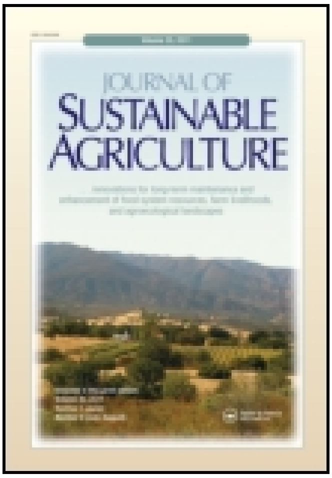

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Sweetpotato Seed Systems in Uganda, Tanzania, and Rwanda

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Surveys were made of the seed systems used in Uganda, Tanzania, and Rwanda and to investigate the reasons underlying them. Along the equator in Uganda, where rainy seasons are evenly spaced and occur twice a year, vine cuttings from mature plants only are used as planting material. Where there is a long dry season, the seed system includes a diversity of means of conservation: the passive production of volunteer plants from groundkeeper roots sprouting when the rains come; small-scale propagation of plants in the shade or backyard production using waste domestic water; and relatively large-scale propagation in wetlands or irrigated land. The last is the only means of obtaining sufficient quantity for sales, but is also the most expensive. Volunteers only produce planting material one or two months after the start of the rains and tend to be regarded as common property; nevertheless, they are an important source of planting material for poorer farmers. Although farmers perceive multiple benefits from planting early, planting material is in short supply at the beginning of the rains and mainly larger scale farmers gain these benefits. Farmers select carefully to avoid using plants with symptoms of virus disease as planting material and may also remove any diseased plants from crops.

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KEYWORDS *Africa, volunteers, virus infection, propagation, planting material*

INTRODUCTION

Seed systems have several purposes and effective seed systems provide the different categories of farmers with planting material 1) in sufficient quantities, 2) at the right time, 3) of an appropriate physiological state, vigor, and health, 4) of superior genotypes appropriate to the farmer's purposes, and 5) at an affordable price. To maintain superiority of genotypes and health, there may need to be capacity within seed systems for dissemination of new cultivars and pathogen-free stocks. Sweetpotato is propagated through vine cuttings. In Tanzania, Uganda, and Rwanda, planting material originates almost entirely within the farming community (Ndamagé 1990; Bashaasha et al. 1995; Kapinga, Andrade, et al. 1995), with only occasional formal distributions for disaster relief (Kapinga, Andrade, et al. 2005) and of new varieties (Kapinga et al. 2000).

Viruses have been reported as damaging in all three countries (Carey et al. 1998; Tairo et al. 2004; Njeru et al. 2008) and an International Potato Center (CIP) survey in 2005 reported that "virus management, seed quality and supply systems" were the highest priority for future research and development against all other listed sweetpotato technologies for 91 respondents from them and 31 other developing countries (Fuglie 2007). Farmers select against infection with the severe disease, *Sweet potato virus disease* (SPVD), caused by the synergism of *Sweet potato chlorotic stunt virus* (SPCSV) on sweet potato feathery mottle virus (SPFMV; Gibson et al. 1998). However, they cannot select against infection with symptomless viruses, notably SPFMV when infecting alone.

Sweetpotato seed systems in East Africa fall into two categories: along the equator where two evenly spaced rainy seasons occur at and after the equinoxes; and away from the equator, where the dry seasons are asymmetric, there is a prolonged dry season and special measures are necessary to survive it (Gibson et al. 2009). Uganda is the only country of the three discussed that has such an area along the equator; on either side of it, all three countries have areas where there is a prolonged dry season. A "hunger gap," whereby severe food shortages occur when the grain harvest is exhausted in the late dry season and early part of the rainy season before the harvest of the new season's crop, is common to such areas. In such areas, sweetpotato is potentially an early source of fresh food. However, traditional vine sources usually fail to provide sufficient planting material at the onset of the rains, delaying planting, preventing the crop from satisfying demand, and limiting its role as a famine relief crop (e.g., in northern Uganda, sweetpotato root prices increase from December with the start of the dry season through to June when harvesting starts; Hall et al. 1998). Shortages of planting material have been reported from Uganda (Dunbar 1969) and Tanzania (Mwanbene et al. 1994; Kapinga et al. 1995, 1998) and calls made for community-based nurseries (Kapinga et al. 1998), later evolving into a call for a decentralized farmer-based seed multiplication system (Kapinga, Tumwegamire, et al. 2005) to address the problem.

This article looks at various aspects of the different seed systems utilized in the three East African countries, with the particular aim of understanding how better to provide planting material following the long dry season. The lack of a major formal sector also creates particular difficulties in understanding how to disseminate new cultivars and stock free from disease, particularly asymptomatic viruses, in this clonally propagated crop.

METHOD

The results were obtained from questionnaire-based surveys in:

- Uganda of 271 farmers in Soroti, Kamuli, Bukedea, and Mukono districts in 2008;
- Rwanda of 434 farmers in the east, west, north, and south Rwanda and Kigali town in 2009;
- Tanzania of 126 farmers in Mara and Mwanza districts in 2010;

and other more informal observations conducted in the three countries from 2005 to the present. The surveys involved sweetpotato farmers—mostly women and mostly small-scale—who grow the bulk of the crop in all three countries. Farmers were selected for interview at random from lists provided by local extensionists. Farmers were asked about the sizes of their holdings, how much land was planted to sweetpotato, their sales, as well as how they obtained planting material in a series of relatively open questions to which they could provide extensive replies. Some chose not to answer certain questions. Table 1 is developed from observations in Soroti District Uganda made in 2007; Tables 2 and 3 are from a general survey of sweetpotato farmers in the Lake Zone of Tanzania in 2010; Tables 4 and 6–8 are from a general survey of sweetpotato farmers in Uganda in 2008; and Table 5 is from observations made in the Lake Zone of Tanzania in 2005.

RESULTS

Some eight different methods were observed to be a part of the seed system, each practiced to differing extents in different parts of Tanzania, Uganda, and Rwanda.

TABLE 1 Weight, Average Number of Sprouts and Weevil Infestations of 20 Volunteer Plants from Groundkeeper Roots of Each of Three Cultivars in Fields in Soroti, Uganda

Cultivar	Weight range (gm) of roots	Average number of sprouts/root	% root infestation by weevil
Araka	120–618	33.6	96.9
Ejumula	30–232	26.7	94.6
Kakamega	30–176	31.7	94.4

TABLE 2 Criteria for the Identification of Vines for Multiplication (from Tanzania Survey)

Criteria for identification of planting material	Number of farmers giving opinion
Healthy/disease-free/well developed/with good leaf formation/green leaves/plants or vines	44
Pest free vines	10
Get production history/observe roots produced/High yielding plants	8
Attractive plants	4
<2 farmers giving a particular opinion	11
Total	77

TABLE 3 Treatments Applied to Ensure Planting Material is of Good Quality (from Tanzania Survey)

Treatments	Frequency
Weeding	60
Roguing	11
Irrigating during drought	10
Timely planting	9
Inspecting the fields	9
Store in a cool place (postharvest treatment)	8
<2 giving a particular opinion or don't know	18
Total	125

- *Farmers use vines collected from fields of growing crops* as their source of planting material at some point in the cropping cycle everywhere. Close to the equator, where there is no prolonged dry season, this may be the only source throughout the year. Where there is a prolonged dry season, it is also the source of planting material during the rains as crops established from other sources become mature. Apical portions of vines are preferably taken from young/mature crops, to benefit from their physiological youth (Martin 1984) as well as freedom from pests, especially weevils, which infest mainly the stem bases. Vines are selected for a healthy appearance, particularly freedom from SPVD [as in other means of planting material production]. Generally, vines are given to neighbors freely.

TABLE 4 Characteristics of the Three Common Sources of Sweetpotato Planting Material in Areas With Long Dry Seasons in Uganda

Management activity	Conserving in the valley bottom/swamp	Volunteer plants	Conserving plants under shade
Fence	Yes	No	No
Month of planting	Dec–Jan	Not relevant	Oct–Dec
Average area (ha)	0.6	Not relevant	< $10m^2$
Irrigated	Yes	No	No
Expected harvesting month	March	May	April
Total cost (Ug/-)/ha	925,237*	0	0
Quantity harvested/ha	605 bags	Not relevant	A few m^2
Average farm gate price/bag (100 kg maize bag)	10,000	[7,300] [Not sold]	[8,750] [Not sold]
Total income	6,050,000	Not relevant	Not relevant
Gross margin	5,124,763	Not relevant	Not relevant
Common varieties	Kakamega,* Vita A,* Kabode,* and Araka	Araka and Osukut	Araka and Osukut

Rate of exchange: 1,900 Ug /- = $1 US in 2009.
*Kakamega, Vita A, and Kabode are released varieties; Araka and Osukut are local landraces.

- *Volunteer plants* growing from unharvested roots provide a major source of cuttings in more-or-less all areas in which the dry season has become sufficiently harsh to prevent crops surviving with foliage. Usually, it is small buried roots that have been overlooked during the harvest or larger damaged ones that have been rejected that produce shoots when the rains arrive. It is a passive means of production; nevertheless, large amounts of vines are produced in this way. They are a free source of cuttings and are particularly popular amongst poorer farmers. The process, however, requires that the land is not planted or closely grazed. Because they occur naturally and by chance, they may be considered to be "common property," free for all. This may result in them being harvested prematurely even by the owner—in case another person harvests them. Another disadvantage is that they grow aboveground only once the rains occur and so are always late. They are also often severely infested by weevils (Table 1).
- *Growing a crop during the dry season in swampy land* usually provides a dual purpose crop, providing roots at a time when there are shortages of food and also vines for planting material at the beginning of the rains. This is common practice around the shores of Lake Victoria in Tanzania, of Lake Kyoga in Uganda and in the valley bottoms in Rwanda. In Tanzania, rice paddy fields are sometimes used, the sweetpotato surviving on the residual moisture. The system reaches its peak in Rwanda, crops being planted in large beds in valley bottoms at the start of the dry season in May and June, harvested in October and November and their vines used to plant the main crop on the valley sides. This practice, which has traditionally helped assure food security in Rwanda, is being undermined by the spread

TABLE 5 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

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

TABLE 6 The Numbers of Farmers in Two Districts in Uganda Giving Particular Explanations Why Planting Early Creates a More Useful Yield

	Districts in Uganda		
Advantages	Bukedea	Soroti	Total
Provides food [when other sources are running out]	55	36	91
Enables dual benefits: can sell as well as eat	26	1	27
Early maturity of crop	12	4	16
High yield	2	8	10
Helpful for food preservation	3	1	4
Better for sales [good early-season market]	1	1	2
Fits well with cassava	0	2	2
Total indicating advantages*	99	53	152
Total indicating disadvantages	0	0	0

TABLE 7 The Amount of Money (Ug/-) Spent by Ugandan Farmers to Buy Additional Planting Material

	District		
Money spent (Ug/-)*	Bukedea	Soroti	Total
≤1,000	1	1	2
1,001–5,000	3	2	5
5,001–10,000	7	9	16
10,001–20,000	3	4	7
20,001–30,000	2	4	6
30,001–40,000	2	1	3
40,001–50,000	1	1	2
50,001–60000	1	1	2
>60,000	0	1	1
Total	20	24	44

*\$1.0US = 1,700/- Ugandan in April 2008.

TABLE 8 A Comparison of the Number of Farmers in Soroti and Bukedea Wanting to Buy Extra Sweetpotato Planting Material But Not Doing So and Those Actually Buying

Hectares	Wanting to buy	Buying
≤ 0.04	39	6
0.04–0.2	43	16
0.21–0.4	21	14
>0.4	3	4
Total	106	40

of large irrigation schemes designated for growing rice, beans, maize, and potatoes instead in these valley bottoms, with sweetpotato often banned from such land. Elsewhere, although there are laws against the cultivation of wetlands, these often seem to be broken. Crops grown in wetlands are at risk of being eaten by grazing wild or domestic animals because they may be the only young vegetation around and sited far from homesteads. They are consequently often fenced, usually with thorn. These crops, as with others grown specifically for seed, are carefully planted with healthy-looking and pest (mainly weevils) -free vines; planting material may even be positively selected based on the root formation of the parent plant (Table 2). The crop is valuable and is weeded regularly, inspected and rogued for off types and diseased plants especially SPVD (Table 3).

- *Irrigating a crop during the dry season* from a river, waterhole [often in a dried-up river bed] or lake is widespread, particularly in Tanzania. The crop is often hand watered, for example, by buckets. In Tanzania, watering is done on average every other day from May to September inclusive, reaching a peak of almost every day in July, and for 3 ± 2.5 hours a day. It is done primarily by women and young girls; in one location in Shinyanga Tanzania, 22 women and older girls were busy watering but, although several men and older boys were present, none were watering. As with growing a crop in swamps, both roots for eating and vines available in time for the rains are produced. Irrigating allows the crop to be grown close to, but not in, wetlands, thus, avoiding laws on the cultivation of actual wetland. A petrol or diesel powered pump may be used, especially if it is an NGO. Again, these crops are carefully planted with healthy-looking and pest (mainly weevils) -free vines and planting material may even be positively selected based on the root formation of the parent plant (Table 2). The crop is valuable and is weeded regularly, watered, inspected and rogued for off-types and diseased plants especially SPVD (Table 3).The Ugandan Soroti Sweetpotato Producers Association (SOSPPA) provides an example of a large-scale farmers' association equipped with a pump used to irrigate several hectares of land.
- *Growing plants in the shade* occurs in areas with only a moderately prolonged dry season. Often, the shade is provided by bananas, as in the Kagera region of Tanzania and in Rakai and neighboring districts in Uganda, but coffee, avocados, and such are also used and also sometimes cassava or the dried-up stalks of harvested maize and millet. In very prolonged dry seasons, shade vegetation either does not survive or loses its leaves, so this method cannot be used. Generally, only small amounts of vines are produced by individual homesteads; storage roots are generally not produced because of shading. Usefully, vines are available for the start of the rainy season.
- *Plants grown in the backyard* and watered from waste water from the house, or downstream of village pumps, are common in dry areas of Uganda and Tanzania. Because only small amounts of water are generally available, only small amounts of vines are produced; the crop generally does not produce storage roots. However, almost anyone can do it and crops are generally easy to protect against grazing animals. Vines are also

produced in time for the rainy season. They are, however, often affected by weevils.

- *Planting a crop, often late, for production of vines from the roots* is occasionally done but generally results in crops badly affected by weevils.
- *Use of trash vines* growing from vines discarded during harvest is rare.

In all systems, even when vines are purchased, it is usually farmers who select and cut the vines. This allows them to avoid collecting vines from plants that are affected by virus, especially SPVD. Generally the apical 30 cm of the vine only is taken; this reduces the likelihood of transferring weevils and may be important in ensuring that the vine is physiologically young. In Rwanda, there is a particular problem with erinose, caused by *Aceria* spp mites. Although the parent plants form normal storage roots, the vines are unsuitable for planting as they fail to root well.

Seed systems consist of more than one means of propagation except in the areas of Uganda close to the equator, where continuous production is practiced. Thus, in Tanzania in an area where there is a prolonged dry season, planting material is conserved during the dry season by a variety of means including volunteer plants growing from groundkeeper root, growing in swampy land or by watering. This planting material is then used to establish the initial crop at the beginning of the rainy season and from which vines are taken to establish further crops (Figure 1). The cycle is completed by vines from these crops establishing the conservation crop or providing groundkeeper roots.

The main constraints to seed production are drought, pests, and diseases (Figure 2). The management and outcomes of three common means of maintaining planting material were compared (Table 4) in Uganda. Generally, conserving in wetlands or irrigating requires considerable inputs, including a sturdy fence to protect it, land preparation and weeding during the growing season. Land preparation is often expensive because the land may not be used during the wet season and is colonized by coarse grasses and other vegetation. However, this method results in planting material being available at the beginning of the planting season in March, to be sold at considerable profit. Large-scale planting is mostly to modern varieties, aiming to sell most of the vines to nongovernmental organizations (NGOs) or international relief operations. In Tanzania, it is also done privately by quite small-scale farmers, for example, in Shinyanga District, Tanzania, generating $90–140 US per year from the sale of vines alone. Most sales are then to other farmers and of local varieties. Planting in the shade requires no costly inputs but is done on a very small scale, suitable for the requirements of the homestead only. Relying on volunteers also requires no inputs and may achieve a greater output of vines than production in the shade but the vines are available much later and are also not saleable.

Farmers in all three countries confirmed that shortages of planting material at the beginning of the rains were a major constraint. In Rwanda, nearly

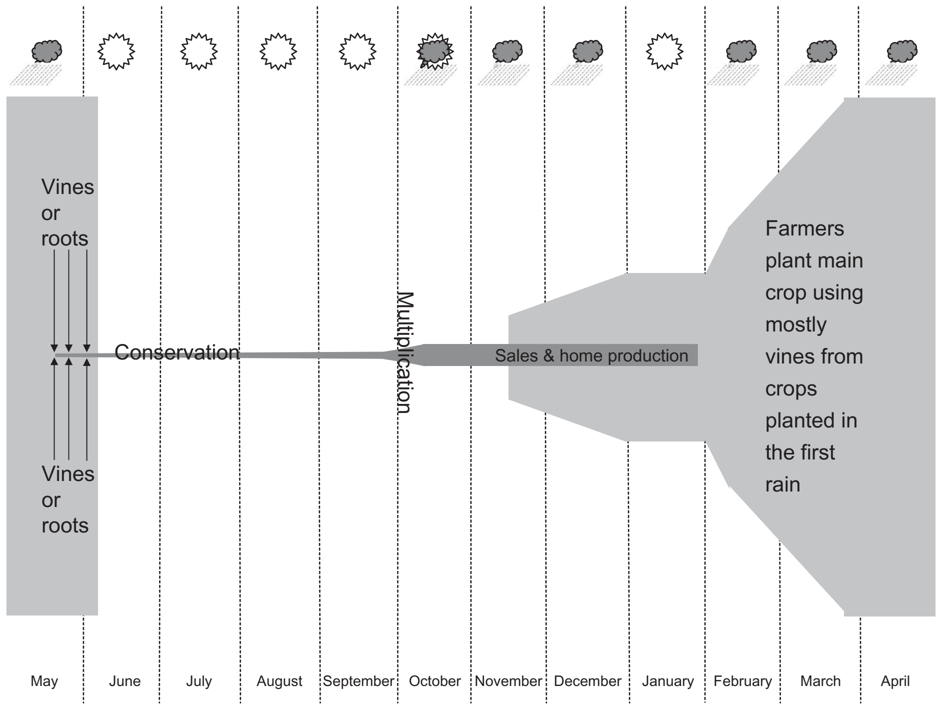

FIGURE 1 The seed system in areas with prolonged dry season in the Lake Zone of Tanzania. (*Note:* The conservation, sales, and initial multiplication of vines are exaggerated in order to be better seen.)

half of the 434 farmers interviewed disagreed with the statement that "supply of planting material is easily available," nearly 40% disagreeing strongly. In the Lake Zone of Tanzania, farmers in Shinyanga and nearby districts confirmed lack of planting material as the main problem in production, both delaying planting time and limiting the area planted (Table 5). The farmers who did not complain of shortages of planting material in Shinyanga grew it in the swamps and were all sellers of planting material. Most farmers bought planting material; the concept of getting it free from their neighbors was unrealistic and some traveled long distances and incurred considerable costs to obtain planting material. In parts of neighboring Meatu district, farmers paid the equivalent of $6 US travelling 50 km and buying a bundle of cuttings filling a 100 kg maize/fertilizer bag, planting perhaps 10–15 ridges each 10–20 m long (as described by purchasers). In Rwanda, a large bundle of vines cost about $2 US. Most farmers in northeastern Uganda thought they would plant about twice as much and about one month earlier if planting material was readily available. Farmers obtained numerous benefits from early supplies of planting material, particularly an early source of food for the family and early, high value sales (Table 6). Ugandan farmers mostly spent

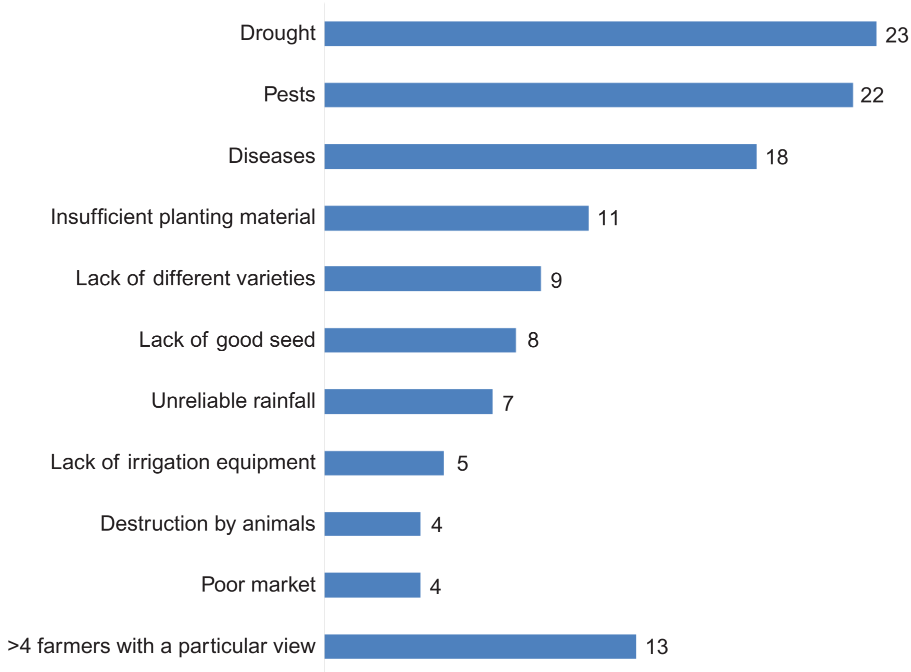

FIGURE 2 The main constraints identified by farmers in sweetpotato seed production. Numbers after each column are the number of farmers responding (color figure available online).

between 5,000 and 10,000 Ugandan shillings (Ug/-) ($3–6 US) on purchasing planting material, although quite a few spent up to 30,000 Ug/- ($18 US) (Table 7). Interestingly, many more farmers wanted to buy than actually bought; since it was mainly farmers owning large areas of sweetpotato that actually bought (Table 8), it seems likely it was lack of funds that prevented purchase by smaller-scale farmers. A similar situation occurred in Rwanda; there the farmers who did not buy relied on vines from sprouting roots and on neighbors to supply them freely when their early-planted crops from bought vines had matured.

DISCUSSION

The sweetpotato seed system varies from country to country and from region to region within each country but there are commonalities across agro-ecological zones. Uganda is the only country with an area running along the equator and which, therefore, has an area with no prolonged dry season. This is the only region for which the seed system involves only the use of vines from growing crops, vines being taken from a mature crop to establish a new crop which, when mature, is itself used as a source of vines and so on. Elsewhere, there is at least a moderate, and in parts of northern and northeastern Uganda and in Tanzania and Rwanda, a prolonged, dry season and a diversity of means such as growing in the shade, in swamps, and use of sprouting roots is used to maintain planting material until the rains return. Growing crops in swampy areas and/or watering is the only current mechanism which produces large enough quantities for sale. Watering by buckets is used mostly in private enterprise small-scale farming, with the planting material sold to farmers. Mechanically-powered irrigation is restricted to large-scale production of vines, often by NGOs, which are important in secondary multiplication of vines in both Tanzania and Uganda (Kapinga, Tumwegamire, et al. 2005). In all areas, once the rainy season is established and mature crops are available, farmers start to use vines from their own crops as their main source lack of planting material (Figure 1). The use of sprouting roots suffers from two major disadvantages: that the vines from the sprouting roots may be seen as common property and that the vines grow in response to the rains and so always occur *after* the rains. Despite this diversity of mechanisms, the overwhelming situation at the beginning of the rainy season in all three countries is one of scarcity of planting material. In Rwanda, scarcity has mostly been created artificially by government forbidding most sweetpotato from the valley bottoms during the dry season, although in the drier east of the country, scarcity occurs because of the dry season. In Tanzania and Uganda, scarcity of vines due to the dry season (Bashaasha et al. 1995; Kapinga et al. 1995, 1998) means that the farmers are unable to plant enough land with resultant food shortages and high prices.

The seed systems for sweetpotato do not by themselves provide a means by which virus infection is avoided as the crop is always propagated vegetatively. Some viral diseases, such as SPVD, are severe, clearly very damaging and visual inspection provides an effective means by which farmers can select against them. Others such as SPFMV and sweet potato mild mottle virus (SPMMV) are generally symptomless when infecting alone. Surprising, the planting material of many landraces seems largely virus free. Thus, when cuttings were obtained from asymptomatic field plants—such as farmers would normally use as planting material (Bashaasha et al. 1995)—and are tested for virus infection by grafting to the indicator plant *Ipomoea setosa*, 85% indexed as virus free and the infected 15% all had SPFMV alone (Gibson et al. 1997). In Tanzania, 38 (52%) of 73 symptomless plants collected from crops were sero-negative for viruses (Tairo et al. 2004) and in Kenya, 477 (75%) of 638 asymptomatic plants collected from crops throughout Kenya were both sero-negative 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 asymptomatic plants was SPFMV alone. It has been shown that some cultivars possess a mechanism by which SPFMV can be eliminated

(Aritua et al. 1998), probably through an RNA silencing mechanism (Kreuze et al. 2005). This appears to be a valuable way by which planting material of landraces is maintained relatively free from such diseases.

Improved seed systems have a proven track record in raising productivity of clonal crops, for example, the adoption of CIP sweetpotato seed technology (virus testing and large scale production of virus-free planting material) in the Shandong province of China in the period 1988–1998 in >80% of the production area of the province, increased average yield by ~30% (Fuglie et al. 1999; Gao et al. 2000). Whether something similar needs to or can be done for small-scale farmers in Africa and whether it will be decentralized and based on farmers' seed systems (Kapinga, Tumwegamire, et al. 2005) or involve commercial producers remains to be seen. The provision of planting material of appropriate varieties is also a key intervention, sometimes to rehabilitate farming systems following natural disasters such as drought, civil unrest, or conflict and to assist the return of displaced persons (Kapinga, Andrade, et al. 2005). Distribution may be of the indiscriminate "truck and chuck" form but it is hoped that this detailed description of the informal systems of farmers will help these interventions to be integrated with them and so also have longer-term benefits.

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