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Review of sweetpotato seed systems in East and Southern Africa

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Abstract

The sweetpotato crop in much of Africa, including East Africa, is largely grown by women in smallholder farming households; its seed systems are, similarly, predominantly in the informal sector and women seem important though their roles are inadequately researched. The crop, as elsewhere in the world, is propagated primarily from foliar cuttings. In equatorial regions where there is bimodal rainfall and the crop is grown throughout the year, these can easily be obtained from existing mature crops and this region is where the crop is mostly grown. Although there are few issues regarding planting material availability or even price as it is mostly free, improvements are needed in quality of the planting material, particularly:

- the range of good varieties (both for all-round better varieties; varieties with specific attributes, such as orange-fleshed to broaden the market and an emphasis on participatory breeding)
- freedom from weevils
- sweetpotato virus disease (SPVD), and
- physiological vigor.

However, even just a few degrees north or south of the Equator, the increasing unimodality of the rains leads to long dry seasons during which sweetpotato cannot survive as an actively growing plant. Although the above issues remain, the overwhelming constraint is lack of planting material at the beginning of the rains, leading to late planting and limited areas planted. The latter leads to the crop failing to fulfill its potential to be the first major food crop to be harvested, to fill the 'hungry gap' when granaries are empty and to realize high sales and prices. This lack of planting material is the main reason why the crop is grown so much less away from the Equator, further impoverishing some of the poorest people in Africa such as in Ethiopia, Sudan and other Sahelian countries, Mozambique, Zimbabwe, Malawi etc. These countries are also particularly threatened by climate change and the associated increasing variability of weather. Sweetpotato is otherwise especially appropriate in view of its robustness, superior ability to generate calories/ha/day and other health properties, including as a source of vitamin A. Most current systems of producing planting material in such regions are already at their limits in terms of quantity of production; environmental concerns may constrain this even further. Dissemination of intensive methods of conserving planting material using domestic wastewater is recommended as a partial solution. A far more extensive solution that has recently been developed is to bury small- to medium-sized roots at the start of the dry season in a small nursery bed, watering it for 4 – 6 weeks before the expected arrival of the rains; such roots sprout prolifically, producing large amounts of planting material from a small area in time for the start of the rains. Validating and disseminating this new robust method to

farmers in areas with prolonged drought has enormous potential benefit for the livelihoods of poor people in Africa.

Despite the overwhelming importance of lack of planting material in such areas, SPVD, weevils and physiological lack of vigor remain of major importance and there is opportunity to improve livelihoods of poor people throughout sub-Saharan countries by evaluation, development and dissemination of improved SPVD-resistant varieties, itself requiring improvements to regional germplasm exchange. Similarly, there is opportunity to benefit poor people through dissemination of knowledge more widely, both within Uganda (where much of the original research was done), but especially in other African countries: this will require training extensionists (nongovernmental organization [NGO] and publicly-funded), developing training materials in local languages and using decentralized and experiential learning approaches. These activities are particularly needed to underpin the adoption of high β-carotene orange-fleshed varieties to eliminate vitamin A deficiencies; many of the original varieties proved susceptible to SPVD.

TOP PRIORITIES FOR ACTION

1) Availability of planting material in drought-prone areas: Validate and extend nursery bed for storage roots system for producing planting material throughout drought-prone areas. Also provide training in systems using waste domestic water.

2) Breeding: Extend breeding for improved SPVD-resistant sweetpotato varieties, particularly for high-yielding orange-fleshed sweetpotato varieties. Continue enhanced farmer involvement.

3) Training: Validate and adapt training messages developed in Uganda and Tanzania for producing high quality planting material for wider regional use; then disseminate regionally using decentralized systems and approaches and a wide range of civil society institutions.

4) Germplasm exchange: Further facilitate rapid but safe regional movement and release of germplasm to maximize use of current improved varieties, both technically and through harmonization of regulations.

5) Use of true seeds: Consider providing limited funds for research into the use of true seeds as planting material.

6) Documentation: Document the few successful private enterprise or cooperative sweetpotato seed organizations in East Africa, together with experiences for potato seed systems. Document the role of women in informal seed systems.

Acknowledgments

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Review of sweetpotato seed systems in East and Southern Africa

INTRODUCTION

Improved seed systems have a proven track record in raising productivity of clonal crops such as sweetpotato through the provision of quality planting material and through the efficient dissemination of improved varieties. The provision of planting material of appropriate varieties is also often a key intervention to rehabilitate farming systems following natural disasters such as drought, civil unrest or conflict and to assist the return of displaced persons. An example of the potential impact of improved seed systems in clonal crops is given by the adoption of International Potato Center (CIP) sweetpotato seed technology (virus testing and tissue culture) in the Shandong province of China in the period 1988 to 1998. The technology was adopted in over 80% of the production area of the province, which represents 12% of global sweetpotato production and amounts to some 17 x 106 tonnes per year, increasing average yield by ~30%. The economic impact of this intervention was estimated as providing an annual productivity increase valued at \$145 x 10^6 by 1998 (a net present value [NPV] of \$550M; internal rate of return [IRR] of 202%) and the agricultural income of some 7 million smallholder farmers had been raised by some 3-4% (Fuglie et al. 1999).

Survey evidence indicates that seed systems, particularly timely supply of planting material and distribution of improved varieties, are a major constraint to sweetpotato productivity in Sub-Saharan Africa (SSA) and provide key opportunities for poverty alleviation. For example, a CIP survey in 2005 reported that "virus management, seed quality and supply systems" were the highest priority for future research and development (R&D) against all other listed sweetpotato technologies for 91 respondents from 34 developing countries (Fuglie 2007). More recent CIP findings indicate that providing virus-free planting material in SSA alone could yield rates of return of between 56-84% depending on rate of adoption and adoption ceiling. The anticipated annual aggregate impact of the technology (assuming a status quo adoption ceiling) is calculated to be \$74 x 10^6 with benefits to the rural poor calculated to be \$49 million per annum. The maximum potential aggregate benefits and benefits to the rural poor for SSA (assuming adoption in all affected areas with no adoption constraint) are calculated to be \$434 x 10^6 and \$287 x 10^6 every year respectively (Fuglie, personal communication).

General requirements of seed systems

Seed system(s) are a requirement for all crops and can involve both formal (national organizations or companies producing seed under national legislation) and informal (mostly farmers and petty traders; unregulated) components. Effective seed systems are needed to provide the different categories of farmers with planting material i) in sufficient quantities ii) at the right time iii) of an appropriate physiological state, vigor and health, iv) of superior genotypes appropriate to the farmer's purposes and v) at an affordable price. In order to maintain superiority of genotypes and, in some cases, health, there needs to be capacity within seed systems for generation, dissemination and multiplication of new stock, new cultivars and/or pathogen-free material (Setimela et al. 2004). There is also need for seed systems to have the capacity to recover from large scale loss of planting material resulting from disasters.

This review, done at the request of the International Potato Center, describes sweetpotato planting material systems used in East Africa and examines their capacities to fulfill these requirements.

Sweetpotato seed systems worldwide

Throughout the world, the common propagule of sweetpotato is foliar cuttings obtained from one of two sources:

- The foliage of a mature crop
- Shoots from storage roots

Obtaining planting material direct from a mature crop is the easiest and cheapest means and is the general practice throughout the tropics wherever cropping is year-round. The use of shoots emerging from storage roots planted out in nursery beds is largely confined to higher latitudes such as N. America and China where the cold winter kills outdoor crops. Storage roots there have to be protected in heated barns or cellars, then planted out in spring, in nursery beds, generally heated (general ref: http://www.hort.purdue.edu/ext/HO-136.PDF); under such conditions, they sprout prolifically and cuttings can be harvested within 1 – 2 months (Deonier and Kushman 1960). Sweetpotato can also be propagated by planting roots or root pieces directly; although these can generate good yields, this is not a common practice because part of this yield may comprise the swollen (often misshapen) old root; sprouts from the same root, if grown in a bed, would generate many more plants and the old storage roots often rot and are a source of root pathogens (Lutz et al. 1946; Kodama and Kobayashi 1954; Bouwkamp and Scott 1972; Bouwkamp 1982). Sweetpotato can also be propagated from seed but, unlike potato, there appear to be no reports of true sweetpotato seed being used to generate crops for root production. The seeds are difficult to obtain in large quantities, require treatment to break dormancy and the genetic variability of the resulting seedlings has resulted in this means of propagation currently being limited to breeding programs.

Sweetpotato seed systems in Africa, especially East Africa

In most of Africa, winters are not cold enough to kill the standing crop; however, sweetpotato production is mostly limited to the duration of the seasonal rains. These move north and south of the equator, tracking where the sun is directly overhead and generating the inter-tropical convergence zone (ITCZ) (http://en.wikipedia.org/wiki/Intertropical_Convergence_Zone). Consequently, these rains occur twice yearly (bimodally; around the equinoxes) in equatorial areas but become unimodal towards the Tropics of Cancer and Capricorn where the sun is directly overhead only once a year. This conversely means that there are two relatively short dry seasons in equatorial regions but a single prolonged dry season at the higher latitudes. In districts in Uganda close to the Equator such as Mpigi, Masaka, Rakai, Tororo and Busia districts (Table 1), all within 1° of the Equator, crops planted during the previous rainy season can survive the two short dry seasons, allowing farmers to obtain planting material for new crops from their own surviving mature crops or from those of their neighbors (Table 1).

However, even just 2° north in Soroti District, farmers needed to preserve planting material in swamps or in shade (Table 1) and, 3° north in Arua District, about a quarter of farmers interviewed reported having to buy planting material (Bashaasha et al. 1992). Further north or south of the equator, the dry season generally becomes longer and the supply of planting material increasingly constrained. These areas include some of the poorest regions in Africa, including Sahelian countries (northern Uganda, Sudan, Ethiopia etc.) and southern countries (southern parts of Tanzania, Burundi, parts of D.R. Congo, Mozambique, Malawi, Zimbabwe etc.). Climate change in these countries threatens even longer dry seasons and more erratic rains.

Table 1. The different sources of planting material of Ugandan farmers (Karyeija et al. 1998).

District	Proportions* of different sources of planting material			
	Swamp	Shade	Old crop	Neighbors
Soroti	55	48	40	24
Tororo/Busia	0	4	85	35
N Mpigi	0	0	66	83
SW Mpigi	4	0	85	38
Masaka/Rakai	0	10	97	50

* Values may sum to >100 because most farmers used several sources

This report therefore distinguishes:

- Seed systems where crops can be grown throughout the year, and
- Seed systems in regions with prolonged dry seasons.

Although seed systems for most crops in Africa are predominantly in the informal sector (Setimela et al. 2004), sweetpotato in Africa is unusual in how overwhelmingly dominant the informal system is, providing perhaps >99% of the planting material for the crop except in the small commercial sector in South Africa, e.g., the lack in Tanzania of an established formal seed multiplication unit for any vegetatively-propagated crops including sweetpotato (Kapinga et al. 1995). It is also a crop dominated by women (Bashaasha et al. 1995; Kapinga et al. 1995) though there appears to be no specific study of gender issues in sweetpotato seed systems. Factors in the particular predominance of the informal sector in sweetpotato are:

1) The normal clonal propagation of sweetpotato through foliar cuttings ensures farmers have little difficulty in controlling the genotype.
2) Foliar cuttings can often be obtained in abundance from standing crops so there may be little incentive for farmers to buy planting material.
3) Foliar cuttings are perishable, bulky and not easily stored or transported for marketing purposes.
4) Sweetpotato is grown primarily by smallholders, mainly for home consumption and petty trading. Farmers appear unwilling to purchase inputs for a crop that brings in little cash. Also, although there are millions of smallholders throughout Africa, each may require only a few cuttings, making marketing relatively unrewarding.
5) Planting material of local cultivars seems to maintain its vigor.

As well as a lack of commercial opportunity, this predominance of the informal sector may reflect an underlying lack of perceived national need and concern amongst policymakers that a nationwide, nationally-funded formal system would be unsustainable in the long run and risks disrupting an informal system which more-or-less functions (except in regions with prolonged dry seasons). Instead, national and international NGOs have been occasional actors in this sector. Their funding is often international and for time-restricted specific projects, such as delivery of planting material of particular improved varieties in an area. The predominance of the informal system has the attribute of being self-sustaining, but does it satisfy the requirements of client farmers? The lack of a major formal sector creates particular difficulties in three aspects which will also be reviewed in detail:

- Dissemination of new improved cultivars in a largely informal seed system (therefore without national or commercial schemes for distribution)
- Health, particularly freedom from asymptomatic viruses, in clonal propagation (Plant viruses are commonly systemic and so transmitted through cuttings; in many clonally propagated crops, asymptomatic viruses may cause degeneration which farmers cannot easily counteract by simple visual selection)
- Development of new cultivars (Lack of a major commercial sector means there are no private breeders, only publicly funded and traditional breeding).

SEED SYSTEMS WHERE CROPS CAN BE GROWN THROUGHOUT THE YEAR

Despite the apparent ease of obtaining planting material from the foliage of a previous crop, farmers in areas where crops can be grown throughout the year can face major pest and disease problems in maintaining the health of their planting material, partly because the crops are grown continually and pests and diseases can move easily from one to the next crop generation. There are three main issues:

- Sweetpotato virus disease and related diseases
- Weevils, particularly *Cylas* spp.
- Physiological vigor

Sweetpotato virus disease and related diseases: There are a series of severe diseases of sweetpotato caused by co-infection of *Sweetpotato chlorotic stunt virus* (SPCSV) synergizing the multiplication of otherwise relatively mild viruses. The commonest of these complex diseases is sweetpotato virus disease (SPVD) caused by co-infection of SPCSV with *Sweetpotato feathery mottle virus* (SPFMV) (Gibson et al. 1998); co-infection of SPCSV with *Sweetpotato mild mottle virus* (SPMMV) similarly causes the (next most common) Sweetpotato severe mosaic disease (Mukasa et al. 2003). These diseases occur throughout Sub Saharan Africa (SSA) though with differences in prevalence and strain. They are transferred through planting material and affected plants have negligible yield, especially if infection is early, as when derived from planting material (Gibson and Aritua 2002). Although farmers in East Africa are generally unaware of the causes of these severe diseases, associating the symptoms with factors such as drought, insect pests or too much sunshine, they recognize their unsuitability as planting material (Bashaasha et al. 1995; Aritua et al. 1998a; Gibson et al. 2000; Tairo et al. 2004), such diseases being the main reason for their rejection (Table 2) [but also see later section on **Health, particularly freedom from asymptomatic viruses, in clonal propagation**].

Table 2. Criteria used by Ugandan farmers for rejecting vines as planting material (Bashaasha et al. 1995)

District	Number of respondents	Reasons for rejecting vines (% respondents)				
		Diseased	Wilted	Diseased & wilted	Too old/ young	Other
Kabale	52	43	-	5	-	2
Gulu	50	64	-	34	-	2
Iganga	46	98	-	-	-	2
Mpigi	40	80	-	20	-	-
Luwero	50	100	-	-	-	-
Kabarole	40	63	2	35	-	-
Arua	46	80	11	-	9	-

Table 3. Ranks given by farmers in Tanzania (Bukoba and Karagwe districts) and Uganda (Rukungiri, Mpigi and Soroti districts) to different control measures for SPVD (Gibson et al. 2000).

Locality	Farmers (%) giving a particular rank to a control measure									No. of farmers
	Symptomless planting material			Roguing			Resistant cultivars			
Rank	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
Bukoba	100	0	0	0	33	0	0	0	0	20
Karagwe	80	0	0	20	10	0	0	0	0	28
Rukungiri	82	14	0	11	50	7	7	14	18	50
Mpigi	88	10	0	2	10	27	10	54	7	50
Soroti	100	0	0	0	17	17	0	17	0	50
Total	**87**	**9**	**0**	**7**	**28**	**13**	**6**	**25**	**9**	**198**

This rejection as planting material of diseased vines is amongst the main control strategies for SPVD (Gibson et al. 2000) (Table 3). Rejection of vines with symptoms of SPVD (to an extent but limited by the local germplasm available) also automatically selects for local varieties which are sufficiently resistant to infection to ensure adequate quantities of unaffected vines are available for planting subsequent crops. Consistent with this, local varieties widely grown in areas where SPVD is common are generally more resistant to infection than ones grown in areas where the disease is rare (Aritua et al. 1998a; Bua et al. 2006). Growing more resistant varieties also generates a 'virtuous cycle' of reducing local sources of SPCSV and so reducing subsequent spread (Aritua et al. 1999). Unfortunately, superior yield, early maturity and other desirable qualities are often less prevalent in SPVD-resistant local varieties even though superior, SPVD-resistant varieties would be the farmers' preferred means of controlling SPVD (Gibson et al. 2000). Releasing superior but SPVD-resistant varieties is one of the main aims of many East African national sweetpotato programs, particularly the Ugandan National Sweetpotato Programme which has recently released the NASPOT series (1 to 6) and other varieties (Mwanga et al. 2007a) and has included the development of a farmer participatory breeding approach (Gibson et al. 2008). One of its outstanding successes has been NASPOT 1 (Mwanga et al. 2003), already one of the most widely grown cultivars in central Uganda due to its high yield and other attributes

(Gibson et al. 2008) and widely grown in the neighboring Lake Zone of Tanzania (I. Ndyetabura, draft report).

Plate 1.
A farmer roguing out SPVD-diseased plants from a young crop.

SPCSV, being the source of synergy for the co-infecting SPFMV (and other viruses), is the pathogen driving the incidence of SPVD. It is transmitted by whiteflies, particularly Bemisia tabaci (Schaefers and Terry 1976). Use of sticky-trap poles has demonstrated that whiteflies remain predominantly within the crop canopy, relatively few being trapped outside a crop (Byamukama et al. 2004). SPCSV is also retained only semi-persistently, making *B. tabaci* viruliferous for at most 1 – 2 days following access to an infected plant (Larsen et al. 1991). Consequently, spread of SPVD occurs only within short distances of infected crops (Aritua et al. 1999) and on-station trials have demonstrated that a distance of only 15 m can dramatically reduce spread from an affected plot to adjacent plots (Gibson et al. 2004; Figure 1).

The occurrence of mainly short-distance spread of SPCSV also means that infection sources within a crop are relatively important and, in crops, plants newly-affected by SPVD are generally concentrated around previously-affected plants.

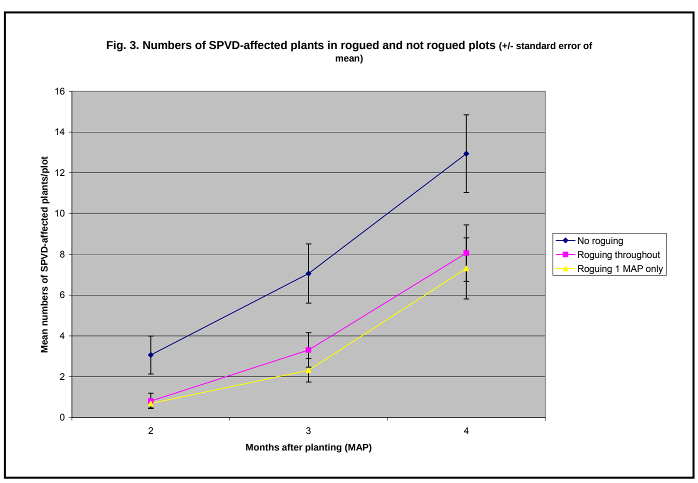
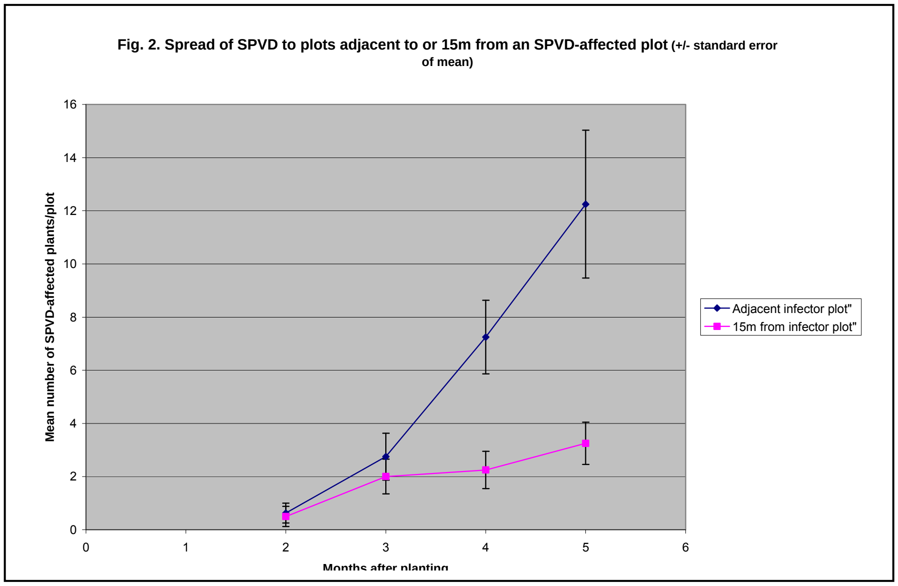


Figure 1.
Spread of SPVD to plots adjacent to or 15 m away from an SPVD-affected plot (+SE) (Gibson et al. 2004).

Figure 2.
Effect of roguing on the spread of SPVD (Gibson et al. 2004).



Consequently, roguing out for the first few months any plants that appear affected also reduces the spread of SPVD within-crop (Plate 1). In on-farm trials (Figure 2), spread of SPVD was reduced by removing the few affected plants appearing in plots even when apparently disease-free planting material is used. Other trials have shown that roguing is a relatively cost-free practice, removing even 50% of cuttings having little apparent effect on the root yield, the non-determinate growth of sweetpotato allowing neighboring plants to compensate for any early-season roguing. Farmers also remarked that planting material taken from rogued crops generated very few infected plants and this long term effect may actually be the main benefit of roguing. Other trials have shown that barrier crops such as maize can further reduce spread but farmer participatory research has so far failed to identify a convenient barrier crop.

Weevils: There are two common species of weevil attacking sweetpotato in East Africa: *C. puncticollis* and *C. brunneus*. The female adults chew small holes in stems or exposed roots in which they lay single eggs. These hatch in a few days and the resulting larvae cause damage by tunneling into stems and exposed roots. When a new crop is planted, eggs and larvae can be transferred on the planting material. On the foliage, eggs are laid and weevil larvae tunnel into mainly the basal part of stems (Plate 2), in extreme cases causing the stems to become extremely swollen and brittle, sometimes breaking. The adults are relatively poor flyers, generally flying <1 km, making it worthwhile to use only the younger portion of shoots as planting material to minimize transfer of eggs and larvae to new crops (Wilson 1988; Stathers et al. 2005); this, and that apical cuttings generate greater yields than basal cuttings (Tewe et al. 2003), appear largely responsible for farmers preferring apical cuttings (Table 2).

Plate 2.
Weevil larva infesting a sweetpotato shoot at its base.

No strong source of natural resistance has been identified to weevils, though it may be possible to combine several weak sources of resistance. However, the storage roots of cultivars in which these form deep underground are largely out of reach from the adults and thus protected from egg-laying and subsequent tunneling by the larvae (Stathers et al. 2005).

Table 4. Ugandan farmers' preference for the apical or middle portion of the vine as planting material (Bashaasha et al. 1995).

District	Number of respondents	Portion of vine planted (% respondents)		
		Apical	Apical + Middle	Middle
Kabale	52	54	44	2
Gulu	53	87	13	-
Iganga	49	94	6	-
Mpigi	47	100	-	-
Luwero	50	100	-	-
Kabarole	44	100	-	-
Arua	49	59	39	2

Physiological vigor of cuttings: Generally, farmers prefer apical portions of vines to plant and it seems significant that this preference is greater in districts in Uganda close to the Equator (Iganga, Mpigi, Kabarole and Luwero), where there is abundant planting material, than north (Gulu and Arua) or south (Kabale) of it, where planting material is scarce after the longer dry season (Table 4). Although there has been relatively little research conducted on the role of the physiological state of cuttings in determining yield, youth generally is associated with greater yields and this may be a greater driving force behind farmers' preference for apical cuttings than the weevil infestations on basal parts of the vine. Thus, cuttings taken from young crops (Wilson 1988; Table 5) or from the younger apical portion of a vine (Belehu 2003; Tewe et al. 2003) generate greater yields than cuttings taken from old crops or mid or basal parts of the vine respectively, presumably some physiological aspect of 'youngness' somehow enabling the resulting plant to be more vigorous.

Table 5. Effect of age of vine cuttings used as planting material on the total root yield (Kg/plant) of four sweetpotato cultivars (Wilson 1988, adapted from F.W. Martin. 1984. Effect of age of planting material on yields of sweetpotato from cuttings. Tropical Root and Tuber Crops Newsletter 15, 22 – 25)

Age of parent crop (Months)	Cultivar				
	Gem	**Miguela**	**Chipper**	**Bonara**	**Mean**
2	1.67a[1]	0.51ab	1.08a	1.38a	1.16a
3	1.65a	0.62a	1.10a	1.38a	1.19a
4	1.62a	0.43b	0.66b	1.05b	0.94b

[1] Means in columns followed by the same letter are not significantly different (*P* = 0.05)

Conclusions on seed systems where crops can be grown throughout the year

Overall, in areas where crops can be grown throughout the year and cuttings obtained readily from the mature crops, there are few constraints on availability of sufficient quantity of planting material but there are quality concerns leading to farmers currently having three main criteria when selecting planting material. These are listed below *together with suggested improvements*:

- Obtain cuttings from plants which are SPVD-free. *Training protocols should be improved to include roguing source crops so they have few diseased plants, and selecting relatively young crops in which SPVD shows up more clearly and in which infection is less likely to have built up.*

- Select varieties which have the attributes desired by the farmers, households or customers, in which the storage roots develop deep underground to protect them from weevil damage and are resistant to SPVD. *Farmers can select only from amongst currently available cultivars; long-term improvement relies on plant breeding.*

- Select apical parts of vines as planting material. *This is beneficial because such cuttings are likely to carry few eggs of weevils and be higher yielding than basal cuttings but additional benefits may be achieved by selecting such cuttings from relatively young crops as they may be physiologically more vigorous and carry even fewer weevil eggs.*

It should be noted, however, that the evidence for these criteria and suggested improvements is based largely on experiments done in central Uganda and the Lake Zone of Tanzania. Although it seems likely they will be effective elsewhere, there is a need to validate them more widely. Once done, there is also a need to disseminate them throughout SSA. Even in Uganda and Tanzania, there has been only limited training of farmers and extensionists and there is a lack of training material in local languages in other SSA countries. There is also a lack of locally-adapted improved SPVD-resistant varieties in most SSA countries. There are therefore still major problems with the quality of sweetpotato planting material throughout SSA. These problems have been particularly critical for the successful adoption of high β-carotene orange-fleshed sweetpotato (OFSP) varieties to eliminate vitamin A deficiencies. Initially, most of the OFSP varieties were exotic and very susceptible to SPVD. This situation was eventually addressed by identifying a few OFSP local varieties such as Ejumula and Kakamega (SPK 004) but these are not as SPVD-resistant and high yielding as white-fleshed sweetpotato (WFSP) such as NASPOT 1. Only now are high-yielding OFSP varieties bred for resistance to SPVD being released (Mwanga et al. 2007a).

SEED SYSTEMS IN REGIONS WITH PROLONGED DRY SEASONS

Accounts of shortages of planting material caused by prolonged dry seasons have been widely reported: e.g., from Uganda (Dunbar 1969), Tanzania (Mwanbene et al. 1994; Kapinga et al. 1995, 1998) and Swaziland (Nsibande and McGeoch 1999). As described earlier, the monsoon rains tend noticeably towards unimodality even just a short distance from the Equator and, in countries like Mozambique, Zimbabwe and Malawi, where the sun is directly overhead only once a year, the single rainy season may last for just 3 - 4 months coupled with a single 8 – 9 months dry season. Sweetpotato crops cannot retain their foliage during such a prolonged dry season. Virus diseases, weevils and the need for young planting material remain as problems but consequent **scarcity of planting material when the rainy season starts** is the factor limiting sweetpotato production in countries located at higher latitudes (Figure 3); the exceptions, such as Madagascar, are generally coastal areas or highlands which obtain sufficient rainfall to ensure adequate supplies of planting materials though special geography.

Table 6. Responses by interviewees in the Lake Zone of Tanzania indicating the extent to which access to planting material is a constraint at the start of the rains (Gibson, unpublished).

District and number of interviewees		Availability of planting material is a problem?					For planting material, do you:	
		No	Small	Main	Limits planting area	Delays planting time	Buy	Sell
Shinyanga	8	3	1	4	7	5	4	3
Meatu	9	0	1	8	9	9	8	3
Mwanza	1	0	0	1	-	-	1	0
Total	18	3	2	13	16	14	13	6

In Tanzania, shortage of planting material, most acute at the beginning of the growing season just after the long dry season, was the major constraint identified by 66% of 77 farmers interviewed and 70% of 80 farmers interviewed in the Lake and Northern zones of Tanzania respectively (Kapinga et al.1995). Farmers may travel long distances to obtain planting material (Mwanbene et al. 1994; Kapinga et al. 1998). In a recent survey (2005) in the Lake Zone of Tanzania (Gibson, unpublished), farmers in Shinyanga and nearby districts confirmed lack of availability of planting material as the main problem in production, both delaying planting time and limiting the area planted. Most farmers thought they would plant about twice as much and about one month earlier if planting material was readily available. Most farmers bought planting material; the concept of getting it free from their neighbors was unrealistic to most farmers and some travelled long distances and incurred considerable costs to obtain planting material. In parts of Meatu district, farmers traveled 50 km (Fare, 3,000/- + 700 – 1,000/- extra for transport of cuttings) and paid 3,000/- (Total = 6 USD) for a bundle of cuttings filling a 100 kg maize/fertilizer bag (as described by producers), planting perhaps 10 – 15 ridges each 10 – 20 m long (as described by purchasers) (Gibson, unpublished). An additional problem that can be created by shortages of planting material is that farmers may be forced to choose from amongst only a limited range of varieties (Kapinga et al. 1995, 1998).

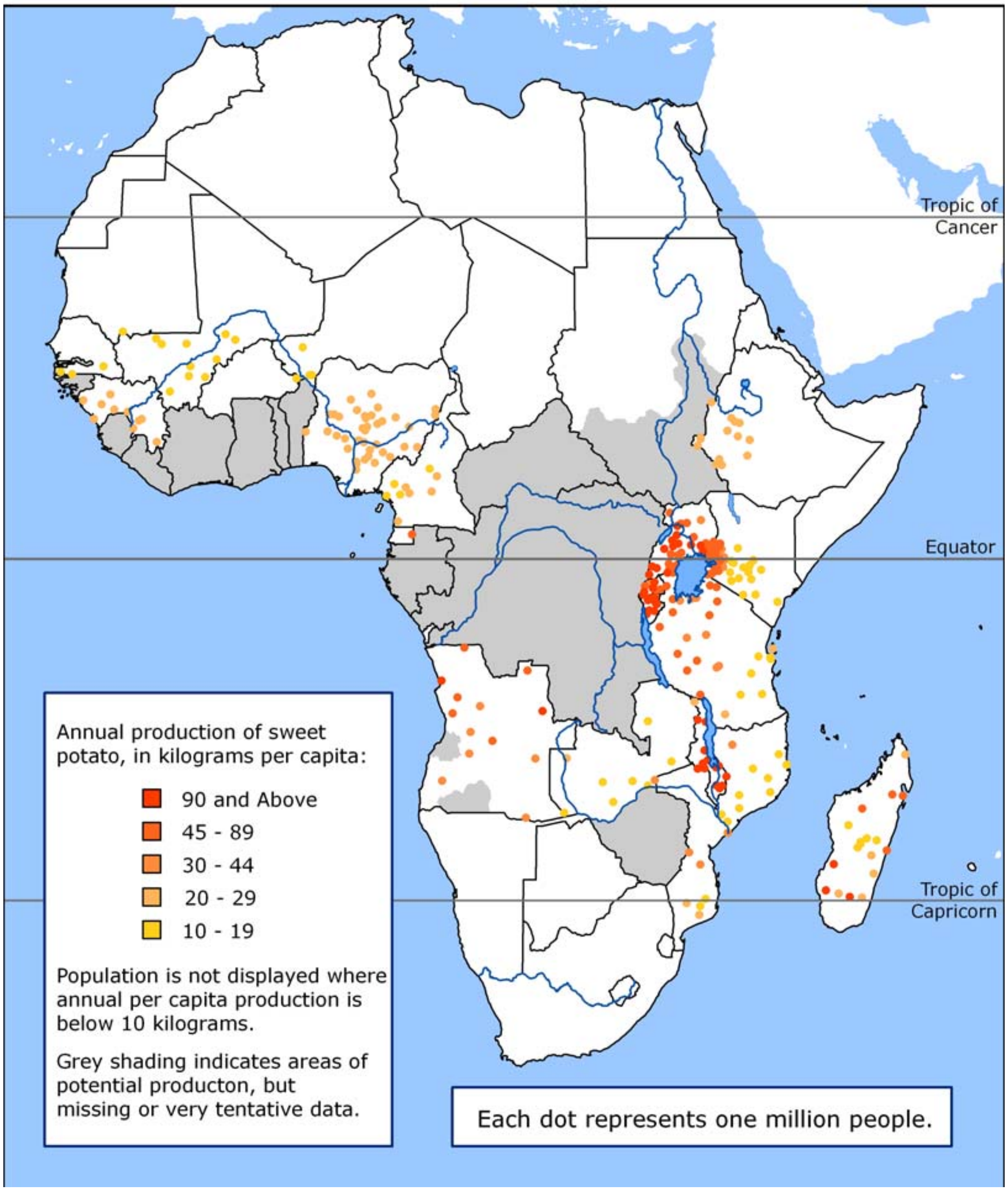


Figure 3.
Map* showing per capita production (kg) in 2006 of sweetpotato in African countries where this exceeds10 kg (http://faostat.fao.org/), showing how production is concentrated along the Equator.

*Map is an adaptation from http://allonsy.files.wordpress.com/2008/03/africa-map.jpg

Current seed systems for regions with prolonged dry seasons

In surveys in Uganda (Gibson, unpublished; Namanda, unpublished; Isubikalu 2007) and Tanzania (Gibson, unpublished; Ndyetabura, unpublished), seven main methods by which farmers conserve planting material during dry seasons can be distinguished:

1) Growing in wetlands (no watering)
2) Growing around waterholes and watering (Plates 3 & 4)
3) Planting in the backyard, watering with 'waste' water (Plates 5 & 6)
4) Taking cuttings from shoots sprouting from roots missed during harvest (Plate 7)
5) Taking cuttings from shoots sprouting from roots of unharvested crops or from sprouts on harvested roots
6) Planting in the shade
7) Planting a late crop that survives the dry season.

All the methods currently have major disadvantages (Table 7), explaining why sweetpotato as a major staple food still remains limited to countries lying close to the Equator (Figure 3). Wetlands or areas where the water table remains high enough to irrigate are relatively rare, often owned by richer farmers, flooded as soon as the rains start (so any planting material becomes inaccessible), may require laborious work to clear abundant natural vegetation, and their future use is likely to be increasingly restricted through environmental concerns. If watering is necessary, doing so throughout the dry season is very laborious and seems largely to involve women and their children (Plate 4). Planting in the backyard and using wastewater is necessarily small-scale (Plate 5); it can be very effective for non-commercial farmers, however, and appears to be particularly widespread in Malawi. Taking cuttings from shoots sprouting from roots, because they involve roots sprouting naturally following the rains, generate planting material only 1 – 2 months after their start and may be less successful with improved varieties that generate mostly large roots, which are not easily overlooked at harvest. These disadvantages are a severe limitation: a survey of some 90 of 105 farmers (Namanda, unpublished) identified early availability of planting material as necessary, mainly because early planting:

- achieves increased and early yields which obtained high prices
- provides a harvest during the time of scarcity before other crops yield
- achieves good establishment in the heavy rains
- ensures good yields, available for preservation by drying when the rains finish.

The last two methods, planting in the shade and planting a late crop, whilst requiring little effort or additional resources, are only effective in areas with relatively short dry seasons such as much of Uganda and Kagera region in Tanzania.

Rapid multiplication techniques (RMT) have been devised for sweetpotato (Benesi et al. 1998; Stathers et al. 2005) but these are suited only for generating planting material during the rainy season rather than in anticipation of it (It is difficult to establish normal-length cuttings in the dry season let alone the very short cuttings used in RMT). Their main role is in making new varieties rapidly available: see **Dissemination of new improved cultivars in a largely informal seed system.**

Plate 3.
Sweetpotato crop (in background) grown close to a waterhole so it can be watered during the dry season (Tanzania.)

Plate 4.
Farmer watering sweetpotato crop grown for planting material (Tanzania).

Plate 5.
A small plot of sweetpotato being conserved from water flowing out from the family washing facility (Tanzania).

Plate 6.
Sweetpotato planting material being multiplied during the dry season in the spillover from the village pump (Malawi).

Plate 7.
A farmer showing the prolific sprouting that occurs when roots are watered after the dry season.

Potential new or improved seed systems for regions with prolonged dry seasons

Roots which survive the dry season buried underground and then sprout with the onset of the rains, despite providing planting material too late to exploit the otherwise early maturity and high yield of sweetpotato, provide a reliable, low maintenance seed system. In order to enable this system to provide planting material in time for the start of the growing season, field trials are currently in progress (S. Namanda, CIP Kampala Regional Office) which test the potential of burying medium to small roots at harvest time at the beginning of the dry season and then watering them 1 – 2 months before the expected start of the growing season.

This mimics the root-based system used in areas with cold winters except that the constraint to crop survival is drought rather than cold. Initial experiments are extremely promising; roots sprout prolifically, each root producing about 10 cuttings within a few weeks and a series of experimental treatments achieving average production of cuttings of 130/m^2 with some treatments reaching 160 cuttings/m^2. This method is also expected to use far less water/cutting than current methods of sustaining planting material since the bed of roots does not need watering till just before the arrival of the rains and since roots establish easily. Indeed, Ugandan and Tanzanian farmers report that early storms enable roots to sprout early and then provide cuttings in time for the arrival of the main rains; a Ugandan farmer in Gulu has reported how he can get about 120 cuttings from just three roots by this method (S. Namanda, personal communication, 2008), Indian farmers in Orissa State apparently also use a similar system already (SK Naskar, personal communication, 2006) and Malawian farmers may use sprouts from stored roots to provide starter cuttings for rapid multiplication (F. Chipungu, personal communication, 2008) , so there seems every reason to expect this modification to be successful.

Seeds provide the natural means by which most plants survive adverse conditions such as drought and are perhaps one of the more obvious ways in which sweetpotato planting material could be made available to farmers at the beginning of the rains, through farmers planting it in nursery beds ahead of the rains. This would also have additional benefits such as ensuring freedom of planting material from many viruses. True potato seed (TPS) (http://www.cipotato.org/regions/swca.asp) is an established means of propagation, especially in India, but there appears to be no report of true sweetpotato seed (TSS) being used to generate crops for root production. TSS does need to be treated with sulfuric acid to break dormancy but, once this is achieved, can easily be sprouted by farmers in small nursery beds (Gibson et al. 2008). The main problem it then has for farmers, though, is that the resulting seedlings are currently extremely heterogeneous.

Table 7. Different seed systems farmers currently use in areas of Africa to cope with prolonged dry seasons.

METHOD	COMMENTS
1. Growing in wetlands (no watering): Farmers have traditional areas of wetlands where they plant sweetpotato as an otherwise normal crop on mounds or ridges at the beginning of the dry season **2. Growing around waterholes and watering:** Where the water table is relatively high, shallow wells are dug and plants are established at the end of the rainy season	**Disadvantages** Wetlands are often either not available or in limited supply. Wetlands are increasingly being protected from farmer use in order to conserve natural resources. A lot of labor may be required to clear wetlands before planting. Being the only green vegetation around, the sweetpotato plots attract grazing domestic and wild animals. When the rains do come, the wetlands may be flooded, destroying the planting material or making it unavailable. During extremely prolonged dry seasons, the water supply may fail and the entire crop lost. *Where watering is done*: If the dry season exceeds 4 – 5 months, a sequential crop may need to be established but establishing cuttings during the dry season is difficult. **Advantages** Planting material is generated in time for the arrival of the rains. Large quantities of planting material are generated in some areas, e.g., around the shore of Lake Victoria, sufficient to plant large areas of land. There may be surplus planting material which can be sold at a high profit. An example is Chibe village in Shinyanga district where some farmers reported obtaining 90 – 140 USD equivalent each year by selling to farmers. Large roots are also generated which can be sold or eaten during a period of food scarcity. *Where watering is needed*: The land may be high enough to avoid flooding.
3. Planting in the backyard, watering with 'waste' water: Planting in a small depression near the homestead that is watered 'automatically' by water from washing, runoff from the roof etc.	**Disadvantages** Because the amount of water available is limited, only small quantities of planting material are generated. No storage roots are generally generated. **Advantages** Labor-saving. The crop is easily protected against grazing or theft. It doesn't requires access to special land; more-or-less everyone can do it.
4. Taking cuttings from shoots sprouting from roots missed during harvest: No special activities **5. Taking cuttings from shoots sprouting from roots of unharvested crops:** Farmers may plant a special late crop	**Disadvantages** Because sprouting starts with the arrival of the rains, planting material is generally available only 1 – 2 months later. The planting material is difficult to protect from grazing animals and theft. Any exposed roots are destroyed by weevils. **Advantages** Very easy and labor-saving. Apparently very reliable; some roots seem to survive even the most prolonged dry season. One surviving root can generate many cuttings.
6. Planting in the shade: Planting in the shade of bananas is common	**Disadvantages** In areas with prolonged dry seasons, bananas are rarely grown and even trees may lose their leaves. No storage roots are generally generated. **Advantages** Very easy and labor-saving.
7. Planting a late crop that survives the dry season: Planted late, the crop it is still growing vigorously when the dry season starts.	**Disadvantages** The crop is often badly attacked by weevils (Sandy soil may minimize this). The cuttings are physiologically old and unlikely to yield well. It only works where the dry season is relatively short and where crops can be protected from grazing animals. **Advantages** As well as supplying planting material for the start of the rains, it also provides roots for food or sale, especially during the early part of the rains when food is scarce

DISSEMINATION OF NEW IMPROVED CULTIVARS IN A LARGELY INFORMAL SEED SYSTEM

Superior varieties can spread relatively quickly through the informal sweetpotato seed system. For example, the cultivar known as Tanzania in Uganda occurs as SPN/0 in Tanzania and as Chingovwa in Zambia: much of this international spread has occured through the informal system. Similarly, cv Dimbuka is a landrace which has been spreading rapidly in Uganda through the informal system; it and cv Tanzania's superiority is recognized in Uganda by national release (Mwanga et al. 2007a). The abundance of foliar cuttings on a crop is such that they are often given freely; indeed, during surveys of the impact of a newly-released variety, it is common for farmers to mention that they had passed planting material on to neighbors and relatives. In this way, planting material can quickly pass to all members of a community. Increasingly, farmers also have relatives who live outside the home community; again during surveys, farmers have occasionally mentioned passing material on to relatives living perhaps >100 km away. Because the cuttings can remain viable for several days after being cut, they can be carried long distances as part of luggage on a bus or other vehicle; the storage roots (unlike cassava storage roots) can also survive several months and produce shoots.

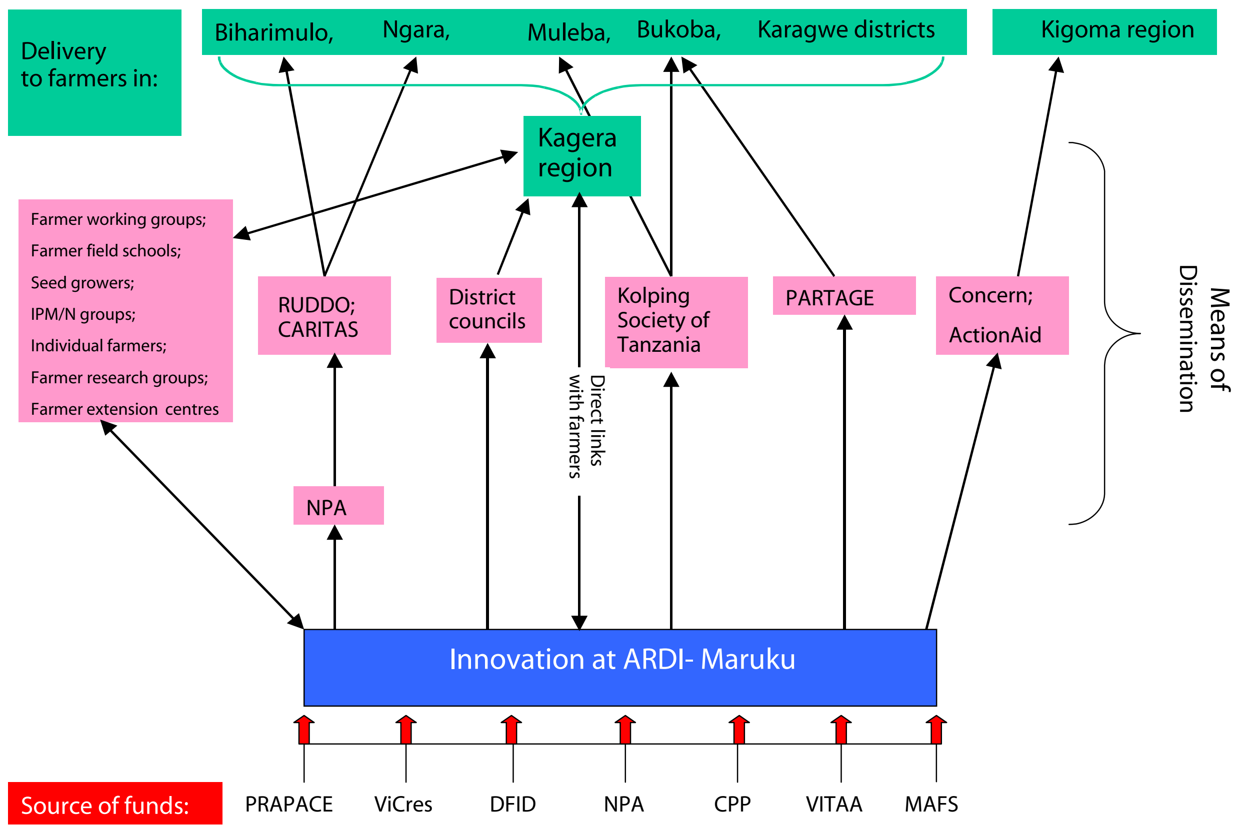
Despite this, it is beneficial if the spread of planting material of superior varieties is facilitated by the formal system (and this is a major advantage of releasing an already established landrace as it allows official resources to be used for this purpose). As mentioned in the **Introduction**, the 'formal' sector of sweetpotato seed systems is often funded through projects of fixed duration and often managed by NGOs. Such a system is suited to the rapid injection of new varieties into the informal system, the formal sector achieving long-distance spread of the new varieties whilst the informal sector sustains it and provides short-distance spread within and to neighboring communities. There are several examples of these, providing 'casebook' examples:

1. **The dissemination of the high yielding Ugandan NASPOT varieties and orange-fleshed varieties of sweetpotato in Uganda** by the Ugandan NGO, BUCADEF (Buganda Cultural and Development Foundation) 2001 - 2003 funded by the Crop Protection UK Department for International Development (DFID) (http://www.research4development.info/SearchResearchDatabase.asp?ProjectID=2917). BUCADEF, with technical support from PRAPACE/CIP and the National Agricultural Research Organization, used farmer-based sweetpotato planting material multiplication. Twenty-five ha of primary multiplication and 18 secondary multiplication fields in nine districts were established with each field capable of producing planting material for 13 ha. Under multiplication were varieties: NASPOT 1,

NASPOT 2, NASPOT 4, NASPOT 5, SPK 004, Ejumula and Kala. Within one year, 30% of BUCADEF's 3000 farmers had accessed the improved varieties and were multiplying them further on over 170 ha across the target districts. The £11 789 cost of the project was estimated to generate over 34 000 tons of improved sweetpotato worth over UK £1 200 000 during the lifetime of the project alone. Since then, NASPOT 1, which has a yield in farmers' fields roughly twice that of the local varieties (Gibson et al. 2008) has become the dominant variety in the Kampala market.

2. **The distribution of NASPOT and Tanzanian varieties in the Lake Zone of Tanzania** also provided a clear example of the efficacy of this approach. NASPOT varieties were transferred to Maruku Agricultural Research Institute (ARI) through quarantine in 2000 funded by Crop Protection UK Department for International Development (DFID) project A1178 and earlier. During the first few seasons, the varieties were trialed on station and then with farmer field schools in Bukoba district. Because of expense and distance from client farmers, the researchers at ARI-Maruku and at the sister ARI-Ukiriguru (comprising the Lake Zone Agricultural Research and Development Institute (LZARDI)) linked with a range of civil organizations, including prisons and training colleges, and with NGOs funded through the Norwegian People's Aid (NPA) decentralizing multiplication of the NASPOT and Tanzanian varieties to farmer groups (Figure 4) (Marandu and Toroka 2003). NPA bought planting material from ARI-Maruku, first multiplied it further at their own nursery and then distributed it to farmer groups on condition that, at harvest of planting material, 1/3rd remained with the group and 2/3rds was distributed to other farmers. Kapinga et al. (2000) also describe how NGOs, special government projects and farmers' community benefit groups were used to promote new varieties in the Lake Zone; then, farmer groups which received planting material were contracted to provide 50% of the harvest of planting material freely to another farmer group, and so on. From a survey of farmers in May 2008, NASPOT 1 is already being grown by some farmers in most of the regions of the Lake Zone and represents about half the crop in Kagera region.

Figure 4. Maruku ARI strategy for developing and disseminating knowledge and resistant varieties to address need for control of SPVD and for high-yielding and orange-fleshed sweetpotato varieties in north-west Tanzania.



1) **The Southern Africa Regional Crops Research Network (SARRNET) project 1998 – 2001** for the multiplication of elite varieties in Malawi (*The Accelerated Multiplication and Distribution of Improved Cassava and SweetPotato Planting Materials and Dissemination of Post-harvest Technologies in Malawi*)
2) [http://www.sarpn.org.za/documents/d0001223/P1355-ASAP-eval-report_Jan2003_obj3_G.pdf]. Four elite varieties were introduced: Mugamba, Kenya, Semusa and Tainoni. To achieve its objectives, SARRNET linked with research institutes, national extension services and NGOs operating in Malawi. Three regional research stations at Chitedze, Lunyangwa, and Bvumbe managed four primary nursery multiplication sites, with a total of 8.5 ha. The Department of Agricultural Research and Technical Services, working through the Agricultural Development Divisions in Lilongwe, Salima, Kasungu, Machinga, Blantyre, and Shire Valley, managed 15 secondary nursery sites covering 53.4 ha. Sixteen tertiary nursery sites were managed by nine NGOs, including one farmers' group, and one private sector business organization. These tertiary nurseries covered an area of 134.5 ha. These NGO partners included: the Christian Service Committee, Evangelical Lutheran Development Project, Save the Children Federation US, CARE International, World Vision International, Sustainable Livelihood Project, the Ntendere Catholic Parish in Dedza, the Lutheran Mobile Clinic, the German Technical Assistance Agency, and the Chilaza Farmers Group. Universal Industries Limited also operated a small tertiary nursery of 1.5 ha. These NGOs had farmer extension networks in different parts of Malawi and established nursery multiplication/ demonstration plots strategically in client communities.

Table 8. Sweetpotato planting materials distributed from project nurseries and estimated area planted 1997 – 2001

Year	Vines distributed	Area planted (ha)	% increase from previous year
1997/98	82,460	9	-
1998/99	434,422	47	817
1999/00	998,715	108	230
2000/01	3,816,000	413	382

In addition to project supported nurseries, private farmers managed an additional 240 ha of nurseries, producing planting material in 2000/01 alone for 3,600 ha. The combined total of this and project nursery production sums to sufficient to plant 4,013 ha in the 2000/01 season. This compares with an initial starting point of 9 ha of improved planting materials in 1997/8 and constituted some 2.5 percent of sweetpotato planted that year in Malawi; it was estimated that the improved varieties provided average yield increases of about 3 t/ha.

3. The GTZ-funded CIP project, 'The large-scale deployment of improved sweet potatoes in sub-Saharan Africa' (Potts 2006). This international project involved two international organizations (CIP & PRAPACE), scientists in four national agricultural research organizations (National Agricultural Research Organization (NARO), Uganda, Kenya Agricultural Research Institute (KARI) Kakamega, Ethiopian Institute of Agricultural Research (EIAR) and Tanzanian Root and Tuber Programme), four universities (Makerere University, Nairobi University, Kenyatta University, University of Hohenheim), 22 NGOs (Ethiopia 8, Kenya 10, Tanzania 2, Uganda 2), various church groups and Government Ministries in target countries (Agriculture, Health and Education) and other international agricultural research centers [IARCs] (ILRI, ICRAF). Over 40 million vines have been distributed in Ethiopia, Uganda, Tanzania and Kenya with emphasis on introduction and promotion of orange-fleshed varieties because of the health-promoting properties of the β-carotene (pro-vitamin A) they contain (Plate 8). RMT were not adopted by either NGOs or farmers, the additional labor making them unattractive (Gonzales de Uzquetta de Lorza 2006). The involvement of NGOs provided both a quick entry for the project through their established farmer groups and access to training and extension services for their farmers. However, NGOs provided vines freely and led to an expectation of further free supplies which was not sustainable and disrupted informal seed systems. Schools were also successfully involved in Uganda, both in Kampala and also in all 248 primary schools in the more rural Tororo District.

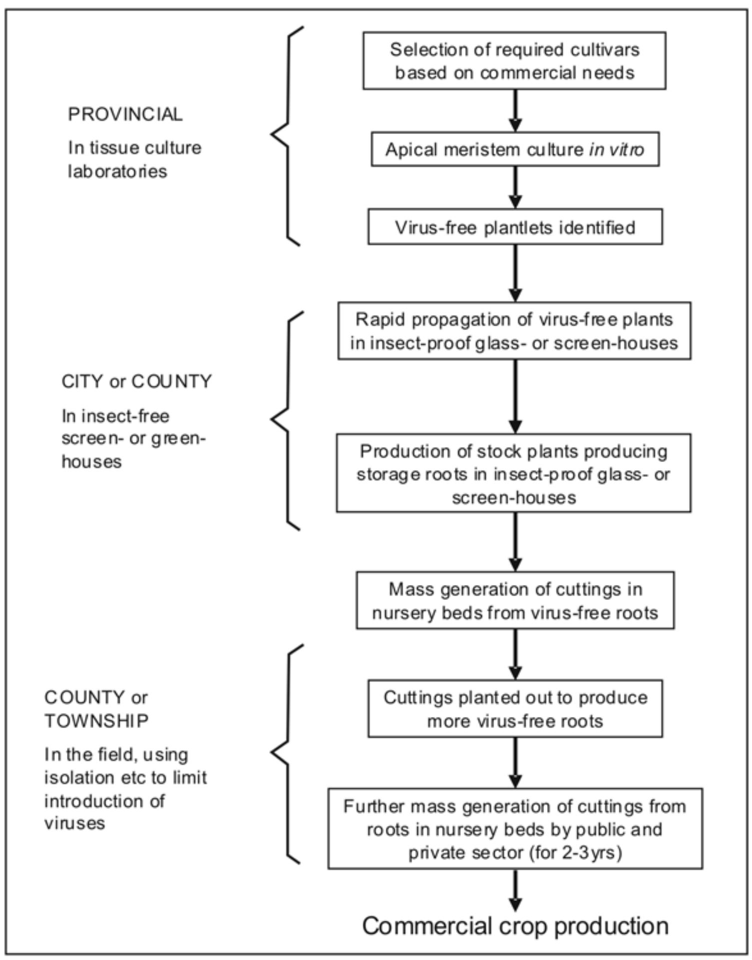
Plate 8. A cross-section of a root of cv Ejumula, showing its deep orange, β-carotene-containing flesh.

There appear to be several commonalities amongst the four examples. They all focus on, and were successful at, introducing elite varieties. The first two examples also show that not all varieties were equally adopted by farmers, indicating that the ultimate success of the ventures was driven by the superiority of the introduced varieties as well as the system used for their dissemination. All four examples involved scientists at national ARIs providing initial planting material and perhaps the initial appreciation of the potential value of particular elite varieties. They often were also involved in training of trainers and technical quality (plant health particularly) control but not otherwise: most activities in all four projects were decentralized and through a wide range of civil organizations. In this, there was always a strong NGO component and their extension services appear to have been very important; however, rather than providing vines to individual farmers, their entry point was generally through communal nurseries which served the double function of multiplication sites for planting material and demonstration plots, sometimes supported more purposely in this role by farmer field schools. Educational civil societies were also prominent, particularly rural primary schools and agricultural training institutes and universities. Although with a focus on providing virus-free planting material (see next section), Robertson (2006) recommended the use of churches as well as schools for group training and also challenged recipient farmers to sell planting material to at least 10 more farmers rather than giving planting material to just one (Kapinga et al. 2000) or two (Marandu & Toroka 2003) other groups.

HEALTH, PARTICULARLY FREEDOM FROM ASYMPTOMATIC VIRUSES, IN CLONAL PROPAGATION

Vegetatively-propagated crops such as sweetpotato are prone to so-called degeneration, in which yields of crops planted with succeeding generations of the same vegetatively-propagated stock decline. In most cases, this is associated with a progressive build-up of viruses in the stock as a result of systemic virus infections in the plants being transferred through each generation. This, combined with natural spread, leads to infection remorselessely building up. In sweetpotato, this process has been demonstrated in stocks of commercial varieties. In China, yield of virus-free planting material of various Chinese sweetpotato varieties was initially, according to the variety, from 10 -134% more (cv Guangzhou) and 6 – 41% (cv Zhanjiang) more than 'normal' planting material, but gradually declined over generations, becoming similarly low by generation five (Lepoivre 1996). SPFMV, Sweetpotato virus G (SPVG) and Sweetpotato latent virus (SPLV) potyviruses were identified as the cause of the degeneration. In the late 1980s, CIP began a collaboration with Chinese agricultural scientists, developing new methods of propagating virus-free materials (Fuglie et al. 1999). Use of virus-free planting material has now become widespread amongst Chinese farmers as a result of the very evident increase in root yield: for the most widely grown variety, Xushu 18, virus-free material yields about 11t/ha, more than 30% greater than normal planting material and, in Shandong Province, has reached at least 78% of farmers. Use of virus-free planting material is estimated to have increased production by 3.965 x 10^6 t/yr with an estimated value of US$167 x 10^6/year and net benefit of US$145 x 10^6/year (Fuglie et al. 1999). Because of its success, the Chinese procedure is described in Figure 5. Similarly, commercial varieties released in South Africa were found to quickly decline in yield, virus-free material yielding about 50% more than field material which was found to be largely infected by SPFMV; replacement every three years was sufficient to maintain yields (Joubert et al. 1979; Laurie et al. 2001). In Nigeria, planting material derived from *in vitro* (presumed virus free) plantlets of five International Institute of Tropical Agriculture (IITA) varieties mostly yielded 30 – 40% more than field derived planting material even though there were no apparent morphological differences (Tewe et al. 2003).

Figure 5. The system of generating virus-free planting material in China (adapted from Gao et al. 2000).



Even more dramatically, farmers in Zimbabwe are reported to usually get only 3 – 4 t/ha from their local planting material but virus-free planting material can yield 20 t/ha (Robertson 2006). These outcomes have led to field stock of commercial varieties being freed of viruses by meristem tip culture sometimes supplemented by thermotherapy and have led to the development of an extensive scheme to provide commercial farmers in South Africa with virus-free planting material (Laurie et al. 2001). This is based on identifying virus-free stocks of important cultivars by indexing to the virus indicator test plant, *Ipomoea setosa*, maintaining them in insect-proof screenhouses and routinely re-indexing. Virus-free material is provided to the Sweet Potato Vine Growers Association and other growers who further multiply the material before cuttings are used to grow commercial crops: an estimated 80 – 90% of commercial sweetpotato production in South Africa originates from this virus-free scheme. The concept has also been extended in Zimbabwe to deliver virus-free planting material to small-scale farmers. Rooted cuttings of virus-free material are packed in cardboard boxes and sent to nursery farmers who have access to year-round water. After training in groups at local schools and churches, each is challenged to sell planting material to at least 10 more farmers when the rains arrive. With funding from various NGOs including the Swedish Cooperative Centre (SCC), they have reached 400 000 families, probably at least 2 million people and, because of the high yield of the virus-free material, a plot just 20 x 20 m can feed a family of 5*.
A cost benefit analysis from revitalizing sweetpotato in Zimbabwe has shown an impressive 17:2 benefit-cost ratio**. However, new stock does not maintain its high yield; viruses reinvade and further supplies of clean material need to be obtained and the long-term sustainability of this approach without external donor funding is still unclear.

Despite the above, landraces bred and grown by farmers in Africa, together with some researcher-bred varieties (with the breeding being carried out in East Africa), mostly seem to show little evidence of degeneration. Landraces such as Kyebandura, Kalebe and Bitambi were being grown in Uganda in 1963 (Dunbar 1969) and retain a competitive yield such that they are still grown (Bashaasha et al. 1995). Similarly, the variety NASPOT 1 was grown from seed generated in 1991 by uncontrolled cross-pollination in a crossing block at the Namulonge Agricultural and Animal Production Research Institute (NAARI) (now the Ugandan National Crops Resources Research Institute (NaCRRI)) in which a high proportion of the parental clones were local Ugandan varieties. Following preliminary screening at NAARI where SPVD is extremely common, it was tested for 10 generations on-station and on-farm during 1993 – 1998 in Uganda,

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* Robertson 2006; http://www.guardian.co.uk/world/2005/feb/18/outlook.development

**http://www.britishembassy.gov.uk/servlet/Front?pagename=OpenMarket/ Xcelerate/ShowPage&c=Page&cid=1184758048512

including areas where SPVD is prevalent (Mwanga et al. 2003). Since then, it has been maintained by farmers and at NAARI, remaining popular because of its high yield.

The first apparent direct confirmation of a lack of viral degeneration amongst such local cultivars was obtained during a CIP-led DFID-funded holdback project in which extensive field trials compared the productivity of virus-free and farmer-derived planting material (Carey, Turyamureeba, Kasule, Mwanga and Gibson, unpublished) of three Ugandan sweetpotato cultivars Tanzania, Bwanjule, and Wagabolige, selected from amongst Ugandan local germplasm (Mwanga et al. 2001). Pathogen-tested *in vitro* plantlets of all three varieties were provided by CIP Lima from clones that had been subjected to thermotherapy, *in vitro* meristem culture and indexing using indicator plants, serological techniques and electron microscopy. These were propagated in a screenhouse and subsequently in the field at the NaCRRI farm under whitefly- and aphid-proof row covers. Apparently healthy, but not pathogen-tested, planting material of the same cultivars obtained from the NaCRRI farm was also propagated under the vector-proof row covers to provide physiologically similar planting material. These latter materials were originally collected from farmers' fields where they had been vegetatively propagated for many generations, had also been propagated for several generations outside at NaCRRI farm and had never been subjected to any artificial procedure for freeing them from viruses.

Trials (randomized complete block design with three replications) were planted for two successive growing seasons and at three locations in Uganda: Kachwekano near Kabale in the southwestern highlands (1 trial), Nakabango near Jinja about 80 km to the east of Kampala (2 trials), and NAARI near Kampala (2 trials). As is standard for sweetpotato production in Uganda, the trials were grown without chemical inputs under rain-fed conditions. There were no significant effects of source of planting material in any trial (P>0.05) (Table 9).

Table 9. Fresh storage root yields of three sweetpotato cultivars (Tanzania (TZ), Bwanjule (BJ) and Wagabolige (WB)) grown from pathogen-tested (PT) and farm-derived (F) planting materials at three locations in Uganda during two seasons.

		Location and season				
		Kachwekano	**Nakabango**		**NAARI**	
		1995	**1995**	**1996**	**1995**	**1996**
Cultivar[a]	**Source**[b]	**t/ha**	**t/ha**	**t/ha**	**kg/plant**	**t/ha**
TZ	PT	15.00	39.79	11.43	0.29	22.47
	F	12.57	28.68	13.32	0.27	14.63
BJ	PT	5.90	28.19	19.21	0.25	18.15
	F	9.86	22.08	17.93	0.30	13.66
WB	PT	6.25	20.83	20.28	0.38	15.88
	F	10.49	23.82	17.47	0.29	17.82
F Significance[c]						
Source (S)		NS	NS	NS	NS	NS
C x S		NS	NS	NS	NS	NS

Similarly, Ndolo et al. (2007) reported that, in one experiment, there was no difference in the root yield of planting material derived from virus-free pathogen tested or from healthy-appearing, farmer derived in five varieties [Kembe 10, KSP 20, Mogamba, Mugande and Zapallo] grown in Kenya. However, in a second experiment in Western Kenya, farmer-derived material of the same five varieties yielded about 30% less than the virus-free material.

Table 10. Infections revealed by grafting symptomless field plants from different locations in Uganda onto *I. setosa.*

Cultivar - District	Infected/tested	% negative
Cv Tanzania – Mpigi (NAARI)	9/31	71
Tanzania – Soroti (Farmer)	3/20	85
Tanzania – Mpigi (Farmer)	0/8	100
Unknown cv – Luwero (Farmer)	1/20	95
New Kawogo – Mpigi (NAARI)	4/29	86
Total	17/116	85
Positive controls [SPFMV-infected cv Tanzania]	*31/35*	*11*

When cuttings were obtained from asymptomatic field plants in farmers' fields or at NaCRRI - such as farmers would normally use as normal planting material (Bashaasha et al. 1995) – and tested for virus infection by grafting to *I. setosa*, most were virus-free and the infected 15% all had SPFMV (Table 10) (Gibson et al. 1997). These results have been confirmed by subsequent independent studies in Uganda and elsewhere in Africa:

- In Uganda, Mukasa et al. (2003) also reported that 'The vigorous and healthy looking plants sampled from the fields during the survey did not develop symptoms in the screenhouse and did not react with any virus antisera'. The 'results indicate that Ugandan farmers are successful in obtaining a reasonable proportion of virus free plants by selecting for healthy and vigorous vines for the next cropping cycle'.
- In South Africa, 32% of cuttings from symptomless field plants of local farmer varieties were found to be virus free when indexed on *I. setosa* (Laurie et al. 2001)
- In Tanzania, 38 (52%) of 73 symptomless plants collected in field crops were seronegative for viruses (Tairo et al. 2004)
- In Kenya, 477 (75%) of 638 asymptomatic plants collected from farmers' fields throughout Kenya were both seronegative for viruses and found to be virus free when indexed on *I. setosa* (Ateka et al. 2004).

In all cases, the main virus infecting the infected asymptomatic plants was SPFMV (Table 11)

Table 11. Viruses detected in 638 asymptomatic sweetpotato plants collected in the field in Kenya (Ateka et al. 2004)

None detected	SPFMV	SPMMV	SPCSV	SPFMV + SPMMV	SPFMV + SPCFV	SPFMV + SPCSV	SPFMV + SPMMV + SPCFV	SPMMV + SPCFV
477 (75%)	109 (17%)	21 (3%)	15 (2%)	10 (2%)	3 (<1%)	1 (<1%)	1 (<1%)	1 (<1%)

It should, however, be expected that SPFMV and other largely asymptomatic viruses should accumulate to infect 100% of field plants because:

- Field plants are continuously subjected to inoculation, particularly by aphid-transmitted SPFMV; the high titer of this virus in SPVD-affected plants makes these a potent source (Aritua et al. 1999)
- Since SPFMV (and SPMMV) are largely asymptomatic in sweetpotato when infecting alone, the selection by farmers of disease-free plants as parental material for cuttings cannot select against SPFMV-infected plants

The explanation of this conundrum appears to be that local varieties of sweetpotato possess a capacity to free themselves from infection. Thus, Aritua et al. (1998b) showed that cuttings taken from plants of cultivars (cvs) New Kawogo and Tanzania originally infected with SPFMV gradually developed vines free of these viruses over a six month period in a screenhouse in Uganda (Table 12). In the same period, a further 16 cuttings of both varieties planted in the field at NAARI provided shoot tips, all of which were virus-free.

Table 12. Changes in the % of shoot tips of cvs New Kawogo and Tanzania previously graft-inoculated and infected with SPFMV which tested SPFMV-free in subsequent back-tests to I. setosa.

Months after planting in screenhouse	Number of shoot tip cuttings (out of 16) testing SPFMV-free	
	Tanzania	New Kawogo
2	3 (19%)	5 (31%)
4	5 (31%)	9 (56%)
6	8 (50%)	11 (69%)

Although this appears to be remarkable, it should be appreciated that cassava varieties resistant to African cassava mosaic virus have the capacity whereby diseased plants gradually revert to healthy (Fargette et al. 1994), reversion being particularly favored in hot conditions (Gibson and Otim-Nape 1997) such as must especially occur in sweetpotato crops growing close to the ground. This capacity to revert to healthy is a key component in the survival of cassava in Africa (Fargette et al. 1994); unlike SPFMV which is asymptomatic in sweetpotato, reversion can be seen in cassava because *African cassava mosaic virus*-infected plants show severe symptoms and the plants recover from the disease as they revert to healthy, so its significance has been long appreciated. The mechanism by which this occurs is associated with RNA (ribonucleic acid) silencing (RS). RS, triggered by double stranded RNA (dsRNA), is a fundamental RNA surveillance system controlling gene expression in eukaryotes and is a key plant defense against systemic virus infection (Voinnet et al. 1999; Waterhouse et al. 2001). Short (21-26 nucleotide (nt)) interfering RNA (siRNA) (Hamilton and Baulcombe 1999) is generated from target dsRNA by RNaseIII type enzymes, also known as Dicer (Baulcombe 2002) from their ability to cut dsRNA into many siRNA. These siRNA then serve as guides identifying homologous sections of dsRNA for cleavage and further degradation. This degradation of dsRNA produced, e.g., during replication of invading RNA viruses, provides the main viral defense in plants once infection has been initiated. The Biotechnological and Biological Science Research Council (BBSRC) of the UK has recently funded a research team including NRI, CIP, NaCRRI and Makerere University to research the exact mechanism of reversion in sweetpotato (How resistant plant varieties avoid suppression of RNA silencing by viruses as exemplified by sweetpotato: *Better food security through virus control*: ref BB/F004028/1).

For local varieties in tropical Africa, the ability to revert to healthy is likely to be an important survival attribute and almost immediately so because, in smallholder farming systems, seedlings which are unable to free themselves of infection would otherwise quickly become infected and inevitably degenerate: although SPFMV alone causes negligible foliar symptoms, it can quite markedly reduce yields of some varieties in Africa (Njeru et al. 2004; Gibson et al. 1997). For plant breeders, it may be that the inability to see reversion occurring in sweetpotato has made it difficult to select for this character purposely. Most formal sweetpotato breeding occurs in warm temperate climates where SPVD is rare so the spread of SPFMV is slow (Milgram et al. 1996) and effects of infection therefore take much longer to affect yield. SPVD is common at NaCRRI, CIP-Mozambique and CIP-Lima, so spread of SPFMV at these sites may be sufficiently rapid to ensure selection for reversion through maintained high yields.

The key question raised by the contents of this section is: 'Is there a need for seed systems in Africa which provide virus-free planting material for farmers?' As regards local landraces, the answer seems to be 'No'. This outcome is fortunate because it would be extremely difficult, probably impractical, to provide such a system to the millions of smallholder farmers who would otherwise need to receive them. However, for commercial farming, it is perhaps not yet certain that it will prove possible to identify varieties which combine resistance to degeneration with the high qualities and yield demanded by commercial farmers and the market, although NASPOT 1 is probably an example of a variety that does achieve this.

DEVELOPMENT OF NEW CULTIVARS

There is only a small commercial sector involved in production of sweetpotato in much of Africa including East Africa. There are mainly local markets for planting material and, with no easy way of marketing its product, there is no formal commercial breeding, a situation that seems unlikely to change in the near future. Currently, there seem only three main sources of new cultivars in East Africa (and a similar situation seems to be present throughout Africa). These are:

- Farmers
- National agricultural research institutes
- International agricultural research institutes belonging to the Consultative Group for International Agricultural Research (CGIAR).

Although relevant in cassava breeding, for example, in Ghana, national agricultural universities appear not yet to have become involved in sweetpotato breeding; NGOs and other civil society organizations also seem absent.

Farmers

The hundreds of local landraces bred informally by farmers have long been the mainstay of sweetpotato production; only in the last decade have purposely-bred varieties had even a minor role in production in East Africa. Correspondingly long lists of landraces are included within the reviews of the Tanzanian (Kapinga et al. 1995) and Ugandan (Bashaasha et al. 1995) sweetpotato food and farming systems and the latter highlights some of their diverse qualities. This adaptation of sweetpotato to African conditions and the creation of this diversity of landraces in just the few hundreds of years since the arrival of the crop from the Americas is one of the major, but seldom mentioned, achievements of African farmers. Despite this and the overwhelming predominance of landraces in Africa, the exact process by which this occurs is more-or-less undocumented but, presumably, chance seedlings occurred, robust ones survived and ones which were both robust and had other good attributes were noticed by farmers and propagated. Despite the seeming simplicity of the process, Gibson et al. (2000) describe many of the difficulties of the process: the farmers themselves do not understand the value or the process by which seedlings express diversity, pollen incompatibilities reduce seed set, sweetpotato seeds themselves have prolonged dormancy, few seedlings consequently appear in farmers' fields, most of those that appear are hoed up and the majority of those that avoid this will not be superior to the farmers' current varieties in their yield or resistance to pests, diseases and the adverse climate and soil conditions. Despite this (or perhaps because of the many barriers landraces have had to surmount), some farmer varieties are very good and have been officially released (Mwanga et al. 2001; Mwanga et al. 2007a and b).

The success of farmer breeding despite its many obstacles has led to researchers adopting closer links with farmers in screening. Generally, initial screening is done on-station and only the relatively superior clones are tested on-farm and with farmers at multilocational sites. However, the participation of farmers has been experimentally extended in Uganda and Tanzania to the point where only the production of seeds (and that from mainly local germplasm) is done on-station, seedlings being generated on farm and selected for superior traits by researchers and farmers in on-farm trials (Gibson et al. 2008). Again, the strategy of taking successful material back into the formal system is being done, superior clones identified by this process being tested in multilocational trials as part of national release.

Plate 9. Farmers and researchers selecting superior clones during farmer participatory plant breeding.

National Agricultural Research Institutes

Formal plant breeding of sweetpotato throughout Africa is concentrated in national agricultural research institutes and ones such as NaCRRI also provide a regional service, supplying seed and selected clones to other national programs. At NaCRRI, sweetpotato seed is generated predominantly in a crossing block in which bees provide uncontrolled natural cross-pollination, although controlled crossing is also practiced.

A synopsis of breeding work of the Ugandan National Sweetpotato Program

Crossing block and initial screening: At NaCRRI: 1,150 masl in Central Uganda, tall grassland ecozone, red sandy clay loam
Other main trial sites:

- Kachwekano: 2,220 masl in southwestern Uganda, short grassland ecozone, sandy clay loam
- Ngetta ARDC: 1,180 masl in northern Uganda, savannah grassland ecozone, sandy loam soil
- Serere: 1,140 masl; in north-eastern Uganda, savannah grassland ecozone, sandy loam soil

Key attributes selected for include: root & vine yields, early maturity, % dry matter, orange flesh (β-carotene), cooked root acceptability, resistances to weevils, SPVD, Alternaria, sprouting, rotting, cracking.
Varieties released: 19 varieties released in total: six in 1995 (Mwanga et al. 2001); six in 1999 (Mwanga et al. 2003); two in 2004 (Mwanga et al. 2007a) and five in 2007 (Mwanga et al. 2007b).

Plate 10. The crossing block at NaCCRI, Uganda.

In such circumstances, only the mother is known and so-called 'half-sib' populations are generated. At the NaCRRI crossing block, most parental genotypes are East African landraces; a major problem with exotic germplasm is that most is highly susceptible to SPVD. For example, during 2000 – 2001, the crossing block comprised 11 landraces, four of which have been released, five varieties bred at NaCRRI, five advanced clones and three exotic varieties introduced from the Americas (Mwanga et al. 2007a). Similar crossing blocks are, for example, at Maruku Agricultural Research I in the Lake Zone of Tanzania. Because of the polyploidy and heterozygosity of sweetpotato, thousands of seedlings generally need to be screened in order to identify superior SPVD-resistant clones (Carey et al. 1997); hand-pollination is very laborious under such circumstances. In general, seedling populations are initially screened on-station and apparently superior clones are then tested in multilocational trials, often on-farm, for yield stability and other attributes, prior to submission to a national release committee.

International CGIAR Agricultural Research Institutes

The International Institute for Tropical Agriculture had (now ceased) an extensive sweetpotato breeding program at its headquarters in Ibadan, Nigeria, generating the extensive 'TIS' (Tropical Ipomoea species) series of about 50 improved clones which were released to national programs. Several resulting clones have been adopted in West Africa (Whyte 1992). These were tested in East and Central Africa, for example, in Rwanda (IITA 1986); however, the strain of SPCSV present in East Africa is different from that found in West Africa and the TIS clones were generally found to be susceptible to SPVD in East Africa (personal observations in Tanzania; at NaCRRI in Uganda (Mwanga et al. 1991)). From 1977 to 1988, when IITA passed responsibility for sweetpotato improvement to CIP, a sizeable amount of breeding stock was developed and distributed as virus-free plantlets to national programs worldwide. By 1988, at least fifty improved clones, based on IITA germplasm, had been officially released.

CIP now has adaptive breeding projects in East and Southern Africa based at its liaison offices in Kampala, Uganda [R. Kapinga and S. Tumwegire] and in Mozambique [M. Andrade] and has strategic breeding projects at its headquarters in Lima. The SSA activities are mainly coordinated with national programs and involve multilocational and multinational trials. Seedlines from within its international germplasm collection at CIP-Lima with specific valuable attributes such as orange flesh high β-carotene or virus resistance are also imported for collaborative testing with, and incorporating into, national programs. Support is provided for regional quarantine services at the Kenya Quarantine Service, Kenya and CIP Seed Unit in Kenya, enabling regional and international germplasm to be available for exchange within the region.

DISCUSSION

The greatest limitation of the current sweetpotato seed system is the supply of planting material at the beginning of the rainy season in areas where there is a prolonged drought. This is also one of the greatest opportunities for sweetpotato: as an early-maturing high-yielding crop, early-planted sweetpotato has the potential to provide food during a period when grain stores in such regions are generally empty, other foods are not available and prices are high. Early planting also realizes the potential of the crop to produce very high yields, higher than any other widely grown alternative such as maize or sorghum: sweetpotato can generate 194 MJ food energy/ha/day as compared with 145 MJ/ha/day for maize and 101 MJ/ha/day for sorghum (Woolfe 1992). It is also significant that this limitation occurs especially in some of the poorest countries in Africa, generally in the poorest parts of individual countries and in the parts of Africa where climate change is likely to exacerbate poverty the most. In areas which are commonly calorie deficient, the high productivity is also crucially important.

The single most required improvement to sweetpotato seed systems is therefore one that enables planting material to be available in abundance and of the right variety etc. at the beginning of the rains. Although no current system has the potential to fully address the problem, some of those used could beneficially be disseminated more widely. The most notable example of this is:

- **Systems which automatically channel waste domestic water** into nursery beds or more intensive systems of vegetative maintenance around the house.

Though valuable, all current systems seem to have insufficient production capacity/household and none solve the problem.

Instead, a new technology developing current farmer practice seems likely to have the potential to achieve the required step change in secure production of planting material in areas with prolonged dry seasons. This immediate opportunity is:

- **Use of root nursery beds combined with timely watering**: Field observations and farmers' current use show that roots left unharvested in the soil can survive the dry season and will sprout upon arrival of the rains. The successful use of such shoots as planting material by farmers in Africa and the purposeful planting of roots for such shoots in nursery beds in northern cropping systems confirm the utility of these shoots as planting material. The new concept that has been developed is to collect small- to medium-sized roots at harvesting time at the end of the rainy season, plant them in a nursery bed but to start watering (and only small amounts are needed) about 5 – 7 weeks before the expected arrival of the rains, so obtaining large amounts of planting material from a small area and with only limited watering. **This protocol now needs testing widely with farmers both as part of necessary applied research and as the start of its dissemination to farmers**.

A longer term approach still requiring strategic as well as applied research to validate is the use of seeds. Seeds are nature's common answer to survival during adverse conditions such as prolonged dry seasons. They are currently not used for producing crops of sweetpotato because their heterozygosity leads to diverse phenotypes in seedling populations, dormancy and probably a host of minor problems. However, these problems are surmountable, perhaps even relatively easily through doubling dihaploids and then generating F1 hybrid seed. Relatively small resourcing over several years might thus provide a completely new means of addressing the critical constraint of shortage of planting material at the beginning of the rainy season.

Much of the work described in this review is based on work done in Uganda. To build and extend from this, there is a need for limited work to validate the training messages elsewhere in Africa. These will also need modifying, for example, translated into local languages and adjusted for local cultures. The predominance in Africa of the smallholder sector in sweetpotato production and in sweetpotato seed systems means that improvements need to be focused here if they are to have impact, particularly in improving the livelihoods of large numbers of relatively poor people. The lack of a large national or commercial sector interacting with this smallholder sector and the sheer numbers of smallholder farmers growing sweetpotatoes mean that it is necessary for innovations to be presented directly to farmers, often in groups for economy and other reasons, so that they are in a position to choose which to adopt and they themselves can further disseminate the new process or product through informal channels. These circumstances have led to innovative learning systems incorporating decentralized approaches, for example, farmer field schools (FFS) (Stathers et al. 2005) and participatory plant breeding (PPB) (Gibson et al. 2008) such that farmers can readily learn the benefits of new production or postharvest processes or new cultivars. Allowing farmers a major role in development of the new processes or cultivars, they enable technologies to be adapted to fit the needs of farmers more closely and so achieve greater/faster adoption. Use of informal systems means that the spread of the new process or variety become self-sustaining, fitting into time-bound projects. They have also led to projects involving diverse organizations, particularly involving civil societies, as a means of presenting new products or processes as widely and as quickly as possible (Figure 4); as well as NGOs, the involvement of rural schools seems particularly appropriate (Potts 2006).

In the informal sector of sweetpotato seed systems, the introduction of new varieties has currently had most impact, whether this introduction has been largely informal as with Tanzania/SPN/0 spreading south into Zambia etc. or the intervention-led spread of NASPOT 1 in Uganda and the Lake Zone of Tanzania. Although poorly documented, it seems likely that it is the spread of such high yielding and good tasting, quality varieties rather than programs simply popularizing the crop that has enabled also wholesale changes to be made in the production and marketing system of sweetpotato. Thus, these new varieties have underpinned the increased importance of sweetpotato in the diets and livelihoods of people in southern Africa and, in Uganda, the arrival of a high-yielding, SPVD-resistant NASPOT 1 has allowed production for the Kampala market to shift from being based mainly in the north-east around Soroti (where SPVD is rare) to the Central Zone around Kampala (where SPVD is prevalent). The introduction of orange-fleshed varieties is also already having a similar wholesale change, shifting sweetpotato from being just a stomach-filling staple food to also being a health-food appreciated as being particularly valuable for children. There is also an immediate need to extend local breeding for improved SPVD-resistant varieties of white-fleshed, but especially OFSP, throughout SSA from its current bases, which, in East Africa, is primarily Uganda. Logically, this success of plant breeding should continue to build upon:

- The success of varieties such as NASPOT 1 pointing to the value of simply continuing to breed for all-round better sweetpotato varieties (higher yielding, more resistant, good taste etc.)
- The success of orange-fleshed varieties pointing to the benefits of developing sweetpotato varieties with different attributes and the need to think of attributes a little outside the current range: possibilities might include varieties which are non-sweet like cassava or varieties which have particularly juicy and nutritious leaves for human consumption. (There are already such varieties bred for animal fodder).
- The success of PPB suggesting the need to extend such decentralized plant breeding more widely into range of agro-ecologies in Uganda and Tanzania and to a wider range of countries.

There is also a need to safely maximize the use of improved SPVD-resistant varieties already developed throughout SSA. This needs support by policymakers to speed up through harmonization of regulations, variety exchange and variety release in different countries and through improved facilities for exchange such as tissue culture facilities. Rapid multiplication techniques using short, 1 – 3 node cuttings, would also have a key role in the initial multiplication of planting material of new varieties. Current in-country multilocational trials often focus on trialing of varieties across different ecozones in one country whereas regional funding could beneficially support trialing of varieties across similar ecozones in a range of countries – which seems more likely to yield positive outcomes. Currently, there appears to be no opportunity for private sector breeding in sweetpotato. Although potentially very beneficial, this progression is waiting for and dependent on the development of large-scale commercialization of the sweetpotato planting material supply chain. Such commercialization is evident only in commercial farming in southern Africa.

As regards developments in formal seed systems, these would appear to divide into those in the national and the commercial sectors. The need for a formal supply system for sweetpotato planting material has been suggested for farmers generally, perhaps through a decentralized approach (Kapinga et al. 1998) or resembling the Chinese system (Gao et al. 2000) or involving pathogen-tested (Mukasa et al. 2003) and even tissue-cultured (Robertson 2006) material. There must, however, be concerns over the sustainability of such systems if funding is mainly by donors; even local or national government funding may not be sustainable. It also risks farmers cutting back on their informal supply system leading to severe shortages in the event of externally-driven cutbacks. A better scenario may be for the commercial sweetpotato sector to increase in importance gradually and for a planting material supply chain to develop to serve it. This has already developed in South Africa (Joubert et al. 1979; Laurie et al. 2001) and seems likely to be a natural progression as commercial production increases elsewhere. The Ugandan National Seed Potato Producers Association (UNSPPA) has developed a farmer-based seed potato production system serving the market rather than driven by centralized state action (http://www.cipotato.org/publications/annual_reports/2000/04.asp). Uganda also has the greatest production of sweetpotato on the continent. There, Sulma Foods Ltd and Biofresh Ltd have won contracts to supply Uchumi supermarkets in Kampala with fresh sweetpotato and retailers in England respectively; other smaller companies supply boarding schools and other large consumers of food with sweetpotato. A sweetpotato crisp product has also been developed and is being marketed by TomCris Enterprises and the Njukunju Group is developing another competing product (Horton 2008). These developments associated with the introduction and large-scale dissemination of orange-fleshed sweetpotato has led to the development of the Soroti Sweetpotato Producers Association (SOSPPA) in Uganda (Plate 11) to supply large quantities of vines, driven by market demand and with no government intervention. Currently, the main market for these vines seems to be NGOs supplying farmers with vines free or subsidized, which may lead to instability, but the entry of private companies into the business may address this. If virus-free planting material is ultimately necessary to achieve high yields and quality requirements of commerce, such organizations may be suitable platforms. Although this review is identifying the potential for farmer-based, demand-driven seed systems, it has also identified a lack of careful documentation of the few successes (for example, SOSPPA, the spread of NASPOT 1 in Uganda and the international spread over decades of cv Tanzania), along with the problems they have had to surmount and are still encountering.

Although sweetpotato is predominantly grown by women for family food and any surplus traded also by women, how gender impacts on its seed systems seems unresearched, although it is likely to have a large impact, for example, on resource allocation within a family or family business, on the ability to travel independently long distances to obtain planting material or on the demand for research to develop particular kinds of seed systems, for example, nursery beds, which can be looked after close to home and may be preferred over planting material conservation by distant waterholes.

Plate 11. The large-scale production of sweetpotato planting material by the Soroti Sweetpotato Producers Association (SOSPPA).

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