers perception and selection criteria

A farm-level nationwide survey was carried out by the National Coordination Unit of Farming Systems Research in 1996 to identify the criteria used by farmers in variety selection (NCU-FSR 1996) and limiting factors associated with the production of sweetpotato as perceived by farmers. The limiting factors mentioned by farmers included insect pests (mainly sweetpotato weevils), drought, shortage of planting material, diseases, low root yield, lack of good varieties, vertebrate pests and late maturity (NCU-FSR 1996; Kapinga et al. 1995). These factors, together with socio-economic factors (gender problems, labour and land shortages, and limited utilization of the crop), contribute to the limited production of sweetpotato at the farm level. Research to address these issues is currently on-going. At the farm level, the participatory approach of working with farmers to assess varieties has led to flexible recommendations that give options to farmers to grow several varieties for different objectives under different practices (Table 2). Yields of varieties tested under different agro-ecologies are presented in Figure 2. Varieties SPN/O and Sinia were stable in yield and acceptable to consumers in all locations and have now been released nationwide. Other popular varieties and their desirable characteristics are presented in Table 3. Farmers' selection criteria in order of importance were divided into pre-harvest and post-harvest characteristics (Kapinga et al. 1997a). Pre-harvest qualities include: high yield, early maturity, disease tolerance, extended inground storability, ability to produce leafy vegetable and stress tolerance. Post-harvest qualities include: sweetness, low fibre content, high root firmness, marketability, storability, large root size and good root shape (Kapinga et al. 1997a).

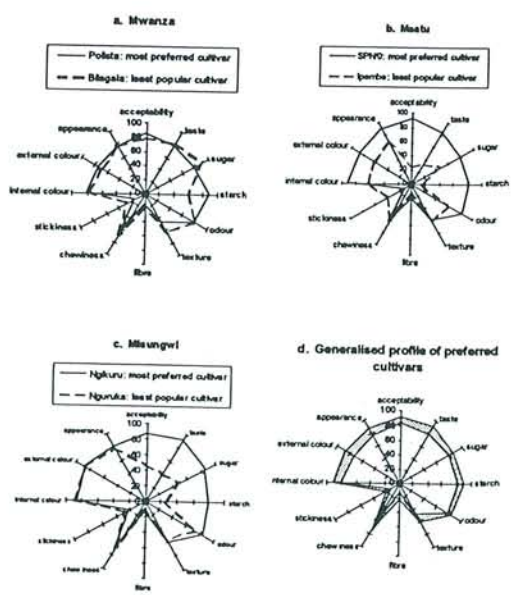

Fig. 3
Sensory profiles of the most preferred and least preferred sweetpotato variety for each location, and the generalised profile of preferred varieties.

Table 2. Assessment of sweetpotato varieties by FARMERS for suitability in diverse production systems and for different objectives in the Lake Zone of Tanzania

Do you.....?	Then grow.....	But do not grow.....
Have a sandy field with low soil fertility	Sinia-B*, SP93/2**, SP93/34** SPN/0*	Iboja, Mwanamonde Biganana
Want high yield	SPN/0*, Sinia-B *, SP93/2**, SP93/34**, Iboja, SP93/5	Biganana
Want cooked roots	SPN/O*, Sinia-B*, SP93/34**, SP93/2**	Iboja
Want to harvest by piece-meal	Mwanamonde, Sinia-B*, Iboja, Biganana	SPN/0*
Have problems with weevils in your field	Biganana, Iboja Sinia-B*, SP93/23**	SPN/0 *, Mwanamonde
Want vines for livestock	Biganana, SP93/34**, Sinia-B*	Iboja
Want to process	Biganana, Iboja, SP93/2**, Sinia-B*, Mwanamonde	SPN/O*
Want leaves for vegetable	Biganana, SPN/O*, SP93/34**, SP93/23**, SP93/30	Iboja
Weed smothering	SP93/93/30, Mwanamonde, SP93/23**	SPN/O*, Budagala
Want roots for selling	Sinia-B*, SPN/0*, SP93/2**	Iboja

* Selected and released varieties countrywide,
** Selected and released in the Lake Zone of Tanzania
Adopted from: Msabaha et al. 1999

To ensure a timely and continuous supply of planting material of selected varieties, an informal seed multiplication and dissemination system has been put in place (Chirimi et al. 2000). This involves the active participation of NGOs and local farmers' groups.

Consumers' perception of sweetpotato

Urban consumers obtain most of their sweetpotato roots from markets. Some consumers supplement these by growing sweetpotato themselves (Kapinga et al. 1997b). In a survey conducted in 1997 (Kapinga et al. 1997b), consumers indicated their preferred varieties and reasons for their selection. Desired attributes of sweetpotato are high starchiness, good taste, good root colour, large root size and good shape, tolerance to market damage, and low/less fibre content (Kapinga et al. 1997a). Interviewees were also asked which varieties they did not like to buy, and for what reasons. The reasons given for unacceptability of specific varieties are watery roots, bad taste, unattractive root appearance, high fibre content and poor cooking quality. Uses of sweetpotato by urban consumers are listed in Table 4.

Traders' perception of sweetpotato

Traders identified similar characteristics to consumers. These included good taste, high starchiness, good cookability, good root appearance, low fibre and extended root storability after harvest (Kapinga et al. 1997b). These criteria are currently being used as a basis for selecting varieties for marketing.

Use of trained panellists to assess sweetpotato varieties

Many of the sensory criteria of sweetpotato cultivars identified by consumers and traders are very complex. Many are subjective and are therefore very difficult or impossible to measure by analytical means. Direct consumer testing of new varieties is expensive and time consuming, as, in order to get a reliable result, it is necessary to use a large number of consumers (usually at least 100). Small trained taste panels of 10-20 people can, however, be used to produce sensory profiles of varieties. Such a panel would be asked to assess, as objectively as possible, cooked sweetpotato samples for a range of pre-chosen characteristics. Thus for each sample they would create a sensory profile. A study was carried out to investigate whether such panels could be used as a means of screening new varieties for consumer acceptability. The procedure would depend upon the identification of a sensory profile that accurately represented the preferences of consumers. Key questions are how consistent consumer

Table 3. Popular sweetpotato varieties preferred for growing by FARMERS and their desirable characteristics across zones in Tanzania

Local name(s)	Other names in other countries	Zones in Tanzania where grown	Desirable characteristics
Suguti, Songea Simama, Tulwawima (SPN/O)*	Kemb10 (Kenya) Tanzania (Uganda) Sauti (Ghana) Chingowva (Zambia) Kenya (Malawi) SPN/O (Botswana)	Eastern, Southern Highlands, Lake, Central, Western and Northern Highlands	White skin, Yellow flesh, High yielding, Floury, Early maturing, Large root size, Moderate sweet, Very firm/floury, No fibre, Good for relish, livestock feed
Mwezigumo		Western, Lake	Very early maturing to bridge a famine gap between major harvests
Karoti		Eastern, Southern	Early maturing, Red skin, Yellow flesh, Medium fibre content, Moderate sweet, medium root size, firm and Moderate drought tolerant, Good for marketing
Sinia Kasinia (SINIA)*		Southern Highlands, Lake, Eastern, Northern Highlands	Early maturing, Large root size, Red skin/yellow root flesh, Very sweet, Very firm, No fibre, Enough foliage for livestock feed
Kandoro		Western, Southern Highlands	Medium maturity, Large root size, White skin, White flesh, Sweet, Firm, Not fibrous

Adopted from Kapinga *et al.* 2000
*Varieties released for distribution in all of the country.

preferences are across the country, and whether one consistently preferred profile exists.

Table 4. Different uses of sweetpotato by urban consumers in the Lake Zone of Tanzania

Uses of sweetpotato	Number of representative households which use this method			
	Mwanza	Meatu	Ukerewe	Total
	(N=18)	(N=20)	(N=20)	(N=58)
Boiling (whole roots)	18	14	14	46
Mixed with gnut/beans/etc to make soft meals	9	6	6	21
Slicing into Michembe/Matoborwa (Processed products)	6	12	0	18
Making fried chips	4	4	4	12
Roasting (whole roots)	2	1	2	5
Flour for porridge	0	1	1	2

Source: Kapinga et al. 1997b

In a pilot study, three sites were chosen in the Lake Zone. At each site, a consumer study was carried out to determine the preferences of the local population for a range of locally available cultivars. For each of the cultivars a sensory profile was then created by a trained panel based at A.R.I.–Ukiriguru, Mwanza in the Lake Zone. Figure 3 shows the profiles for the most and least preferred varieties at each site. A very interesting and encouraging finding was that although the most preferred varieties were not the same, they had very similar profiles. Although a more extensive study is needed, this may mean that in terms of sensory characteristics, specific varieties will not need to be bred for specific regions.

Selection of cultivars with extended shelf life

Traders identified extended root storability as a desirable cultivar characteristic. Given the right conditions in terms of temperature and humidity, sweetpotato roots can store for many months. For example, in the United States, roots stored at 13-15 °C and 90% humidity can be kept for up to a year (Picha 1986). In Uganda, it has been shown that even at much higher temperatures (>25°C) it is possible to store roots for 4-5 months in pits and clamps where humidity is kept high (90 – 100%) (Devereau 1995). Despite this, under the normal marketing conditions in Tanzania it has been found that roots have a very short shelf-life, and can be kept for only 2-3 weeks. This provides a serious constraint to the marketing of the commodity.

Research carried out at five locations in Tanzania has shown that as a result of the low humidity to which roots are exposed during marketing, the main cause of deterioration relates to water loss through the root periderm. This causes loss of quality due to weight loss and shrivelling, and also leads to more rapid rotting, presumably as the stressed tissue is unable to mobilise a defence against the invasion of rotting pathogens. Rate of weight loss is increased by mechanical damage incurred during handling. However, it was also found that cultivars differ very significantly in their rates of water loss. Figure 4 shows the weight loss for roots of 22 sweetpotato cultivars over two weeks of storage at A.R.I.- Ukiriguru under simulated market conditions. This ranged from 8.5% to

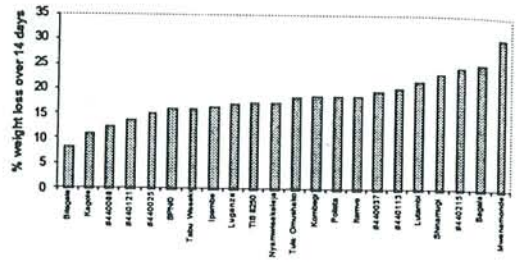

Fig. 4
Percentage weight loss over 14 days storage under simulated marketing conditions for 22 sweetpotato cultivars grown at ARI Ukiriguru in 1997

30%. Encouragingly, the behaviour of cultivars was consistent between years at the same site. More variability was found when comparing cultivars over different locations in Tanzania, but nevertheless, even in this case there were cultivars that were consistently good and others that were consistently bad. These results suggest that there is great potential for improving the shelf-life of cultivars through breeding. The physiological basis for the differences in rates of weight loss has been studied, and is considered in another paper at this conference (Van Oirschot et al. 2000 a).

Improving handling to avoid losses in quality and incomes

Most sweetpotato in Tanzania is marketed as fresh roots. Work has been undertaken to understand the causes of losses between the farm and the market. On the basis of this a number of techniques have been evaluated to reduce losses.

These studies on sweetpotato handling are underpinned by novel techniques to understand the impact of different quality parameters on the economic value of roots (Ndunguru et al.1998). It was shown that weevil damage caused the greatest loss in value (30-50%), while smaller, but significant, discounts of 10-30% occurred when roots were shrivelled, cut or broken.

While weevil losses occur in the farm, little was known about where in the marketing system damage resulting in shrivelling, cuts or breaks occurred. Commercial consignments of sacks of sweetpotatoes (100 kg) were surveyed from harvest to markets at Mwanza and Dar es Salaam (Tomlins et al. 2000). As a result of the handling and transport, up to 20% of roots in a sack had severe breaks and 35-86% had severe skin injury. This resulted in reductions in market value (due to breakage) which could be as high as 13% per sack. Impact loggers located at the

centre of sacks were used to continuously monitor shipments. The most severe impacts occurred during unloading and loading from road vehicles and ships. However, multiple regression analysis indicated that a large number (800 – 1200) of minor impacts between 0.2 and 2 g correlated with skin injury and broken roots. The impact logger results also indicated that when transported in sacks containing 100 kg of roots, both of the cultivars assessed (Polista and SPN/0) were equally susceptible to skinning injury and root breakage and this was not affected by season.

The effect of handling during loading and unloading (weight of sack, height and number of impacts) on the quality and shelf-life of sweetpotatoes (SPN/0 cultivar) was investigated. Considerable damage due to broken roots occurred when a sack was dropped from a height of 0.25 m or greater, whereas skinning injury steadily increased with drop height. Breaks and skinning injury increased with the number of drops. The weight of the sack (50 or 100 kg) had no effect on the occurrence of broken roots or skinning injury. The shelf-life indicated by weight loss, was influenced by the height that a sack was dropped and to a lesser extent the number of drops. Weight loss during storage was mostly influenced by skinning injury and to a lesser degree by broken roots. Loss in value after 14 days of storage was estimated at 60% due to transport induced damage.

While improved management of the existing transport system may lead to reduced loss, other methods such as improving packaging methods for handling and transportation and pre-harvest curing were investigated. The use of cardboard cartons during transport (Table 5) and pre-harvest curing by pruning 14 days or more before harvest improved quality by reducing the occurrence of skinning injury. This, however, did not improve the market value of the roots because traders and consumers in Tanzania do not consider skinning injury to be unacceptable. There is, however, potential to improve shelf life of marketed roots.

Table 5. Effect of packaging materials on root injury after handling and transport in Gairo, Tanzania

	Root quality (total score*)				
	Fresh roots (at harvest)	Cardboard box (20 kg)	Wooden box (30 kg)	Polypropylene sack (20 kg)	Polypropylene sack (100 kg)
Skinning injury	6	12	19	38	43
Broken roots	3	2	2	4	5

* Forty roots were selected and assessed. Each roots was scored on a scale between 0 (no damage) and 5 (extremely damaged). The scores for individual roots were summed giving a total maximum possible score of 200.

Reducing weevil infestation

Unlike cassava, in Tanzania sweetpotatoes cannot generally be left in the ground after they reach maturity (in-ground storage). This is because once the dry season starts the crop becomes susceptible to attack by the sweetpotato weevil (*Cylas* spp.). Globally, several attempts have been made to breed for resistance to *Cylas* spp. However, the rate of success has been slow, leading some breeders to conclude that an adequate source of resistance may not exist within sweetpotato germplasm (Talekar 1987). Nevertheless, there are numerous reports of variation among varieties in susceptibility to weevil attack. Trials were therefore conducted at two sites in Tanzania, (Ukiriguru and Kibaha), and a third site in Uganda (Serere), over two years to compare susceptibility of a range of cultivars, and to determine which plant characteristics might contribute to reduced susceptibility. From the results it was hoped to determine the feasibility for breeding for reduced susceptibility in Tanzania, and to develop a strategy for doing so. A full report of these trials is given in Stathers et al. (1999).

Significant cultivar differences in susceptibility to *Cylas* spp. infestation were observed for all trials conducted at Ukiriguru and Serere, and multiple regression analysis confirmed that cultivar was the most important factor. However, cultivar effects were not observed at Kibaha, most likely because of the very low *C. puncticollis* infestation in 1997 and very high infestation in 1998. Encouragingly, there was considerable consistency of cultivars by season at Ukiriguru and Serere. The wide range of *C. puncticollis* infestation levels of the 16 cultivars trialled at Ukiriguru is shown in Figure 5.

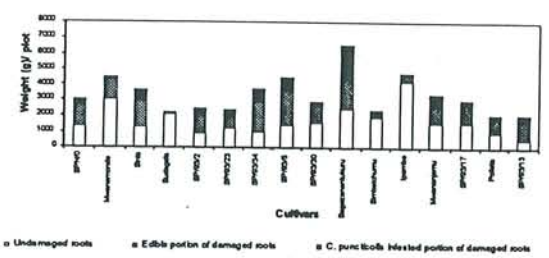

Fig. 5
Comparison of *Cylas puncticollis* damage on the mean marketable yield of 16 different sweetpotato cultivars at Ukiriguru, Tanzania in 1997.

The main characteristic that was found to be associated with reduced infestation was rooting depth. However this had to be measured directly in the ground and more straightforward measurement of root neck length gave a poor estimate. Laboratory studies indicated that root composition did not have a significant effect on levels of field infestation. Soil cracking around roots is important for levels of susceptibility and appears to be cultivar dependent. A positive relationship between root yield and susceptibility to infestation was also found, but is not useful as a selection criterion.

These findings suggest that it might be possible to breed for reduced susceptibility, in particular by breeding for deep rooting cultivars. However, rooting depth is a difficult characteristic to breed for, being difficult to assess. It is also likely to be very dependent on soil conditions and growth environment, and the consistency of cultivars between sites for this characteristic has not yet been tested. An alternative approach to controlling weevils in East Africa, which is presently being given high priority, is the promotion of improved cultural practices, including education of farmers on the habits and lifecycle of the pest.

Long-term storage as a means of increasing rural incomes

During the course of sweetpotato studies, it became evident that there were large variations in market price of fresh sweetpotato related to seasonality of production (Ndunguru et al. 1998). These observations have been confirmed and the potential for using long term storage in pits or clamps is being investigated as a means of marketing roots out of season. Preliminary results from the storage trails are presented at this scientific meeting (Van Oirschot et al. 2000 b)

Major observations and recommendations:

In conclusion, the major observations and recommendations from our research have been:

- Farmers' participation in variety testing and surveys have provided feedback on cultivar selection criteria that need to be taken into account to ensure acceptability. The relative importance of criteria varies with the categories of end-users, with the exception of root starchiness/mealiness, taste and root texture.
- Sensory properties of sweetpotato are complex to assess and can be variable between populations. However, a preliminary study has indicated that preferences are reasonably uniform across Tanzania, and that trained panels may provide a practical method for preliminary assessment of cultivars.
- The finding that water loss is the main factor affecting shelf-life and that cultivars differ greatly in their susceptibility to water loss allows easy cultivar selection for shelf-life. Studies to identify the root characteristics that can control water loss will help breeders to actively select for long shelf-life.
- Poor handling of roots has been shown to create direct economic losses through lower quality roots being sold in the market. Damaged roots also do not store as well. Improved handling techniques or the use of pre-harvest curing could help reduce damage and so improve returns to farmers and traders.
- Although susceptibility to sweetpoptato weevil infestation has been shown to vary greatly between cultivars, it is not clear that breeding will provide significant stable resistance to this pest. The promotion of improved cultivation practices in conjunction with innovative farmer training would have greater impact at this time.

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