CROP PROTECTION PROGRAMME

Promotion of and technical support for methods of controlling whitefly-borne viruses in sweet potato in East Africa

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FINAL TECHNICAL REPORT

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Executive Summary

Sweet potato virus disease (SPVD) is the main disease of sweet potato in Africa and is caused by dual infection of sweet potato by the aphid-borne virus *Sweet potato feathery mottle virus* and the whitefly-borne *Sweet potato chlorotic stunt virus*. Extensive on-farm and on-station trials have shown that some newly-released sweet potato varieties maintain low incidences of SPVD in areas of Uganda around Lake Victoria where SPVD has previously been shown to be prevalent whilst achieving tuberous root yields considerably exceeding those of local checks selected by collaborating farmers. One variety in particular, NASPOT 1, achieved marketable yields about twice that of the local checks. A wide range of attributes of sweet potato were identified by farmers and ranked. Most attributes involved some aspect of the tubers, though drought resistance and, to a lesser extent, pest and disease resistance, were also included as important attributes. NASPOT 1 was ranked highly, primarily because of its big, early yield of large, sweet, mealy tubers. These newly-released varieties are now being disseminated in districts around Lake Victoria. Preliminary results suggest that some are being adopted enthusiastically and farmers with access to the new varieties of sweet potato are increasing production; however, their impact continues to be monitored. In a further set of on-farm and on-station trials in Kanungu District in the western Rift Valley, a very different agroecology, these varieties failed to yield better than the local checks although maintaining resistance to SPVD: a relatively SPVD-susceptible local cultivar yielded similarly or better. In trials around Bukoba in Kagera Region, Tanzanian released varieties also failed to outyield a local, relatively susceptible local cultivar and the Ugandan varieties have been taken through open quarantine to start an extensive trials programme there. Phytosanitation is being tested as an additional control to the use of resistant varieties. Initial results of trials indicate that the epidemiology of SPVD is largely local and consequently local sanitation practices have a big impact. Roguing in just the first month after planting halved the spread of SPVD with no apparent loss in yield. These and other related trials are continuing. Two reports on previous work funded by R6617 as part of the Tropical Whitefly IPM Project were completed. A session on sweet potato viruses was successfully organised at the Fifth Triennial Congress of the African Potato Association, 29th May – 2nd June, 2000 in Kampala, Uganda.

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Background

African sweet potato production is concentrated in East Africa, especially in countries around the perimeter of Lake Victoria. Uganda has the second largest production of sweet potato in the World and Tanzania has the second largest area of production (after Uganda) in Africa (FAOSTAT). Sweet potato production is projected to expand in Africa and has been increasing steadily in importance in most countries in eastern and southern Africa. This is partly because of negative influences on other crops, for example, withdrawal of cheap inputs and/or guaranteed prices and because of increasing damage to other staple crops such as cassava and bananas by pests and diseases. Sweet potato is also being promoted widely in Africa because it is seen as a means of guaranteeing national food security through its tolerance of adverse climatic condition and because orange-fleshed sweet potatoes have a high vitamin A content (VITA A Project). Sweet potato is grown particularly by women around the homestead for daily food and to sell for family needs (Bashaasha *et al.*, 1995; Kapinga *et al.*, 1995). It is also grown extensively in some areas as a cash crop, sold particularly to the urban poor as a staple food.

Sweet potato virus disease (SPVD) is the name used commonly in Africa to describe a range of severe symptoms on sweet potato generally attributed to virus infection. Symptoms vary with plant genotype but typically include stunted plants with small distorted leaves, the latter often also being distorted, narrow (strap-like) and crinkled with a chlorotic mosaic and/or vein-clearing, giving affected plants an overall pale appearance. SPVD is the most serious and widespread disease of sweet potato in Africa including the Lake Victoria region (Geddes, 1990) where the bulk of African production occurs. Affected plants commonly yield less than half that of symptomless ones (Mukiibi, 1977; Hahn, 1979).

SPVD was first associated in Nigeria with the presence of both an aphid-borne potyvirus now known to be *Sweet potato feathery mottle virus* (SPFMV) and a closterovirus transmitted by the whitefly *Bemisia tabaci* called *Sweet potato chlorotic stunt virus* (SPCSV) (Schaefers & Terry, 1976). The presence of a whitefly-borne component to SPVD in East Africa was confirmed during the ODA Holdback project R5878 (1994-7) and it was identified as the East African strain of SPCSV by work done within the CPP RNRKS-funded R6617 (Gibson *et al*., 1998). Work done under R6617 and an international CGIAR-led initiative on whiteflies and whitefly-borne viruses called the Tropical Whitefly IPM Project confirmed the importance of SPVD, identified areas in East Africa where it was particularly prevalent (Aritua *et al*., 1998) and obtained preliminary evidence that most spread was local (Aritua *et al*., 1999). Landraces resistant to SPVD are well-known in East Africa but work done in R6617 showed that these resistant landraces are mostly low-yielding and/or late maturing (Aritua *et al*., 1998; Gibson *et al.*, 2000). The challenge was therefore to identify superior, high-yielding varieties whilst maintaining adequate levels of SPVD resistance. Several SPVD-resistant sweet potato varieties bred at Namulonge Agricultural and Animal Production Research Institute (NAARI) have recently been released in Uganda. Furthermore, the pandemic of cassava mosaic disease spread from Uganda to the Kagera Region of Tanzania, resulting in localised food shortages and generalised food insecurity in the region.

Project Purpose
The project evaluates varieties resistant to SPVD for areas of Uganda and Tanzania where high levels of SPVD occur and monitors their impact. It also investigates local phytosanitary practices for controlling SPVD. It will check previous identification of whiteflies as the vector of sweet potato mild mottle virus. Following on from R6617, it will work within Phase II of the Tropical Whitefly IPM Project and will disseminate previous achievements on SPVD.

Project output 1: *Superior sweet potato varieties in Uganda and Tanzania identified and evaluated on-farm for resistance to SPVD and yield in areas of East Africa where SPVD is especially damaging; adoption of resistant varieties monitored and impact on local incidences of SPVD assessed.*

Project output 1, Planned activities 1.1 *On-farm trials in Bukoba, Masaka, Rakai and Rukungiri (now Kanungu) Districts comparing yield and resistance of local and released sweet potato varieties; making participatory varietal evaluations with local farmers and consumers.*

Activities in Masaka, Rakai & Kanungu Districts, Uganda

Sweet potato varieties released in Uganda by the national Potato Programme and sweet potato clones on the basis of high yields, resistance to SPVD and other promising characteristics, were tested in Masaka, Rakai and Kanungu districts of Uganda using two approaches. These were:

- **On-station trials**. Replicated trials done on-station or on a large farm in each district, aiming to test a diversity of varieties and other on-station bred clones. Tuberous root yield, insect and pathogen damage were recorded for each plant genotype.
- **On-farm trials**. Single-replicate on-farm trials testing about six sweet potato varieties and other on-station bred clones done on about twelve farms and grown under the farming system of the owner farmer in each district. Two locally-grown landraces chosen by each farmer were always included. Insect and pathogen damage were evaluated for each plant genotype by scientists and the palatability of the tuberous roots by farmers.

On-station trials. Trials in Masaka were planted at the Agricultural Institute farm at Kamenyamiggo, trials in Rakai were planted at the Kabira Sub-District Headquarters and trials in Kanungu were planted either at the Kihihi sub-county headquarters or in a commercial farmer’s fields. The varieties and other on-station bred clones, and the local check cultivars used in each test are listed in Appendix: Table 1). Planting material of the new clones was obtained from NAARI; planting material of the local check cultivars was from local farmers. Trials were planted in Masaka and Rakai in the second rains of 1999 and the first rains of 2000; trials were planted in Kanungu in the second rains of 1999 and both the first and second rains of 2000. Plots were each planted with a single cultivar and comprised at least 2.5m length of 2 ridges (1m spacing between ridges) with cuttings planted at about 0.3m intervals. Plots were arranged in a randomised block design with three or four replications depending on land availability.

Trials were monitored monthly for pests and diseases: the few SPVD-affected cuttings found at the first monitoring were removed and not included in the final count on the assumption that disease had been brought in on infected cuttings. Plots were harvested after about 6 months. Total and marketable yield of tuberous roots and weevil (*Cylas* spp) damage were recorded.

On-farm trials. On-farm trials were done with ten to twelve contact farmers of BUCADEF (Buganda Cultural and Development Foundation) in both Masaka and Rakai Districts. On-farm trials in Kanungu were done with ten to twelve farmers recommended by the Sub-county Agricultural Extension Officer. Trials were planted in all three districts in the second rains in 1999 (planted December 1999; harvested June 2000) and in the first rains in 2000 (planted May 2000, harvested October 2000). In Masaka and Rakai, trials were also planted in the second rains in 2000 (planted November 2000, harvested April 2001) but were discontinued in Kanungu because farmers were disheartened that none of the introduced cultivars seemed superior to their local landraces.

A single block comprising single plots of each of the introduced test cultivars (see Appendix: Table 1 for genotypes) plus two popular local cultivars chosen as checks by each participating farmer were planted in a randomised order in each farmer's field (farmers' fields were too small to allow replication). Farmers in Masaka all chose cvs Old Kawogo and Somba Busero; farmers in Rakai all chose cvs Old Kawogo and Kampala. Farmers made their traditional heaps of soil using hoes, each heap usually occupying about $1m^2$ with four cuttings planted in each heap though bigger heaps with more cuttings were planted where this was the local practice. Clusters of heaps planted with one cultivar formed a plot. Planting material of the introduced cultivars was mostly derived from NAARI farm though occasionally cuttings were obtained from a previous trial at that farm. NASPOT 1, 2 and 3 were included in all trials. For the 2000 second rains trials in Masaka and Rakai, 93-29 and NASPOT 4 were excluded because of their relatively poor performance and New Kawogo, Wagabolige, Tanzania and 1096 were included as a result of their relatively good performance in the formal replicated variety trials. Planting materials of the local cultivars were supplied by the farmer. Plots were monitored monthly for pests and diseases and at harvest when total and marketable yields of tuberous roots were also recorded.

At the end of the 1999 second rains and 2000 first rains growing seasons, farmers in Masaka and Rakai came together to assess the palatability of the tubers of each cultivar. In Rakai in the 1999 second rains growing season, this was done twice. Tubers of each cultivar were steamed as is traditional there. Each tuber was identified by a code so farmers did not know which cultivar they were tasting. Farmers then ranked the tubers either for overall eating quality (1999 second rains growing season) or for specific eating qualities (2000 first rains growing season). Similarly, in Kanungu, farmers came together twice during May 2000 to rank boiled (the normal way of cooking sweet potato there) tubers of the different sweet potato cultivars for general palatability.

The yields of both formal variety evaluation trials and on-farm trials were compared using analysis of variance (Genstat 5: Release 4.1).

Outputs

Yields. There were no significant (P>0.05) differences in the total (Appendix: Table 1) or marketable (Appendix: Table 2) yields of the different cultivars tested the on-station trial in Masaka District planted in the second rains of 1999. In on-station trials planted in Rakai in the second rains of 1999, cvs NASPOT 1 and Tanzania yielded significantly (P<0.05) more than the best yielding local cultivar (Old Kawogo), cvs Tanzania: NASPOT 1 yielded nearly twice the marketable yield of the mean of the two landraces (Appendix: Tables 1 & 2). The severe drought in 2000 led to the failure of the trial planted in Masaka. There were also very poor yields in the trial planted in Rakai and no significant differences, the local cultivars performing relatively well in these adverse conditions. In a series of on-station trials conducted in Kanungu District during 1999 and 2000, none of the introduced cultivars out-yielded the best of the local cultivars and several yielded significantly less (Appendix: Tables 5 & 6).

In most cropping cycles at Masaka and Rakai, NASPOT 1 had most total (Appendix: Table 1) and marketable (Appendix: Table 2) yield on-farm though it yielded significantly (P<0.05) more than the local cultivars only in the trials at Rakai planted in the second rains of 2000. Cv 93-493 also yielded significantly (P<0.05) more than landrace checks in the trials at Rakai planted in the second rains of 1999, but this high yield was not generally present in the other trials. In on-farm trials planted in Kanungu during the second rains of 1999 (K1), none of the introduced cultivars outyielded the local cultivars (Appendix: Tables 5 & 6).

In the on-farm and on-station trials, there was considerable variation in overall yield between cropping cycles. An extreme example was that the failure of the first rains of 2000 caused yields to be very poor at both Rakai and Masaka. There was also considerable between farms (replicates), probably resulting from differences in soil fertility and the incidence of local thunderstorms. Yield results on each farm were adjusted proportionally such that the mean yield of the two local cultivars equalled one, i.e., each of the plot yields were divided by the mean yield of the two check landraces. Analysis of the resulting data confirmed that, in Masaka and Rakai, NASPOT 1 generally yielded the most, yielding twice or more the marketable yield of the local cultivars in most cropping cycles (Appendix: Tables 3 & 4). Other introduced cultivars, notably NASPOT 2, NASPOT 3 and 93-493 also yielded significantly (P<0.05) more marketable yield than the local cultivars in most cropping cycles. Masaka and Rakai Districts adjoin and have similar agroecologies: the combined results show the excellent yields of NASPOT (Table 1). A similar analysis confirmed that none of the introduced cultivars significantly (P>0.05) outyielded the local cultivar checks in Kanungu (Appendix: Tables 7 & 8), although several had a similar yield.

Palatability The introduced cvs Tanzania, NASPOT 1, NASPOT 4 and clone 1096 were ranked highly by farmers in Masaka and Rakai in the tasting trials for overall acceptability (Appendix: Tables 9a & 10), generally being ranked similarly (Old Kawogo) or above (Kampala, Somba Busero) the local cultivars. These cultivars were appreciated particularly for their appearance, taste and mealiness (Appendix: Table 10). Farmers in Kanungu generally ranked their local cultivar, Kyabafiluki, as being amongst the best whereas their other local cultivar, Mulungi ha meza, was generally ranked amongst the worst (Appendix: Table 9 b). Indeed, Kyabafiluki was ranked above Mulungi ha meza sixteen times out of twenty (P<0.001). There were few obvious differences amongst the introduced cultivars: NASPOT 2 and NASPOT 4 were ranked similarly to Kyabafiluki and NASPOT 1 was low in one trial yet high in the other pests.

Table 1. Yields of introduced sweet potato cultivars relative to the mean yields of local cultivars, combining results for Masaka and Rakai Districts over each cropping cycle.

a) **Total yields**

Planting season	1999, 2nd rains	2000, 1st rains	2000, 2nd rains
Introduced cultivars			
NASPOT 1	1.87	1.99	2.30
93-493	1.95	0.93	1.63
Tanzania			1.59
Wagabolige			1.44
1096			1.40
NASPOT 3	1.89	1.14	1.33
New Kawogo			1.28
NASPOT 2	1.69	1.40	1.07
93-29	1.30	0.83	
NASPOT 4	1.23	0.90	

a) Marketable yields

Planting season	1999, 2nd rains	2000, 1st rains	2000, 2nd rains
Introduced cultivars			
NASPOT 1	1.94	2.55	2.48
93-493	1.77	0.76	1.63
Tanzania			1.58
Wagabolige			1.62
1096			1.21
NASPOT 3	2.03	1.24	1.32
New Kawogo			1.48
NASPOT 2	1.52	1.44	1.13
93-29	1.29	0.85	
NASPOT 4	0.84	0.54	

Sweet potato virus disease. SPVD was relatively rare on most of the introduced and local cultivars in most of the trials in Masaka and Rakai (Table 2), seldom exceeding a mean incidence of 10%. However, cvs Tanzania, NASPOT 6 and clone 1096 had significantly ($P<0.05$) more infection than most of the other cultivars in some trials. The incidence of SPVD was much higher in Kanungu District (Table 3), average incidences for each trial generally being about 10% and infection of individual cultivars often exceeding 20%. This was expected as SPVD incidence and whitefly abundance were known to be high in this locality. Interestingly, the local cv. Kyabafiluki was relatively susceptible and generally had a much higher incidence of infection than Mulungi ha meza, the other local cultivar. Indeed, relative to cv. Kyabafiluki, most of the introduced cultivars had significantly ($P<0.05$) less SPVD yet relative to cv. Mulungi ha meza, none had significantly less SPVD. Of the introduced cultivars, Bwanjule, New Kawogo, clone 319, NASPOT 3, Wagabolige, clone 93-493 and NASPOT 4 all seemed “adequately” resistant to SPVD in the trials at Kihihi.

Alternaria disease. *Alternaria* was evident only in trials in Masaka and Rakai and was not observed in Kihihi, probably because of the normally hot, dry climate in Kanungu District. In the four sets of affected trials, negligible damage was noted to the local cultivars Old Kawogo, Somba busero and Kampala but several of the on-station-bred cultivars notably NASPOT 1, NASPOT 2 and NASPOT 4 were severely affected (Appendix: Table 11). In the on-farm trial planted in the second rains of 2000, NASPOT 1 seemed to yield particularly well relative to the resistant local cultivars only at farms where this disease was a minor problem that season.

Weevil damage to tubers. As with *Alternaria*, weevil damage was evident in trials only in Masaka and Rakai (Appendix: Table 12). In Kihihi, the light sandy soils may have helped exclude weevils from tubers. Both local and introduced cultivars were affected and a few of the introduced cultivars, notably NASPOT 1, 93-29, NASPOT 4 and NASPOT 2, seemed especially subject to damage. This appeared at least partly because they have relatively large tubers which often expanded upwards to protrude above the soil surface. Damage was particularly severe to such exposed tubers.

Achievements

As described in the Background, landraces resistant to SPVD occur in East Africa but are mostly low-yielding and/or late maturing (Aritua *et al*., 1998; Gibson *et al*., 2000), leading to farmers continuing to grow high-yielding though SPVD-susceptible landraces. The target of Activity 1 was therefore to identify varieties combining adequate levels of SPVD resistance with other superior attributes. This challenge has been met in Masaka and Rakai, where SPVD is prevalent, as several of the introduced cultivars yielded considerably more than the local cultivar checks selected by farmers as their best local landraces (Table 1) yet had low incidences of SPVD (Tables 2 & 3). NASPOT 1, in particular, consistently yielded very well, generally yielding twice or more the weight of marketable tubers than the local cultivar checks. NASPOT 2, NASPOT 3, clone 93-493, Wagabolige and Tanzania also yielded well in several trials. None of the introduced cultivars yielded poorly.

Table 2. SPVD incidence (%) in on-farm and on-station trials in Masaka and Rakai Districts.

Trial	M1	M3	M4	M5	R1	R3	R4	Mean
Introduced cultivars								
319			0.0	0			0.0	0.0
NASPOT 3	0.0	2.5		0	0.3	4.4	0.0	1.2
New Kawogo	0.4	3.2	0.0	2		3.6	0.6	1.6
Bwanjule			0.0	4.6			0.8	1.8
Wagabolige		7.3	0.0	0.6	0.0			2.0
NASPOT 5			3.6	3.1			0.0	2.2
93-493	0.7	3.8	3.6	6.4	1.4	1.3	0.0	2.5
NASPOT 1	3.4	10.6		0	1.8	1.3	1.3	3.1
93-29	4.9			7	1.1		0.8	3.5
NASPOT 2	8.9	5.6		4.8	1.4	4.6	0.8	4.4
Sowola			1.8	11.4			1.7	5.0
NASPOT 4	6.5			8.3	1.4		5.6	5.5
NASPOT 6			18.2	0			0.0	6.1
Tanzania		15.9	2.4	2.6		12.2	3.8	7.4
1096		26.4	0.0			14.8		13.7
Local cultivars								
Old Kawogo	0.4	10.0		1.0	1.7	9.4	0.6	3.9
Somba Busero	4.3	7.0						5.7
Kampala				14.5	8.7	7.2	4.1	8.6
Replication	7	9	3	3	8	12	4	
LSD (5%)	11.0	8.0	5.1	8.3	4.3	5.4	3.8	
SE of mean	3.7	2.8	1.7	2.9	1.7	1.9	1.3	

M1, M2 and M3 = Masaka on-farm trial planted in the second rains,1999, the first rains, 2000 and in the second rains, 2000 respectively.
M4, M5 = Masaka on-station trial planted in the second rains, 1999 and the first rains, 2000, respectively
R1, R2 and R3 = Rakai on-farm trial planted in the second rain,1999; in the first rains, 2000; in the second rains, 2000 respectively
R4, R5 = Rakia on-station trial planted in the second rains, 1999; in the first rains, 2000, respectively

The trials in Masaka and Rakai alone were done over three growing cycles, included first and second rains growing seasons, two on-station sites and 20 farms and used local planting systems. It therefore seems likely that these results are representative of those which are likely to be achieved by most local farmers in this region. Since the varieties were selected at NAARI, which is located in another district further east but close to Lake Victoria, it seems likely that these varieties are adapted to conditions throughout the districts surrounding Lake Victoria in Uganda. Cooked tubers of NASPOT 1, Tanzania, NASPOT 4 and clone 1096 were also ranked highly in blind tasting trials. Promotion of these varieties here is therefore likely to result in a very considerable increase in sweet potato production with no increased risk of SPVD. The work linked with BUCADEF, a local NGO, allowing CPP to award promotional project funds to them to exploit this result to the benefit of poor local people in the shortest possible time. As sweet potato is a nutritious staple widely consumed both in the rural areas and amongst the urban poor, this will substantially improve the diet of people in this relatively densely populated area of Uganda and increase food security. In order to extend both the use of these varieties and use of this approach, a working paper giving detailed results of these trials has been produced (R.W. Gibson, I. Mpembe, J. Kayongo & V. Aritua. Testing for superior cultivars using on-farm trials in Masaka, Rakai and Kanungu Districts of Uganda) and circulated to CPP, Ugandan and Tanzanian national scientists working on sweet potato and to regional (PRAPACE) and international (CIP) organisations. Separate research papers with a more precise focus are planned. The project has also identified (and informed others of) some disadvantages of the NAARI varieties. The most important may be susceptibility to *Alternaria* and weevils, especially in NASPOT 1. Consequently, a basket of cultivars is being promoted rather than just the best variety in order to provide better yield stability, the mixture ensuring that in years when different pests, diseases or environmental conditions are prevalent, at least one cultivar yields well.

Table 3. SPVD incidence (%) in on-farm and on-station trials in Kanungu District.

Trial	K1	K2	K2	K3	K4	K5	Mean
Introduced cultivars							
Bwanjule			1.4		6.2	3.1	3.6
New Kawogo		1.9	3.8		10.7	4.7	5.3
319		2.5			12.6	4.7	6.6
NASPOT 3	1.6	0.0	8.8	2.3	24.3	5.2	7.0
Wagabolige		0.0	4.4		18.9	4.9	7.1
93-493		5.6		10.7		9.6	8.6
NASPOT 4	17.9	0.0	1.3	9.6	14.7	15.1	9.8
1096		5.6			14.7	16.8	12.4
NASPOT 1	23.6	2.5	4.6	17.2		14.9	12.6
Sowola		3.0	9.4		31.5	8.2	13.0
Tanzania		12.5	13.8		13.4	14.4	13.6
NASPOT 6					18		18.0
NASPOT 2	5.6	0.0	12.5	14.5	46.8	29.7	18.2
NASPOT 5		13.8	8.4		22.7	36.2	20.3
202				20.3			20.3
Local cultivars							
Mulungi ha meza	4.3	0.0	10.6	3.4	16.4	12.3	7.8
Kyabafiluki	29.4	1.3	26.3	16.2	36.7	8.5	19.7
SEM	4.1	*	4.1	4.8	5.2	3	
LSD	12.3	*	11.8	13.6	14.8	8.7	

* Not calculated.
K1, K3 = on-farm trial planted in Kanungu District in the second rains of 1999 and the first rains of 2000 respectively.
K2, K4, K5 = on-station trial planted in Kanungu District in the second rains of 1999, the first rains of 2000 and the second rains of 2000 respectively.

The new varieties were less successful than the local check Kyabafiluki in the trials in Kanungu District. The best had only a similar tuberous root yield to local cultivar checks and several, notably NASPOT 5, yielded considerably less. However, the similar root yield was achieved with a lower incidence of SPVD than in the local cv Kyabafiluki (Table 3). Thus the control strategy was effective but the introduced cultivars seem poorly adapted to the environment there, which, at the relatively low altitude of the Rift Valley, is considerably hotter than that at NAARI where they were bred. Other work completed under R7492 (see later) has indicated that phytosanitation may be a valuable means of controlling the spread of SPVD. Such practices may be particularly appropriate for farmers in Kanungu, enabling them to grow the preferred Kyabafiluki without excessive losses to SPVD.

Activities in Bukoba District, Tanzania

Kagera Region has recently been affected by the pandemic of cassava mosaic disease spreading from southern Uganda, leading to massive losses of cassava production. There have been two main emergency responses to the consequent food shortages:

- Transfer and multiplication of cassava cultivars with resistance to cassava mosaic disease, often obtained through open quarantine from Uganda.
- Transfer and multiplication of high yielding sweet potato varieties obtained from Ukiriguru Agricultural Research Institute.

The initial aim of the project activities in Bukoba was to check whether the introduced sweet potato varieties were sufficiently resistant to SPVD as previous project work had identified high incidences of SPVD here. At the outset of the project, a key Tanzanian staff member of Maruku Agricultural Research Institute moved to a new job and there were difficulties in setting up and recording the results of a first set of trials. The following report details the results of two sets of on-farm variety trials done in villages around Maruku Agricutural Research Institute and around Kyaka Town, Bukoba, done following the appointment of Mr Innocent Ndyetabura. Kyaka had previously been identified as an area where sweet potato virus disease (SPVD) is prevalent whereas the disease is relatively less important at Maruku, perhaps because of its higher altitude and cooler climate. Trials were done with 16 collaborating farmers, eight located around Kyaka and eight around Maruku, in Bukoba District, Kagera Region. As in Uganda, the farmers provided planting materials of their two best local cultivars and cultivated and managed the trials. A single replicate block of the seven sweet potato varieties (SPN/O (Simama), SP 93/23 (Vumilia), SP 93/2 (Juhudi), SP 93/34 (Mavuno), Polista and Mwanamonde) plus two local cultivars were planted in each farmer's field. The selection of the improved cultivars was based on previous research at Maruku (Bukoba) and Ukiriguru (Mwanza) Agricultural Research Institutes. Farmers in the trial areas used their own criteria to select the two local cultivars included in their individual trial. In all cases, these were Kigambilenyoko plus either Hidaya or Kombegi. Each cultivar was planted on single wide ridge *c.* 2m wide x 6m long used traditionally in the region and made by hand using a hoe. Sixty cuttings of each cultivar were planted on each ridge. The first trial was planted in the second rains 2000 and the second trial was planted in the first rains 2001. Generally the same farmers were involved in both trials though a few sites in apparently low-SPVD areas in Kyaka were replaced by sites where incidence seemed greater.   Immediately after sprouting (i.e. one month after planting), all plants which appeared to be virus infected were removed and gaps were replanted with cuttings to maintain the original plant population.

Researchers monitored the trials at monthly intervals, recording the presence or absence of SPVD for all plants of each variety in each field at both sites. The trials were harvested about 6 mths after planting. Immediately before harvesting, an assessment was done of the occurrence of SPVD in each plot and number of plants found to be infected were recorded. A portion of the plot 1m wide by 2m long was harvested. The number of plants harvested, the weight of marketable and non-marketable tubers, the number of tubers attacked by weevils and fresh foliage weight were recorded for this harvested portion of each plot. There was considerable variation in yields at the different sites and years, probably caused by differences in soil fertility and rainfall. In order to exclude this, weights of tubers and foliage were adjusted so that the mean yield of plots at each site was 1, and these values were also analysed.

Outputs

The local landrace, Kigambilenyoko had relatively the largest marketable yield in most sets of trials (Table 4), similar to that of the top-yielding varieties, which were generally Sinia A and SP93/34. Mwanumonde, Polista, Sinia B and SPN0 yielded relatively poorly. SP93/34 also had a large yield of small, non-marketable tubers as did the local landrace Hidaya (Table 5). However, even in total yield, the local landrace, Kigambilenyoko performed similarly to the top-yielding varieties and the main differences amongst the cultivars were the very low total yields of Sinia B and Mwanumonde, and the relatively poor yields of Polista and SPN/0 (Table 6). There were no significant differences in foliage weight (Appendix: Table 17). Using unadjusted tuberous root yields (Appendix: Tables 13, 14 & 15) or measuring yield on a per plant basis (Appendix: Table 16) leads to similar conclusions.

SPVD was relatively rare during both seasons at both sites (Table 7) and only Sinia A was more affected than the local cultivar Kigambilenyoko. However, in an early preliminary trial, high incidences of SPVD had been noted in Sinia A and Sinia B, as well as in Kigambilenyoko. The variety SP93/34 was badly affected by weevils, perhaps partly as a result of its large tubers and expanding to push themselves out of the ground (Appendix: Table 18). The varieties SP93/23 and SP 93/2 also appeared somewhat prone to weevil attack.

Achievements

These results suggest that the varieties introduced from Ukiriguru-ARI offer only limited opportunities for boosting sweet potato yields to farmers in Kagera. The only yields significantly different from the local checks were those of Mwanumonde, Polista, Sinia B and SPN0, all of which yielded relatively poorly. This is perhaps not surprising as agroecological conditions at Ukiriguru, on the eastern side of Lake Victoria (long and hot dry season), are very different from conditions in Bukoba where rain falls throughout much of the year. However, SP93/34 did achieve a similar yield to the local landrace, Kigambilenyoko whilst having significantly less SPVD.

Furthermore, it and several of the other varieties had yielded relatively better than the local checks in a preliminary trial. Consequently, the introduction of this new germplasm to Kagera may well afford some benefits to farmers in Kagera. Despite this, these results suggest:

a) the need for local breeding/selection of sweet potato in Kagera;
b) promoting improved phytosanitation for the local landrace, Kigambilenyoko may give immediate benefits to both yield and food security;
c) the need to seek other high-yielding sweet potato varieties for Kagera (perhaps especially ones developed by the breeding programme at the agroecologically similar NAARI in Uganda.

Links established through R7492 involving both Ugandan and Tanzanian sweet potato scientists assisted our Tanzanian colleagues to appreciate the qualities of several of the newly-released NAARI sweet potato varieties in on-station and on-farm trials in Masaka and Rakai, the latter directly bordering Kagera. Bukoba in particular has a very similar climate to Ugandan districts bordering Lake Victoria. These close links with the Ugandan scientists have led to the project supporting the introduction of these varieties through open quarantine to Kagera Region. These on-farm variety trials are already in progress: preliminary observations indicate that NASPOT 1 is again yielding very highly whilst maintaining its resistance to SPVD.

Table 4. Weights of marketable yield harvested relative to the mean yield at each experimental site

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		1.2	0.9	1.3	1.2	1.1	0.6	0.6	0.5	2.1	0.6	27	0.7	1.4
1999	1	1.0		0.7	1.4	1.1	0.8	0.8	1.2	1.0	1.4	0.7	45	0.4	0.8
1999	2	1.2		1.5	0.6	0.6	1.3	0.6	1.1	1.0	1.2	1.0	45	0.4	0.7
2000	1		1.0	1.7	0.6	0.9	1.3	0.3	1.1	1.1	1.3	0.8	72	0.2	0.4
2000	2	0.9		1.3	0.2	0.7	1.0	0.3	0.8	1.1	0.8	1.2	52	0.3	0.6
All results with Hidaya + K'nyoko controls			1.0	1.4	0.8	1.0	1.2	0.4	1.0	0.9	1.6	0.7	108	0.3	0.5
All results with Kombegi + K'nyoko controls		1.0		1.1	0.7	0.8	1.0	0.6	1.0	1.0	1.1	1.0	160	0.2	0.4
All results combined: K'nyoko controls				1.3	0.8	0.9	1.3	0.6	1.0	1.0	1.4	0.9	242	0.2	0.3

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other ($P<0.05$).

Table 5. Weights of non-marketable yield harvested relative to the mean yield at each experimental site

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		0.8	0.9	1.0	0.9	0.7	1.1	0.7	1.0	2.5	0.4	27	0.5	1.0
1999	1	0.7		1.0	0.8	1.3	0.7	1.1	1.2	1.0	1.3	0.8	45	0.4	0.8
1999	2	1.0		0.8	1.0	0.8	1.4	1.3	0.8	0.7	1.1	1.0	45	0.3	0.7
2000	1		1.5	0.6	0.8	1.0	0.9	0.6	0.9	1.0	1.8	0.9	72	0.4	0.8
2000	2	0.8		0.6	0.6	0.6	0.9	1.0	0.6	0.9	1.5	0.8	52	0.3	0.6
All results with Hidaya + K'nyoko controls			1.3	0.7	0.9	1.0	0.8	0.7	0.9	1.0	2.0	0.8	108	0.3	0.6
All results with Kombegi + K'nyoko controls		0.8		0.8	0.8	0.9	1.0	1.1	0.9	0.8	1.3	0.9	160	0.2	0.4
All results combined: K'nyoko controls				0.8	0.9	0.9	1.1	1.0	0.9	0.9	1.7	0.8	242	0.2	0.3

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other ($P<0.05$).

Table 6. Total weights of tubers harvested relative to the mean yield at each experimental site

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		1.1	0.9	1.2	1.1	1.0	0.7	0.6	0.6	2.2	0.5	27	0.6	1.2
1999	1	1.0		0.8	1.2	1.1	0.8	0.9	1.2	1.0	1.4	0.7	45	0.3	0.7
1999	2	1.2		1.2	0.8	0.7	1.3	0.8	1.0	0.9	1.1	1.0	45	0.3	0.6
2000	1		1.2	1.5	0.6	0.9	1.2	0.3	1.1	1.0	1.4	0.8	72	0.2	0.5
2000	2	1.2		1.2	0.4	0.8	1.1	0.5	0.7	1.1	1.0	1.1	52	0.3	0.5
All results with Hidaya + K'nyoko controls			1.2	1.3	0.8	1.0	1.1	0.5	0.9	0.9	1.7	0.7	108	0.2	0.5
All results with Kombegi + K'nyoko controls		1.1		1.1	0.8	0.9	1.1	0.8	1.0	1.0	1.2	1.0	160	0.2	0.3
All results combined: K'nyoko controls				1.2	0.8	0.9	1.1	0.7	1.0	1.0	1.4	0.9	242	0.1	0.3

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other (P<0.05).

Table 7. The mean number of SPVD-affected plants per plot (2 x $6m^2$; 60 cuttings planted /plot).

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		0.5	5.0	0.0	0.8	9.5	6.0	1.3	0.0	1.8	0.8	27	2.4	5.0
1999	1	1.3		7.5	3.2	2.3	16.5	6.3	0.7	2.8	3.2	6.3	45	2.2	4.5
1999	2	2.0		5.2	0.8	0.8	5.0	1.7	0.8	1.7	1.2	2.0	45	1.6	3.2
2000	1		0.3	3.8	0.0	0.0	4.0	0.9	0.0	0.2	0.1	0.7	72	1.5	3.0
2000	2	0.6		0.6	0.8	0.1	1.9	1.8	0.3	4.7	0.4	1.1	52	2.1	4.2
All results with Hidaya + K'nyoko controls			0.4	4.2	0.0	0.2	5.7	2.5	0.4	0.2	0.6	0.7	108	1.3	2.5
All results with Kombegi + K'nyoko controls		1.3		4.2	1.5	1.1	7.5	3.2	0.6	3.2	1.5	3.1	160	1.3	2.5
All results combined: K'nyoko controls				4.2	0.8	0.7	6.8	2.9	0.5	1.9	1.1	2.1	242	1.0	1.9

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other (P<0.05).

Project output 1, Planned activities: 1.2 *Identification of superior genotypes, linking with local organisations to aid their distribution to farmers, surveys of changes in the frequencies of varieties grown by farmers, particularly of those being distributed and monitoring impact on SPVD incidences in crops.*

Participating farmers were questioned at the end of the above trials in Masaka and Rakai Districts, using a questionnaire, about the usefulness of the introduced sweet potato cultivars, their continued use by the participating farmers and their dissemination to other farmers. Building on the links with BUCADEF, to which CPP had recently provided funds in order to distribute planting material of the SPVD-resistant varieties in areas where SPVD is prevalent, 30 and 28 participating farmers in Luwero and Kiboga Districts respectively were also interviewed. Farmers were interviewed on their family farm, generally as a family group. They were initially asked general questions about the role of sweet potato within the farm and to the family, leading on to questions about the adoption and dissemination to friends of the new varieties. S/he/they were asked to bring samples of all the different cultivars (both local and introduced) of sweet potato grown on the farm and asked what was special (both good and bad) about each cultivar, using the samples of each as a prompt. Farmers then ranked all the attributes and, for each attribute, ranked all the cultivars (introduced and local) from the best (ranked "1") to the worst. A similar ranking method was utilised for sweet potato by Kapinga *et al.* (2001). Different farmers grew different numbers of cultivars and so ranks given to each cultivar were standardised to ten cultivars

Outputs

Cultivars grown by farmers. Farmers grew a range of crops (Appendix: Table 19); sweet potato was grown for family consumption by all the farmers interviewed but was marketed by only about half of them (Appendix: Table 20). Most farmers grew between two and four local cultivars (Appendix: Table 17). In each of the districts, there were just two to four local cultivars widely grown by most of the farmers interviewed, most farmers interviewed in the district growing one or two of them. Apart from Old Kawogo, none of these widely-grown cultivars were common in more than one district. In total, some 20 to 30 local cultivars were grown by farmers interviewed in each district and most were unique to each district (or at least the names were). The farmers also grew a range of the new varieties (Appendix: Table 20). The new varieties had not been distributed identically amongst the farmers, some receiving one range through the on-farm trials (Masaka and Rakai) and the others receiving them through separate dissemination programmes (Luwero and Kiboga). The range of new varieties grown by each farmer was therefore limited by differential access as well as by choice; NASPOT 1 and NASPOT 2 were the most commonly grown new varieties. Most of the farmers had had access to the new varieties for two to three growing seasons.

Following access to the new varieties, most farmers had reacted very positively, giving out cuttings to a range of contacts and increasing their acreage of sweet potato (Table 8). A few had also started selling cuttings; one in Luwero in already built this into a major business. This commercialisation of cuttings in particular has the potential to have major indirect benefits to sweet potato production, providing a means by which new varieties can be quickly disseminated through normal marketing practices and even perhaps feeding funds back into sweet potato breeding.

Table 8. Some actions taken by farmers as a result of their recent access to new cultivars

	Masaka + Rakai*	Luwero*	Kiboga*
Given cuttings to (%):	83	53	86
Relatives (%)	28	27	25
Friends (%)	72	33	46
Neighbours (%)	44	13	57
Others (%)	0	13	20
Sold cuttings (%)?	11	4	14
Growing more sweet potato (%)?	72	83	79
How much more each?	0.9 acres	0.8 acres	0.4 acres

* Numbers of farmers interviewed were:18 in Masaka + Rakai, 30 in Luwero and 28 in Kiboga Districts

Attributes specified by farmers. Individual farmers generally identified 6 –10 attributes of their sweet potato cultivars as worthy of ranking, with a total in each location of between 22 and 28 different attributes (Table 9). In each location, they also mentioned up to 11 further attributes in the preliminary discussion (Table 10). Generally a higher rank given to an attribute was associated with more farmers mentioning the attribute (Table 9). The most important attribute in all three locations was tuberous root yield. This was confirmed by the close positive correlations evident between the overall ranks given to each of the main cultivars and their ranks for high tuber yield in each of the three locations (Tables 11, 12 & 13). Large tuber size, sweetness of the tubers and drought resistance of the plants were all included (though in different orders) amongst the next four most important attributes by all farmer groups. Other aspects of the tuberous roots formed the majority of the other attributes specified. Commonly mentioned ones included mealiness, softness, taste and lack of fibres of the cooked tubers, appearance and marketability of the harvested tubers, their early and continuous production and their ability to be stored unharvested (and retain a good taste) for a long time in the soil. In addition to resistance to drought, resistance to pests was also ranked highly, particularly resistance to weevils, to the caterpillars of the sweet potato butterfly (*Acrea* spp) and to the fungus *Alternaria*. Resistance to SPVD appeared to be rarely mentioned. However, on subsequent questioning, this was revealed to be the result of misunderstandings due to this disease having no clearly understood cause, easy description or a specific name. Thus, when farmers were asked afterwards why they hadn’t mention it, many explained

Table 9. Different attributes identified by farmers, listed by A) number of farmers identifying that attribute, and B) mean rank given to it.

Masaka + Rakai	**A**	**B***	**Luwero**	**A**	**B***	**Kiboga**	**A**	**B***
High tuber yield	17	1	High tuber yield	29	1.4	High tuber yield	29	1.1
Large tuber size	15	3.5	Resistance to drought	28	4.4	Sweet tubers	27	2.4
Sweet tubers	15	4.2	Big tubers	26	4.5	Mealy tubers	27	4.5
Drought resistance	14	4.6	Mealy tubers	26	6.0	Big tubers	23	5.4
Weevil resistance	11	4.5	Sweet tubers	24	3.0	Resistance to drought	22	5.3
Early tuber maturity	9	4	Resistance to weevils	21	4.8	Early maturity	20	4.9
Long-lasting tubers	9	5.8	Resistance to *Acrea*	17	6.2	Continuous tuber yield	17	4.3
Mealy tubers	7	5.3	Early maturity	16	5.4	Resistance to weevils	17	6.5
Extensive foliar growth	5	6.4	Continuous tuber yield	15	5.7	Attractive tubers	8	7.6
Continuous tuber yield	4	5	Marketability	6	7.2	Non-fibrous tubers	5	6.8
Non-fibrous tubers	4	7.3	Nice flavour	5	7.0	Long-lasting tubers	5	6.8
Alternaria resistance	2	5.5	Softness	5	7.6	Nice looking at table	5	7.8
Marketability	2	6	Good vine establishment	5	8.4	Resistance to *Acrea*	4	6.0
Acrea resistance	2	6.5	No loss of taste with time	4	6.0	Marketability	4	7.8
Non-sappy tubers	2	7	Less fibre	4	6.5	No loss of taste with time	4	10.0
SPVD resistance	1	5	Non-sappy tubers	4	7.0	Easy to cook	2	8.0
Unexposed tubers	1	5	Extensive foliar growth	4	7.8	Non-sappy tubers	2	9.0
Soft tubers when cooked	1	5	Resistance to rodents	3	6.7	Less 'kigave' **	1	1.0
Yield on infertile soils	1	7	Performance on poor soils	3	7.3	Straight tubers	1	7.0
Soft skin on tubers	1	7	Attractive tuber colour	3	8.0	Non exposed tubers	1	10.0
Smooth tubers	1	8	Attractive tuber flesh	1	4.0	Extensive foliar growth	1	10.0
Attractive tuber flesh	1	9	Less 'kigave' **	1	6.0	Good yield on poor soils	1	10.0
			Resistant to *Alternaria*	1	7.0	Resistance to rodents	1	12.0
			Lasts long in soil	1	7.0			
			Regrowth after drought	1	8.0			
			Nice looking vines	1	9.0			
			Resistant to cracking	1	10.0			
			Easy to cook	1	11.0			

** Farmers had different numbers of cultivars and ranks for each were divided proportionally between 1 and 10 before averaging. **Black patches within the tuber.*

Table 11. The mean rank given by farmers in Masaka and Rakai to attributes of widely-grown introduced and local cultivars.

	Introduced cvs				Local cultivars				
Attributes	**NASPOT 1****	**NASPOT 2****	**93-493****	**NASPOT 3****	**Old Kawogo**	**Kampala**	**Somba Busero**	**Kalebe**	**Other local cvs**
Overall rank	2.0	3.6	5.0	8.1	5.7	2.8	2.8	3.7	6.7
High tuber yield	2.0	3.6	5.9	7.2	6.0	4.1	2.3	3.3	6.9
Large tuber size	0.9	6.0	6.8	5.4	1.0	3.2	7.5	1.9	7.1
Sweet tubers	3.3	4.8	6.8	6.6	2.6	3.9	3.9	2.5	6.4
Drought resistance	6.7	6.0	1.8	3.8	1.8	2.7	8.1	3.0	6.7
Weevil resistance	5.2	5.7	4.5	5.0	0.5	2.7	8.4	5.7	6.9
Early tuber maturity	1 .2	3.3	4.1	7.1	9.4	5.1	1.7	3.6	6.7
Long-lasting tubers	5.3	7.3	3.1	5.2	0.2	3.2	7.8	3.4	8.0
Mealy tubers	3.9	3.3	6.9	8.2	1.5	6.4	6.1	2.7	5.6
Extensive foliar growth	5.5	8.0	4.7	1.5	3.8	0.0	6.2	6.7	7.7
Continuous tuber yield	7.7	7.4	4.4	7.3	1.0	0.0	3.7	2.5	6.3
Non-fibrous tubers	5.1	0.6	8.9	7.5	3.4	3.1	5.6	3.3	6.4
Alternaria resistance	10.0	8.0	3.4	0.0	2.0	-	6.0	-	3.7
Marketability	2.5	2.9	5.3	9.1	-	2.2	4.4	-	6.8
Acrea resistance	2.7	5.0	8.3	5.0	1.8	5.6	4.4	3.3	5.0
Non-sappy tubers	3.3	2.0	4.4	3.1	8.4	0.0	7.4	1.2	2.2
SPVD resistance	8.5	-	0.0	1.4	4.3	7.1	-	-	7.1
Unexposed tubers	7.5	10.0	2.5	0.0	-	-	-	-	5.0
Soft tubers when cooked	4.5	5.6	2.2	6.7	0.0	-	3.3	-	9.2
Yield on infertile soils	3.3	-	5.6	4.4	8.9	7.8	0.0	6.7	5.1
Soft skin on tubers	2.2	-	4.5	5.6	8.9	3.3	0.0	6.7	9.4
Smooth tubers	6.0	4.0	10.0	8.0	0.0	-	2.0	-	-
Attractive tuber flesh	2.2	-	5.6	3.3	7.7	1.1	0.0	6.7	9.7

Cultivar was ranked above or below the expected mean rank of 5.5 for that particular attribute by significantly (P<0.05; P<0.01) large number of farmers that they had included it as "disease resistance" and the attribute of resistance to SPVD had apparently been "lost" as the interviewer probed to identify what the resistance was against. Another commonly mentioned attribute was extensive growth of the foliage to provide a source of planting material (but not as a source of feed for livestock as sweet potato foliage is seldom used for this purpose by Ugandan farmers) and perhaps as an indicator of good yield.

Table 10. Attributes mentioned but not ranked by farmers in Kiboga, Luwero and Masaka + Rakai districts of Uganda.

Masaka + Rakai	**Luwero**	**Kiboga**
Resistant to rain	Doesn't require big ridges/mounds	Non-fibrous tubers, especially when young
Long tubers	Tubers are close to soil surface for easy harvesting	Does well in all weather conditions
Many tubers	Ease of peeling	Not too sweet
Thin peel of tubers	Long tubers	Good vine establishment
Ample planting material	Straight tubers	Long tubers
Quick to cook	Resistant to millipedes	Soft when peeling
Few cracks in tubers	Suppresses weeds	Soft when cooked
Long-lived plants		Long lived plants
Few black spots on tubers		Hard (solid) tubers
Not watery		Doesn't break when harvesting
Resistant to weeds		Does OK in poorly-tilled soils

Different ranks given to different cultivars. NASPOT 1 was ranked highly both overall and for most of the relatively highly-ranked attributes by farmers in all three locations (Tables 11,12 & 13). It was ranked highly particularly for its high yield of large, mealy, sweet tubers and for its early tuber maturity. It was also ranked first by many farmers for these attributes (Appendix: Tables 21. 22 & 23). Indeed, resistance to drought was the only major attribute for which it was not ranked above average. Farmers in Kiboga and Luwero, but not in Masaka + Rakai, also considered it to be somewhat resistant to weevils and Luwero farmers considered it to be good at yielding continuously. Amongst the other on-station-bred cultivars, none seemed particularly favoured. Indeed, NASPOT 4 was ranked significantly ($P<0.01$) below average overall, and specifically for its apparently low yield and small tubers. Clone 93-493 was rated highly for its drought resistance but for almost no other characteristic. The extreme susceptibility of NASPOT 1 and NASPOT 2 to Alternaria disease was also clearly perceived by those farmers in Masaka + Rakai who commented on this. NASPOT 3, NASPOT 4 and 93-493 seemed generally to be perceived to have relatively poor tuber qualities and not to yield particularly well. Cvs New Kawogo and Tanzania were grown by too few farmers for their responses to be analysed statistically.

Amongst the commonly-grown local cultivars, only cv. Old Kawogo was grown extensively by farmers in more than one of the locations. In neither location (Masaka + Rakai & Kiboga) was it ranked highly overall, perhaps because of its apparently low yield and late maturity. However, farmers in Masaka and Rakai, though not in Kiboga, considered it to have particularly large, sweet mealy tubers. In contrast, cv

Somba Busero was ranked highly overall by farmers in Masaka + Rakai but apparently only for its large and early tuber yield. Elsewhere, similar trade-offs seem to be being made by the farmers. Thus, farmers in Kiboga ranked cv Kyebandula low overall and for its apparently poor and late yield yet its tubers were ranked high for sweetness, mealiness and attractiveness. Similarly, farmers in Luwero ranked cv. Dimbuka highly overall, but largely for its high and early yield - its tubers were apparently not very sweet or mealy. In contrast, cv. Silk was perceived to be relatively poor yielding but its tubers were preferred for their sweetness and mealiness. Similarly, many of the rarely-grown local cultivars were ranked highly for one or a few attributes by the few farmers who grew them, as can be appreciated from the many “firsts” allocated to these “other” cultivars (Appendix: Tables 21, 22 & 23).

Achievements

Farmer interviews identified that farmers were enthusiastically adopting some of the new varieties, accessed either through project variety trials or through active dissemination programmes. Most farmers were growing about four of the introduced cultivars and most had felt sufficiently confident of them to supply friends and neighbours with planting material. Two of the farmers had also sold cuttings, indicating that both they and the recipients considered them to be a valuable commodity. In Luwero District, at least one farmer is selling cuttings of these new cultivars as a major business and the few sales in Masaka and Rakai may be a forerunner of this there. Most of the farmers were also growing more sweet potato as a consequence of obtaining these new cultivars. These trial and survey results all therefore indicate that access to these on-station bred cultivars is, and is perceived by farmers to be, beneficial in Masaka, Rakai, Luwero and Kiboga. Furthermore, the trials by themselves seem to have achieved long-term establishment of the varieties in these areas.

Variety ranking using samples of each cultivar as a physical prompt enabled farmers in each location to articulate some 20 to 30 different attributes of local and/or introduced cultivars that they considered to be important distinguishing factors. It appears likely that these attributes which the farmers identified together with their relative ranks were meaningful because:-

- Several attributes, such as a high yield of large, sweet mealy tubers, were identified as being important by farmers in all three locations;
- Attributes ranked as important by farmers were also mentioned by correspondingly large numbers of farmers ($P < 0.001$);
- The overall rank for each of the main cultivars grown was closely ($P < 0.001$) correlated to the rank of the most highly ranked single attribute (high yield) in each of the three locations;
- Farmers in different locations were consistent in identifying that a cultivar (NASPOT 1) is particularly good (or bad) for certain attributes ($P < 0.001$).

Facilitating farmers to identify the important attributes of sweet potato varieties using variety ranking enabled new information and insights to be achieved. Bashaasha *et al.* (1995) in their study of sweet potato in the farming systems of Uganda used structured questionnaires and checklists to interview farmers. They did not include tuber size or tuber mealiness in their characterisation of sweet potato cultivars, yet farmers in our loosely-structured interviews identified them to be amongst the most important characters. Conversely, Bashaasha *et al*. (1995) included tuber skin and flesh colour, yet few farmers in our survey considered them worth mentioning despite other characteristics of tubers being foremost. We ourselves were also somewhat surprised by a few of the attributes farmers identified as particularly important. One example was drought resistance, ranked frequently and highly by farmers yet the districts sampled all have moderately high rainfall and sweet potato is considered to be a drought-resistant crop. Drought resistance is apparently important for enabling good survival of the cultivar through the dry season so there is sufficient planting material at the beginning of the rains as well as for enabling the cultivar to yield well during dry seasons. Cv 93-493 was particularly appreciated for its drought resistance. These results have been made available to both Ugandan and the CIP sweet potato breeders.

The farmers identified NASPOT 1 as being particularly good, having a high, early yield of sweet, mealy tubers. Indeed, this cultivar was generally considered to be much better than local cultivars. That these results agree with those obtained in Masaka and Rakai using on-farm trials and “blind” palatability tests gave strong support to the decision to distribute this variety more widely. A major difference with these on-farm trials was, however, that other cultivars such as NASPOT 2, NASPOT 3 and clone 93-493, which also had a high yield and were apparently quite palatable in “blind” tests, were generally ranked no better than the local cultivars. The reason for this apparent bias against these particular introduced cultivars is unclear. Furthermore, having identified NASPOT 1 as being very good, farmers seemed to be a little blind its faults, most failing to identify its susceptibility to weevils and *Alternaria.*

The results of this work have been distributed nationally and regionally through two rapidly-generated working papers (R.W. Gibson, I. Mpembe, J. Kayongo & V. Aritua. Use of variety ranking to enable farmers to compare introduced and local sweet potato cultivars *and* Comparison and combination of outputs of on-farm trials and variety ranking for assessing the usefulness of new sweet potato cultivars to farmers)

Table 12. The mean ranks (range 0 - 10) of the four introduced cultivars, for the three main local cultivars and for “other” local cultivars grown more rarely by the farmers in Kiboga.

	Introduced cvs				Local cvs			
	1*	**2***	**4***	**Sowola**	**Kyebandula**	**Old Kawogo**	**Kakooza**	**“Others”**
Overall rank	2.4	5.2	6.7	4.8	8.6	7.3	7.4	5.0
Attribute								
High tuber yield	2.4	5.2	6.8	4.8	8.1	7.3	7.4	5.1
Sweet tubers	3.0	6.8	7.4	5.9	2.3	7.5	5.6	5.6
Mealy tubers	3.7	6.7	7.3	5.6	1.2	6.2	5.6	5.6
Big tubers	2.7	6.9	8.0	6.2	4.6	5.8	5.6	5.2
Resistance to drought	4.6	5.7	6.3	6.6	2.0	6.2	7.4	5.8
Early maturity	2.5	5.0	6.1	5.7	8.7	8.0	7.0	5.4
Continuous tuber yield	3.9	5.7	5.5	6.6	5.8	7.8	5.7	5.6
Resistance to weevils	3.7	5.8	6.0	7.6	4.2	6.6	8.2	6.2
Attractive tubers	2.3	7.8	7.3	4.7	2.2	7.2	2.7	6.2
Non-fibrous tubers	5.5	6.6	1.8	6.0	4.0	3.3	10.0	7.0
Long-lasting tubers	2.2	5.6	8.6	1.0	1.4	7.4	8.7	6.6
Nice looking at table	4.4	7.3	8.4	7.8		8.2	5.5	5.1
Resistance to *Acrea*	2.4	3.4	5.2	4.5	4.1	7.4	6.0	7.6
Marketability	3.9	5.6	7.1	4.8	2.7	6.7	3.6	6.7
No loss of taste with time	1.0	7.8	6.7	4.6	-	-	10.0	6.1
Easy to cook	2.9	2.3	4.9	4.9	8.1	8.7	4.9	6.6
Non-sappy tubers	10.0	2.3	6.3	3.3	9.4	6.1	-	4.5
Less 'kigave'	-	10.0	-	-	-	-	-	
Straight tubers	6.4	-	-	8.2	-	-	-	2.8
Non exposed tubers	7.0	10.0	8.5	1.0	4.0	-	-	3.0
Extensive foliar growth	5.5	6.6	1.0	7.8	2.1	-	10.0	5.5
Good yield on poor soils	1.0	2.8	4.6	-	10.0	-	1.0	6.4
Resistance to rodents	7.0	8.5	10.0	-	4.0	-	1.0	3.0
Mean	4.0	6.1	6.4	5.9	4.5	6.9	6.7	5.5

* NASPOT 1, 2 & 4.

(light shading)	Attribute was ranked significantly (P < 0.05) greater or less than expected mean rank
(dark shading)	Attribute was ranked significantly (P < 0.01) greater or less than expected mean rank

Table 13. The mean ranks (range 0 - 10) for the three main introduced cultivars, for the two main local cultivars and for "other" local cultivars grown more rarely by farmers in Luwero.

	Introduced cvs			Local cvs		
	1*	2*	4*	Dimbuka	Silk	"Others"
Overall rank	2.4	5.6	8.1	4.0	7.2	7.6
Attribute						
High tuber yield	2.4	5.8	8.3	3.8	7.4	7.6
Resistance to drought	5.0	4.3	5.6	7.2	6.7	5.5
Big tubers	2.6	6.4	8.1	6.3	5.6	7.4
Mealy tubers	2.9	5.2	5.4	8.7	2.8	6.5
Sweet tubers	2.7	6.1	6.4	8.9	3.8	7.1
Resistance to weevils	3.7	3.4	5.0	7.9	8.3	5.6
Resistance to *Acrea*	3.1	4.8	3.7	8.8	6.9	4.4
Early maturity	3.6	6.2	8.1	2.2	8.2	7.6
Continuous tuber yield	6.4	3.5	7.6	3.9	5.3	6.9
Marketability	1.0	6.8	5.0	9.3	4.0	6.9
Nice flavour	1.9	3.2	8.0	9.2	6.4	7.7
Softness	4.8	10.0	-	8.3	-	2.9
Good vine establishment	2.4	10.0	4.8	7.3	2.8	7.3
No loss of taste with time	5.5	14.5	-	8.2	-	6.5
Less fibre	-	-	10.0	-	-	9.0
Non-sappy tubers	1.2	3.4	2.5	5.3	6.8	8.2
Extensive foliar growth	6.3	6.7	4.0	4.2	8.2	5.5
Resistance to rodents	8.8	4.6	-	5.5	8.2	1.0
Performance on poor soils	2.0	7.1	2.5	3.3	6.8	8.3
Attractive tuber colour	3.7	8.2	8.2	10.0	6.4	1.0
Attractive tuber flesh	1.8	4.0	3.3	5.5	7.8	8.5
Absence of Kigave	-	-	-	-	-	10.0
Resistant to *Alternaria*	7.0	-	-	10.0	1.0	4.0
Lasts long in soil	-	-	-	1.0	14.5	7.8
Regrowth after drought	1.0	-	-	6.4	4.6	7.0
Nice looking vines	10.0	7.0	1.0	4.0	-	-
Resistant to cracking	10.0	9.4	1.0	8.7	4.2	7.1
Easy to cook	1.0	-	-	10.0	-	-
Mean	4.0	6.4	5.2	7.2	5.8	6.4

1*, 2*, 4* = NASPOT 1, 2, 4 respectively

	Attribute was ranked significantly (P < 0.05) greater or less than expected mean rank
	Attribute was ranked significantly (P < 0.01) greater or less than expected mean rank

Project output 2: A programme of research on the local epidemiology and control of SPVD put into effect.

Planned activities: *Planning , supporting and monitoring work for a PhD on the local epidemiology of SPVD. This work aims to examine the efficacy of local phytosanitary practices for SPVD control.*

Activities

The PhD involved a scholarship included within a planned second phase of the Tropical Whitefly IPM Project. Unfortunately, TWIG's start was delayed until 2001 and alternative funding, for an MSc student (Mr Emmanuel Byamukama) based at Makerere University, was obtained through the Rockefeller FORUM programme. His main experiment examining the epidemiology of SPVD involved a field at NAARI planted wholly with sweet potato but with the central 7 x 7m portion planted with SPVD-affected plants. The proportion of plants infected during the growing season in areas 0 - 5m, 5 - 10m and 10 - 15m away from the SPVD-affected area was recorded. Diseased plants were removed as soon as they were detected to prevent them acting as secondary sources of infection. Low-level aerial abundances of adult whiteflies and aphids were also monitored, using sticky yellow traps mounted at different heights on an array of poles both within and outside the planted area. The experiment was done during 3 growing seasons, namely the first and second rains, 2000 and the first rains 2001.

Subsequently, experiments were conducted by project staff. In a first experiment at NAARI, plots of unaffected sweet potato were planted adjacent and 15m away on all four sides of an SPVD-affected plot. The spread of SPVD to the initially unaffected plots was recorded. This experiment was done twice. A further on-farm trial examined the role of removing diseased cuttings from plots. Three treatments were being tested:

A No roguing;

B Roguing out diseased plants throughout the cropping cycle;

C Roguing out diseased plants at one month after planting (when the first weeding would occur and when diseased cuttings are first obvious.

Treatments were replicated 4 times and the experiment has been done at two farms for two growing cycles. Diseased plants were recorded monthly and the tuberous root yield was recorded at harvest.

Outputs

In two of the three replicates of the experiment examining the spread of SPVD from a central source in a field, SPCSV spread proportionally much faster to plants within 0 - 5m of the central infector plot than to plants further away. However, close examination of the results (Fig. 1) reveals that short-distance spread predominated only during the third (and final) month of these replicates and it is suspected that this apparent change to short distance spread was associated with canopy closure. The replicate in which short distance spread did not predominate was planted in the second rains: these rains are succeeded by a hot dry season delaying canopy closure.

Few aphids were caught on the sticky traps. Similar numbers of whiteflies were trapped at the three positions within the crop (i.e., 3.5, 10.5 and 17.5m from the centre). Similar numbers were also caught at 15m and 100m away from the crop, but these were 2 - 5 times fewer than were caught within the crop (Table 14). Most whiteflies were trapped on the lowermost sticky traps (20 and 50 cm height). There was no significant difference in whitefly catches in sectors of each trap aligned in different points of the compass.

Table 14. Mean number of adult whiteflies on traps with respect to distance from a central (infector) plot

Distance (m)	Short rains (2000)		Long rains (2000)		Short rains (2001)	
	Log transformed	Untransfor-med	Log transformed	Untransfor-med	Log transformed	Untransfor-med
a) from crop centre						
3.5	0.99	9.8	0.92	8.3	1.06	11.5
10.5	1.06	11.4	0.90	8.0	1.08	12.0
17.5	1.03	10.6	0.87	7.4	1.10	12.6
b) from crop edge						
15	0.41	2.6	0.43	2.7	0.71	5.1
100	0.37	2.4	0.43	2.7	0.62	4.2
LSD(0.05)	0.068		0.030		0.033	

In the experiment in which plots were planted adjacent or 15m away from a central infector plot, more spread (80% plants infected) occurred to the plots close to the infector plot than to the ones just 15m away (30% plants infected) (Fig 2)($P<0.05$).

Table 15.The effects of removing SPVD-affected sweet potato plants on spread of SPVD, tuberous root yield and weevil damage in on-farm trials.

	Tuberous root yield (kg/initial 60 plants		No. of new SPVD-affected plants/plot	No. of weevil-damaged tubers/plot
	Marketable	Total		
No roguing	13.6	19.1	13.7	6.6
Roguing 1 MAP	12.8	17.6	7.9	6.8
Roguing throughout	13.4	19.5	7.5	6.2
LSD (P = 0.05)	6.5	7.8	4.3	5.2
SED (d.f = 45)	3.2	3.9	2.1	2.6

In the roguing experiment, removing SPVD-affected plants either just at one month after planting (1MAP) or throughout the six months of the experiment approximately halved the amount of spread of SPVD (Fig 3). There was no increase in weevil damage which could have occurred due to root exposure during roguing of neighbouring plants (Table 15). Roguing was also associated with no significant loss of tuberous root yield. This latter result supports the preliminary results of a PhD study funded by the EU on compensation and competition between sweet potato plants, which show that sweet potato plants can considerably increase their productivity to compensate for the poor growth or absence of a neighbouring plant.

Achievements

These experiments all support the hypothesis that spread of SPCSV is largely a local phenomenon and therefore that local control of SPVD-affected plants provides an effective strategy for controlling this disease. Indeed, the results show that spread is extremely local, spread declining over a space of just a few metres and roguing being effective in plots guarded by only a few rows/plants of sweet potato. It is likely that this is because SPCSV is only semi-persistently transmitted (Larsen *et al.*, 1991) and because the vector whitefly, *Bemisia tabaci*, predominantly makes short flights (Byrne *et al*., 1996). This result opens the opportunity for farmers safely to make increased use of SPVD-susceptible landraces. Bearing in mind that some of these landraces yield at least twice that of widely-grown more resistant landraces, the opportunities to increase production by this means are clear. These results also suggest that other means of cultural control may well be effective; possible options include examining the effects of intercropping. Other observations that whitefly-borne viruses tend to be rare in shaded parts of fields and that sweet potato planting material is commonly planted in the shade of bananas have also instigated an on-station trial examining the effect of shading on SPVD spread.

Project output 3: The vector of SPMMV identified by consistent and repeated transmission under controlled conditions.

Planned activities: *Culturing SPMMV and potential vectors; transmission experiments under controlled conditions.*

Outputs

For many years, *Sweet potato mild mottle virus* (SPMMV) has been the only member of the *Ipomovirus* group. It had been transmitted by whiteflies (Hollings *et al.*, 1976), but this transmission was considered uncertain a) because it might have been difficult to distinguish transmission of SPCSV from a mixed infection of SPCSV + SPMMV with the diagnostics available at that time and b) no-one had been able to repeat this transmission. The closest known relatives of SPMMV at the time when R7492 was proposed were members of the *Tritimovirus* group, all of which are transmitted by eriophyid mites belonging to the genus, *Aceria*. A mite belonging to an undescribed Aceria sp is common in East Africa, causing hairiness (Sheffield, 1954). It was therefore considered possible that this mite could be the true vector of SPMMV and the work targeted this possible vector. Despite several attempts to culture this mite at NRI, this has proved extremely difficulty to achieve as plants failed to grow well in quarantined conditions, repeatedly becoming colonised by spider mites. However, this interest in the eriophyid mite has led to the presence of eriophyid mites causing hairiness being identified as a major pest of sweet potato in South Africa, the first record of this disease outside East Africa. It has also led to a collaboration with a

South African taxonomist, aimed at the first published description and naming of this eriophyid mite. During the period of R7492, *Cucumber vein yellowing virus* has been shown to be another *Ipomovirus* and to be transmitted by *B. tabaci* (Lecoq *et al*., 2000). This removes much of the doubt concerning the whitefly transmission of SPMMV. Also further surveys done by an associated EU-funded project in Uganda and Kenya have confirmed that SPMMV is a “poor third” in incidence after SPFMV and SPCSV (which together cause SPVD) and preliminary results suggest that SPMMV has relatively little effect on yield. Whilst attempts to confirm the transmission of SPMMV by whiteflies continue, it was agreed with CPP advisers to increase the activities on publication of results and testing new varieties.

Project output 4: Two chapters describing the achievements of Phase 1 of the sweet potato component of the Inter-Centers Initiative, a session including these achievements in the African Potato Association meeting in May 2000 and a manuscript describing how local conditions of sweet potato cultivation affect incidence of SPVD.

Planned activities: 4.1 *Analysis and reporting activities on whitefly-borne viruses of sweet potatoes for the final report of Phase I of the Inter-Centers Initiative. This involves analysis, tabulation and description of survey and epidemiology work done since January 1997.*

Outputs

The achievements of Phase 1 of the sweet potato component of the Inter-Centers Initiative have been described in the following two reports delivered to the local project co-ordinator, Dr James Legg:

Report 1:

R.W. Gibson, V. Aritua and S. C. Jeremiah. Factors associated with damage to sweet potato crops by sweet potato virus disease.

Report 2:
V. Aritua, R.W. Gibson and H. J. Vetten. Serological analysis of sweet potato virus disease-affected sweet potatoes in East Africa.

I was informed during recent discussions with Dr Pamela Anderson, Co-ordinator of Phase 1 of the Tropical Whitefly IPM Project, that these reports are being amalgamated into a book.

A further publication based on an amalgamation of two surveys of farmer knowledge of SPVD, done in a) Phase 1 of the Tropical Whitefly IPM Project and b) in an EU-funded project also managed by RW Gibson is being written

Planned activities: 4.2 *Planning and correspondence with sweet potato virologists and APA organisers in order to organise a session on sweet potato virus diseases of* *sweet potato in Africa, the session to include contributions describing the achievements of R6617, R(H)5878 and the sweet potato virus outputs of the Inter-Centers Initiative.*

Outputs

The Fifth Triennial Congress of the African Potato Association was held on 29th May – 2nd June, 2000 in Kampala, Uganda, under the title, "Potatoes for Povery Alleviation". A session entitled "Sweet Potato Viruses", convened by R. W. Gibson, was held on the morning of 1st June, 2000. The session comprised the following presentations.

R. W. Gibson and V. Aritua. Sweet potato virus disease in Africa.

V. Aritua, J. P. Legg and R. W. Gibson. Sweet potato virus disease infection of sweet potatoes exposed to natural inoculum in Uganda.

J. Ndunguru. Incidence of sweet potato virus disease in different sweet potato traditional cropping patterns in the Lake Zone of Tanzania.

C. Jericho and G. J. Thompson. Detection, characterisation and distribution of viruses infecting sweet potato in South Africa.

R. F. Karyeija, J. R. Kreuze, R. W. Gibson and J. P. T. Valkonen. Variability of sweet potato feathery mottle virus in Africa.

W. K. Kaniewski, D. Maingi, M. B. Kaniewski, S. Flasinski, J. B. Lowe, D. Kirubi, C. Macharia, F. Wambugu, R. Horsh and M. A Hinchee. Engineered resistance to sweet potato feathery mottle virus in sweet potato.

J. R. Kreuze, R. F. Karyeija, R. W. Gibson and J. P. T. Valkonen. Mechanisms by which the sweet potato virus disease (SPVD) is caused by co-infection of sweet potato feathery mottle virus and sweet potato chlorotic stunt virus in sweet potato.

B. Odhiambo. Biotransformation, biosafety and sweet potato resistant to feathery mottle virus in Kenya.

J. A. Brink. Plant biotechnology applications in the South African sweet potato industry.

Several of the above presentations were also published in The Proceedings of the 5th Triennial Conference of the African Potato Association (2000). Potatoes for Poverty Alleviation. Editors Adipala, E., Nampala, P & Osiru, M. 544pp. ISSN 1607-9353. The following were direct outputs of R6617, R(H)5878 and/or the sweet potato virus outputs of the Inter-Centers Initiative and prepared with the support of R7492.

Gibson, R. W. & Aritua, V. 2000. Sweetpotato virus disease in Africa. 373-378.

Aritua, V., Mwanga, R. O. M., Legg, J. P., Ndunguru, J., Kamau, J. W., Vetten, H. J. & Gibson, R. W. 2000. Status of sweetpotato virus diseases in East Africa: a 1999 update on incidence. 393-399.

Planned activities: 4.3 *Analysis, tabulation and reporting of work done in R6617 investigating the influence of local conditions on spread of SPVD; submission of prepared manuscript to international refereed journal.*

Outputs

The effect of the proximity and amount of SPVD inoculum on the infection of sweet potato test plots was reported in the following publication.

Aritua V., Legg, J. P., Smit, N. E. J. M. & Gibson, R. W. 1999. Effect of local inoculum on the spread of sweet potato virus disease: limited infection of susceptible cultivars following widespread cultivation of a resistant sweet potato cultivar. *Plant Pathology* **48**: 655-661.

The influence of local factors on the spread of SPVD was further examined in the review article:

R. W. Gibson & V. Aritua. (accepted). Sweet potato chlorotic stunt crinivirus: the key to control of sweet potato virus disease of sweet potato in Africa. *African Crop Science Journal.*

Additionally, a presentation entitled "Control strategies for sweet potato virus disease in Africa" was made to the International Plant Virus Epidemiology Meeting at Aschersleben, Germany, in May 2002. This presentation will be included as a written output in a special volume of **Virus Research**.

Contribution of Outputs to developmental impact

Project activities 1 have identified varieties of sweet potato newly-released in Uganda able to yield about twice as well as the best available local landraces in districts adjacent to Lake Victoria. The best of these varieties are very palatable and are being adopted readily. Adoption is being accelerated through a CPP promotional project funding a local NGO (BUCADEF) to establish large-scale multiplication and dissemination of planting materials to farmers in the relevant districts. This process appears to be progressing well and it is expected that supplies of sweet potato will increase rapidly to the large rural and urban populations living in these districts. Through this process, the project is already making a major contribution towards DFID's developmental goal of alleviating poverty. Since sweet potato requires few inputs, it is expected that this boosted production of sweet potato will be sustainable. Since sweet potato is largely consumed by the poorer sectors of both rural and urban populations, is both grown and sold particularly by women, and is consumed particularly by them and their families (Bashaasha *et al*., 1995; Kapinga *et al*., 1995), the outputs of this project will also benefit specifically these sectors of the community. These Ugandan varieties have also been transferred to Tanzania through open quarantine. Experiments are testing whether any of these varieties can achieve the same massive increases in production as have been achieved in Uganda. The results have been reported and rapidly disseminated to national, regional and international scientists through the circulation of working papers.

The Ugandan varieties were outstanding only in districts with similar agro-ecological conditions to those of the research station where they were bred; similarly, Tanzanian varieties bred on the eastern side of Lake Victoria seemed either worse or no better than the best landraces when tested on the western side of Lake Victoria (Kagera). A method has been developed to identify and rank the main attributes required by farmers in sweet potato varieties in order to assist plant breeders in selection. It was noticeable that the station-bred varieties excelled (if at all) largely in respect of those attributes such as good yield which were easily selected for on-station and that some important attributes such as drought resistance and extended period of tuberisation may be difficult to select on-station. These results all suggest that plant breeding needs to be a local, perhaps therefore, a decentralised process and involve farmers from the outset. **A farmer participatory approach for sweet potato breeding should therefore be tested**.

Project activities 1 also identified in Kanungu, Uganda and Bukoba, Tanzania, that a moderately SPVD-susceptible local cultivar was being grown widely by farmers because of its high yield, palatability and other valuable attributes. For the long term, it is clearly beneficial to aim to select superior cultivars combining these valuable attributes with resistance. However, in the meantime, it is clearly necessary to exploit such landraces whilst using other strategies to control SPVD. Project activities 2 have confirmed the predominance of local spread in the epidemiology of SPVD and have demonstrated the benefits of local phytosanitation. On-station research is still necessary to fine-tune this approach through testing particular techniques, such as intercropping, the use of barriers etc. However, these techniques all require the positive and active involvement of farmers, so it is essential that they are adapted such that they fit into normal farming practice. It is therefore proposed that **phytosanitation and other cultural methods of controlling SPVD should be tested on-farm by farmers in a working collaboration with researchers**. This work should be done with NGOs and Gos already working closely with farmers, for example, as farmer field schools, so that a system for extending the achievements is automatically in place. Project activities should therefore also include the development of extensive training materials.

Project activity 4 involves dissemination of previous project results nationally, regionally and internationally but only to scientists. This was considered appropriate at that stage because control strategies had not been developed for dissemination to farmers. The results of surveys of farmer knowledge and perceptions of SPVD have been analysed by the project and identify that farmers generally do not know that SPVD is insect-borne. Consequently, farmers do not purposefully isolate new plantings from older diseased crops and cannot appreciate that any benefit can be achieved by roguing out diseased plants from crops or eliminating diseased groundkeepers. **It is therefore essential that a plain-speaking, well-illustrated guide to the causes of SPVD and its control should be developed.** This should be available in a format in which the language can easily be changed. This is already being done, but it is considered that this will need to be field-tested and then modified, and perhaps different versions developed for farmers, extensionists, schools etc. in a future project.

In this current project, farmers were involved mainly in the management of trials. This seemed appropriate as the benefits to the farmers were unknown and we did not wish farmers to “risk” large amounts of their time learning about the various attributes of each variety. We now know the benefits of the new varieties can be considerable and would wish farmers to be more active stakeholders. Also, phytosanitation will require much more active involvement of farmers if it is to be successfully tested. However, farmers are interested primarily in crop production; control of SPVD is not their primary interest but is a means to an end. Consequently, **an integrated crop management (ICM) approach is needed if the benefits of the current research successes are to be fully exploited**.

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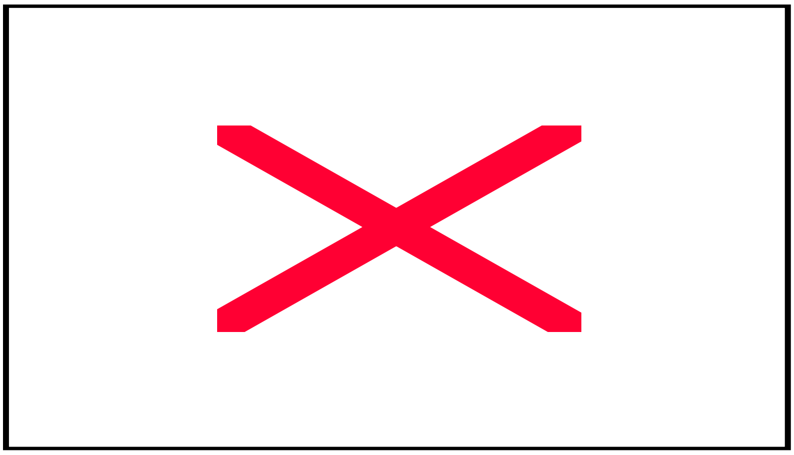
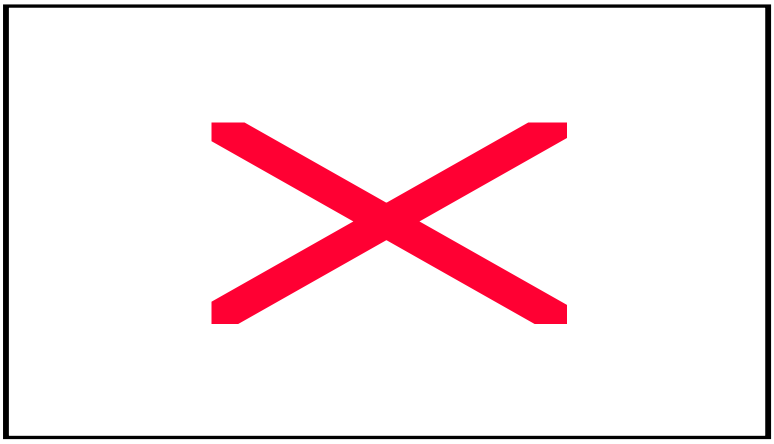
Fig 1. Increases in the percentage of SPVD-affected plants in concentric areas around an infector plot.

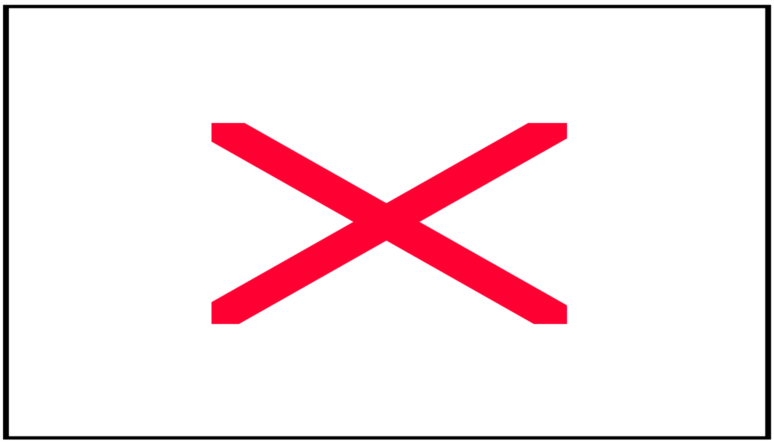
Trial 1

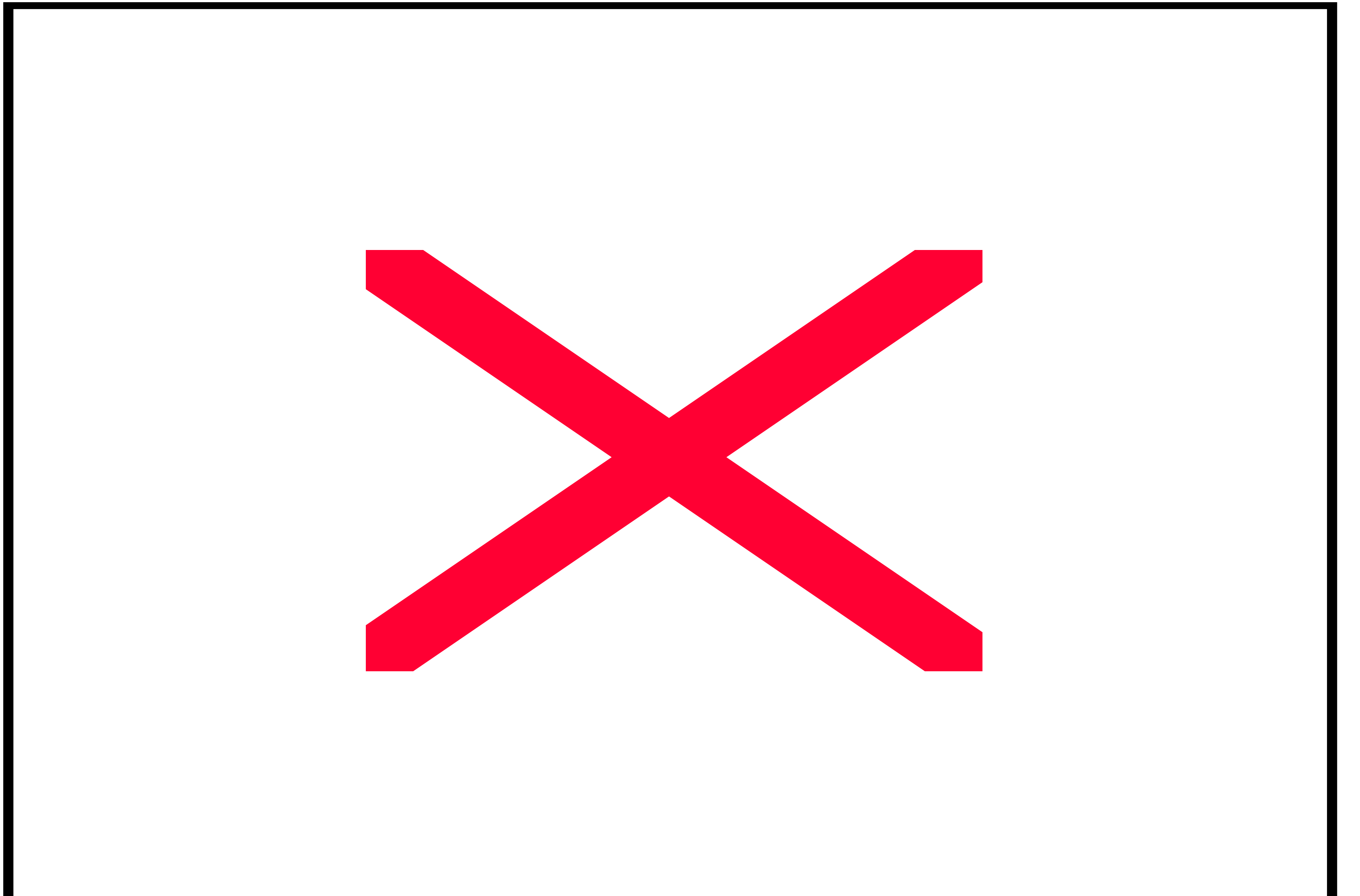


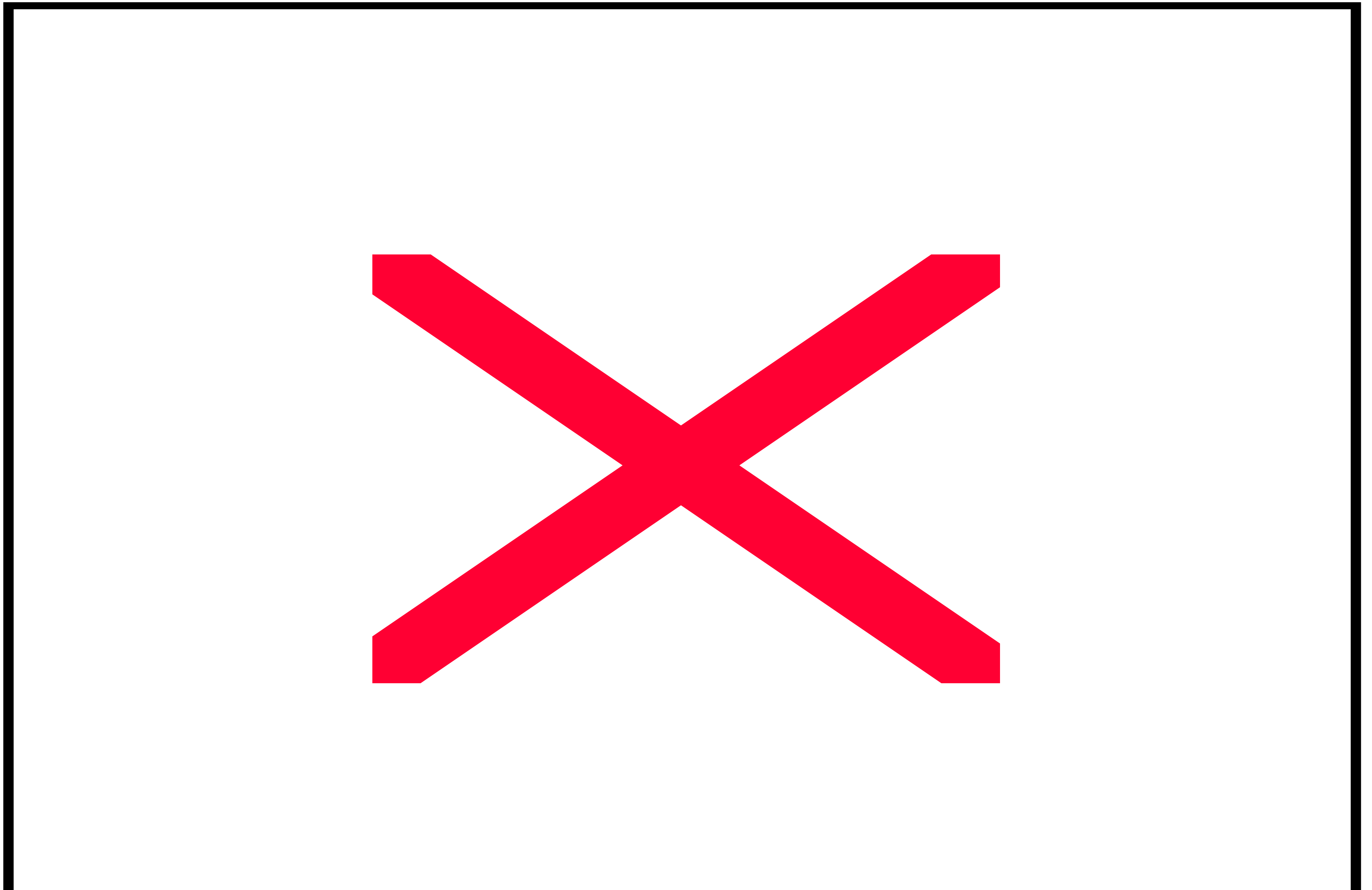
Trial 2



Trial 3







Appendix

Final Technical Report

Project R7492

Table 1. Total yields (tonnes/ha equivalent) of on-farm and on-station trials in Masaka and Rakai Districts.

Trials	M1	M2	M3	M4	R1	R2	R3	R4	R5
Introduced cultivars									
29								26.1	
NASPOT 1	50	7.1	12.9		40.2	13.2	**18.6**	**37.4**	4.4
93-493	38.4	2.7	9.9	37.2	**48.6**	10.3	16	25.8	8.3
319				25.6				17.7	
NASPOT 6				24.8				16.1	
Wagabolige			13.7	34.7			12	36.3	5.3
NASPOT 3	43.9	4	12.2		43	11.1	14.8	28	5.8
93-29	38.6	2.2			36.5	6.5		28.5	6.9
NASPOT 2	41.5	6.8	6.9		36.7	9.3	11.4	29	12.3
1096			9.9	31.8			15.2		
Tanzania			11.8	27.2			14.8	**38**	2.6
New Kawogo			12.6	24.8			11.9	31.8	9.8
Sowola				17.3				29.1	5.3
Bwanjule				23.3				24.6	0
NASPOT 4	32.2	1.7			30	8.5	18.1		5.1
NASPOT 5				11.1				27	2.5
Local cultivars									
Old Kawogo	36.6	4.3	8.1		31.8	9.9	12.7	21.3	7.9
Somba busero	31.3	4.2	13						
Kampala					18.2	9.5	8.8	19.1	6.6
Replication	7	3	9	3	8	8	11	4	4
SE of mean	4.7	1.4	2.1	3.6	4.4	1.5	1.7	4.5	3.1

M1 = Masaka on-farm trial planted in the second rains,1999;
M2 = Masaka on-farm trial planted in the first rains, 2000;
M3 = Masaka on-farm trial planted in the second rains, 2000;
M4 = Masaka on-station trial planted in the second rains, 1999;
R1 = Rakai on-farm trial planted in the second rain,1999;
R2 = Rakai on-farm trial planted in the first rains, 2000;
R3 = Rakai on-farm trial planted in the second rains, 2000;
R4 = Rakia on-station trial planted in the second rains, 1999;
R5 = Rakia on-station trial planted in the first rains, 2000.

A one-way analysis of variance was done for each site/season. Those values that are in **Bold** are significantly different (P<0.05) from the highest yielding local cultivar in that trial.

Table 2. Marketable yields (tonnes/ha equivalent) of on-farm and on-station trials in Masaka and Rakai Districts.

Trials	M1	M2	M3	M4	R1	R2	R3	R4	R5
Introduced cultivars									
29								22.1	
NASPOT 1	39.5	15.1	11.4		35.9	9.1	**14.3**	33.1	2.5
319				23.7				14.8	
NASPOT 6				22.2				13.7	
93-493	29.5	5.1	6.5	32	37.6	6.3	11.8	22.8	4.6
Wagabolige			11.6	26.3			9.2	**33.9**	2.5
NASPOT 3	37.5	3.3	9.2		34.1	6.7	10.6	25.8	2.7
New Kawogo			11	22.9			9.4	30.2	6.9
Tanzania			8.1	22.2			9.8	**34.5**	1.1
1096			5.7	27			11.2		
NASPOT 2	32.6	7.4	4.6		30	4.6	8.4	25	1
Bwanjule				19.4				22.3	0
93-29	30.7	0			31	3.6	0	25.1	4.8
Sowola				15.4				19.9	2.9
29								24	0
NASPOT 4	22.4	1.6			18.3	2.8	0	14.5	2.1
NASPOT 5				4.5					
Local cultivars									
Old Kawogo	33.6	2.3	6.6		26.4	7.7	10.1	20	5.8
Somba Busero	25.7	6.3	8.5						
Kampala					15.3	5.5	6.8	16.3	3.6
Replication	7	3	9	3	8	8	11	4	4
SE of mean	4.6	5.0	1.9	3.86	3.3	1.3	1.3	4.5	1.4

M1 = Masaka on-farm trial planted in the second rains,1999;
M2 = Masaka on-farm trial planted in the first rains, 2000;
M3 = Masaka on-farm trial planted in the second rains, 2000;
M4 = Masaka on-station trial planted in the second rains, 1999;
R1 = Rakai on-farm trial planted in the second rain,1999;
R2 = Rakai on-farm trial planted in the first rains, 2000;
R3 = Rakai on-farm trial planted in the second rains, 2000;
R4 = Rakia on-station trial planted in the second rains, 1999;
R5 = Rakia on-station trial planted in the first rains, 2000.

A one-way analysis of variance was done for each site/season. Those values that are in **Bold** are significantly different ($P<0.05$) from the highest yielding local cultivar in that trial.

Table 3. Total yields of introduced sweet potato cultivars in on-farm trials and in formal variety evaluation trials relative to the mean yields of local cultivars.

Trial	M1	M2	M3	R1	R2	R3	R4	R5	Mean
Introduced cultivars									
NASPOT 1	1.5	2.12	1.61	**2.06**	**1.93**	**2.89**	**1.97**	0.5	1.82
New Kawogo			1.35			1.19	1.61	1.94	1.52
29							1.46		1.46
NASPOT 2	1.37	2.04	0.77	**1.93**	1.16	1.3		1.55	1.45
93-493	1.26	0.8	1.12	**2.75**	0.99	**2.06**	1.39	1.03	1.43
Wagabolige			1.53			1.41	1.92	0.77	1.41
Bwanjule							1.39		1.39
1096			1.14			1.61			1.38
NASPOT 3	1.72	1.19	1.13	**2.04**	1.11	1.48	1.48	0.77	1.37
Tanzania			1.57			1.55		0.57	1.23
Sowola							1.61	0.71	1.16
93-29	1.33	0.67		1.1	0.86		1.5	0.94	1.07
NASPOT 5							1.33	0.59	0.96
NASPOT 4	1.05	0.52		1.38	1.1		0.9	0.72	0.95
NASPOT 6							0.89		0.89
319							0.77		0.77
Replication	7	3	9	8	8	11	4	4	
LSD (5%)	**0.67**	**1.28**	**0.68**	**0.89**	**0.66**	**1.06**	**0.70**	**1.3**	
SE of mean	**0.23**	**0.41**	**0.24**	**0.31**	**0.23**	**0.38**	**0.25**	**0.44**	

M1 = Masaka on-farm trial planted in the second rains,1999;
M2 = Masaka on-farm trial planted in the first rains, 2000;
M3 = Masaka on-farm trial planted in the second rains, 2000;
R1 = Rakai on-farm trial planted in the second rains,1999;
R2 = Rakai on-farm trial planted in the first rains, 2000;
R3 = Rakai on-farm trial planted in the second rains, 2000
R4 = Rakia on-station trial planted in the second rains, 1999.
R5 = Rakia on-station trial planted in the first rains, 2000.

A one-way analysis of variance was done for each site/season. Those values that are in **Bold** are significantly different (P<0.05) from the mean value (1.00) of local cultivars included in each trial.

Table 4. Marketable yields of introduced sweet potato cultivars in on-farm trials and in formal variety evaluation trials relative to the mean yields of local cultivars.

Trial	M1	M2	M3	R1	R2	R3	R4	R5	Mean
Introduced cultivars									
NASPOT 1	1.7	3.46	**2.2**	**2.16**	**3.96**	**2.71**	**2.1**	0.39	2.34
New Kawogo			1.79			1.17	1.71	**3.27**	1.99
NASPOT 3	**2.14**	1.65	1.27	**1.93**	**3.32**	1.35	1.6	0.46	1.72
93-493	1.2	0.8	1.36	**2.44**	**3.1**	1.86	1.41	0.81	1.62
NASPOT 2	1.22	3.11	0.84	1.75	**2.8**	1.32		0.1	1.59
Wagabolige			1.95			1.45	**2.1**	0.49	1.50
Bwanjule							1.48		1.48
29							1.43		1.43
93-29	1.32	1.04		1.12	1.96		1.51	1.21	1.36
Tanzania			1.74			1.35		0.59	1.23
1096			0.78			1.54			1.16
Sowola							1.31	0.73	1.02
NASPOT 4	0.75	0.44		0.93	2.54		0.8	0.42	0.98
NASPOT 6							0.89		0.89
NASPOT 5							1.35	0.1	0.73
319							0.68		0.7
Replication	7	3	9	8	8	11	4	4	
LSD (5%)	**1.06**	**3.26**	**0.97**	**0.78**	**1.31**	**0.88**	**0.85**	**1.69**	
SE of mean	**0.37**	**1.04**	**0.34**	**0.28**	**0.65**	**0.31**	**0.30**	**0.59**	

M1 = Masaka on-farm trial planted in the second rains,1999;
M2 = Masaka on-farm trial planted in the first rains, 2000;
M3 = Masaka on-farm trial planted in the second rains, 2000;
R1 = Rakai on-farm trial planted in the second rains,1999;
R2 = Rakai on-farm trial planted in the first rains, 2000;
R3 = Rakai on-farm trial planted in the second rains, 2000
R4 = Rakia on-station trial planted in the second rains, 2000.
R5 = Rakia on-station trial planted in the first rains, 2000.

A one-way analysis of variance was done for each site/season. Those values that are in **Bold** are significantly different (P<0.05) from the mean value (1.00) of local cultivars included in each trial.

Table 5. Total yields (tonnes/ha) of different sweet potato varieties on-station and on-farm in Kanungu District.

Trial	K1	K2	K3	K4	K5
Introduced cultivars					
New Kawogo		4.3		2.3	18.6
NASPOT 1	4.2		6		15.9
Tanzania		5.3		5.6	15.0
NASPOT 3	1.3	5.5	4.5	2.7	13.1
93-29					12.6
NASPOT 2	1.9	5.7	4.8	7.3	12.2
NASPOT 4	2.7	4.7	3.7	0.6	12.1
Sowola		4.2		3.9	11.0
93-493			5.53	2.3	10.8
Wagabolige		3.9		3.1	9.1
1096					8.5
319				1.3	8.1
NASPOT 5		0.8	0.0	0.4	5.7
Bwanjule		3.2		4.7	
NASPOT 6				2.0	
202			2.8		
Local cultivars					
Kyabafiluki	3.7	3.4	7.8	8.4	15.8
Mulungi ha meza	3.0	4.5	5.1	2.1	7.1
SEM	0.6	0.9	1.0	1.4	2.5
LSD	1.3	2.7	3.1	3.9	7.3

K1 = on-farm trial planted during the second rains of 1999 in Kanungu District
K2 = on-station trial planted during the second rains of 1999in Kanungu District
K3 = on-farm trial planted during the first rains of 2000 in Kanungu District
K4 = on-station trial planted during the first rains of 2000 in Kanungu District
K5 = on-station trial planted during the second rains of 2000 in Kanungu District

A one-way analysis of variance was done for each site/season.

Table 6. Marketable yields (tonnes/ha) on-station and on-farm of different sweet potato varieties in Kanungu District.

Trial	K1	K2	K3	K4	K5
Introduced cultivars					
New Kawogo		3.3		2.0	15.6
NASPOT 1	2.9		4.7		11.8
Tanzania		3.3		4.0	9.3
NASPOT 3	0.9	3.8	2.4	1.3	8.8
93-29					9
NASPOT 2	1.3	3.8	2.3	4.7	10.0
NASPOT 4	1.8	3.2	2.3	0.0	8.9
Sowola		3.0		3.1	7.7
93-493			3.7	1.0	8.1
Wagabolige		3.3		2.1	6.1
1096					5.8
319				0.6	5.6
NASPOT 5		0.3	0.0	0.2	3.3
Bwanjule		2.4		3.4	
NASPOT 6				1.48	
202			1.2		
Local cultivars					
Kyabafiluki	3.2	2.8	6.4	7.1	13.4
Mulungi ha meza	2.2	3.2	3.9	1.1	5.9
SEM	0.59	0.8	0.75	1.2	2.2
LSD	1.3	2.3	2.2	3.3	6.2

K1 = on-farm trial planted during the second rains of 1999 in Kanungu District
K2 = on-station trial planted during the second rains of 1999in Kanungu District
K3 = on-farm trial planted during the first rains of 2000 in Kanungu District
K4 = on-station trial planted during the first rains of 2000 in Kanungu District
K5 = on-station trial planted during the second rains of 2000 in Kanungu District

A one-way analysis of variance was done for each site/season.

Table 7. Total yields of introduced sweet potato cultivars relative to the mean yields of local cultivars yields in on-farm and on-station trials in Kanungu District.

Trial	K1	K2	K3	K4	K5	Mean
Introduced cultivars						
Tanzania		1.3		1.1	1.3	1.2
NASPOT 1	1.2		1		1.4	1.2
93-29					1.1	1.1
New Kawogo		1.1		0.4	1.6	1.1
NASPOT 2	0.6	1.4	0.7	1.4	1.1	1.0
Sowola		1.1		0.7	1.0	0.9
Bwanjule		0.8		0.9		0.9
NASPOT4	0.3	1.4	0.8	0.5	1.1	0.8
Wagabolige		1.0		0.6	0.8	0.8
1096					0.7	0.7
93-493		0.8		0.5	0.9	0.7
NASPOT 3	0.8	1.2	0.5	0.1	1.1	0.7
202			0.6			0.6
319				0.2	0.7	0.5
NASPOT 6				0.4		0.4
NASPOT 5		0.2	0	0.1	0.5	0.2
Local cultivars						
Kyabafiluki	1.1	0.9	1.2	1.6	1.4	1.2
Mulungi ha meza	0.9	1.1	0.9	0.4	0.6	0.8
SEM	0.1	0.2	0.2	0.3	0.2	
LSD	0.4	0.7	0.6	0.7	0.6	

K1 = on-farm trial planted during the second rains of 1999 in Kanungu District
K2 = on-station trial planted during the second rains of 1999in Kanungu District
K3 = on-farm trial planted during the first rains of 2000 in Kanungu District
K4 = on-station trial planted during the first rains of 2000 in Kanungu District
K5 = on-station trial planted during the second rains of 2000 in Kanungu District

A one-way analysis of variance was done for each site/season.

Table 8. Marketable yields of introduced sweet potato cultivars relative to the mean yields of local cultivars yields in on-farm and on-station trials in Kanungu District.

Trial	K1	K2	K3	K4	K5	Mean
Introduced cultivars						
NASPOT 1	1.04		1.1		1.2	1.1
New Kawogo		1.1		0.5	1.6	1.1
Tanzania		1.1		1.0	1.0	1.0
93-29					0.9	0.9
NASPOT 2	0.51	1.3	0.4	1.1	1.0	0.9
Sowola		1		0.8	08	0.9
Bwanjule		0.8		0.8		0.8
Wagabolige		1.1		0.5	0.6	0.7
NASPOT 4	0.28	1.3	0.6	0.3	0.9	0.7
1096					0.6	0.6
NASPOT 3	0.59	1.1	0.4	0	0.9	0.6
93-493			0.7	0.2	0.8	0.6
202			0.4			0.4
319				0.1	0.6	0.4
NASPOT 6				0.4		0.4
NASPOT 5		0.1	0	0.1	0.3	0.1
Local cultivars						
Kyabafiluki	1.1	0.9	1.2	1.7	1.4	1.3
Mulungi ha meza	0.9	1.1	0.8	0.3	0.6	0.7
SEM	0.2	0.3	0.2	0.3	0.2	
LSD	0.5	0.8	0.6	0.8	0.6	

K1 = on-farm trial planted during the second rains of 1999 in Kanungu District
K2 = on-station trial planted during the second rains of 1999in Kanungu District
K3 = on-farm trial planted during the first rains of 2000 in Kanungu District
K4 = on-station trial planted during the first rains of 2000 in Kanungu District
K5 = on-station trial planted during the second rains of 2000 in Kanungu District.

A one-way analysis of variance was done for each site/season.

Table 9. Acceptability (rank) of cooked tubers of different cultivars.

a) Masaka + Rakai

	M1	M2*	R1 Test 1	R1 Test 2	Mean rank
Introduced cultivars					
Tanzania	1.6	1			1.3
NASPOT 1	1.7	2	1.5	2.3	1.9
1096	1.6	4			2.8
Wagabolige	2.2	3	4.2		3.1
NASPOT 3	3.6		4.2	4.1	4.0
93-29			4.2		4.2
93-493	3	4		6.1	4.4
NASPOT 2	2.4	7	4.3	4.2	4.5
NASPOT 4		9	4.3	4.3	5.9
Local cultivars					
Kampala			4.2		4.2
Old Kawogo	2.1	6	6.5	4.1	4.7
Somba Busero	2.8	8		5.1	5.3
n =	4	10	10	10	
*P**<*	*0.001*	*0.05***	*0.001*	*0.001*	

b) Kanungu

	K3 trial 1	K3 trial 2	Mean
Introduced cultivars			
NASPOT 4	2.4	3.1	2.8
NASPOT 2	2.5	3.2	2.9
NASPOT 3	3.7	4.5	4.1
NASPOT 1	5.5	2.9	4.2
Local cultivars			
Kyabafiluki	3.2	2.4	2.8
Mulungi ha meza	4.2	5.1	4.7
n	10	10	

*For Masaka 2000A, cultivars were ranked using paired stepped ranking and the Chi-squared test was based on these results (not the ranks given). Other times, n farmers ranked all the cultivars and the values given are mean values.
** Chance of all cultivars being similar as determined by Chi-squared test

M1 = Masaka on-farm trial planted in the second rains,1999;
M2 = Masaka on-farm trial planted in the first rains, 2000;
R1 = Rakai on-farm trial planted in the second rains,1999.
K3 = Kanungu on-farm trial planted during the first rains of 2000.

Table 10. Mean scores* for acceptability and specific attributes of cooked tubers of different cultivars.

a. Crop grown on-farm in the first rains of 2000 (M2), Masaka District

	Appearance	Taste	Mealiness	Lack of fibres	Acceptability
Introduced cultivars					
NASPOT 1	1.8	1.6	2.4	1.6	1.7
NASPOT 2	2.4	2.8	3.5	1.7	2.4
NASPOT 3	3.7	3.0	3.9	3.2	3.6
93-493	2.4	2.2	2.4	3.0	3.0
Tanzania	1.7	1.3	1.1	2.1	1.6
1096	1.5	1.6	1.4	1.9	1.6
Wagabolige	2.3	2.0	2.3	2.8	2.2
Local cultivars					
Somba busero	3.1	2.8	3.3	2.2	2.8
Old Kawogo	2.2	2.0	2.8	1.9	2.1
n =	19	19	19	19	19
*P***<	*0.001*	*0.001*	*0.001*	*0.01*	*0.001*

b. Crop grown on-farm in the first rains of 2000 (R2), Rakai District

	Appearance	Taste	Mealiness	Lack of fibres	Acceptability
Introduced cultivars					
NASPOT 1	1.6	1.3	1.3	4.2	1.4
NASPOT 2	1.9	2.3	3.5	4.1	2.8
NASPOT 3	3.4	3.0	3.4	2.8	3.1
NASPOT 4	1.7	1.5	2.3	4.2	1.7
93-29	2.7	2.4	3.3	3.9	2.3
93-493	2.7	2.6	3.5	4.0	2.3
Local cultivars					
Kampala	2.5	3.9	3.7	3.4	3.8
Old Kawogo	2.4	2.3	3.0	3.6	2.2
Somba Busero	2.4	2.4	3.1	3.9	2.6
n =	20	20	20	20	20
*P***<	*0.01*	*0.001*	*0.001*	*NS*	*0.001*

* 1 = very good, 2 = good, 3 = fair, 4 = bad, 5 = very bad.
** Chance of all cultivars being similar as determined by Chi-squared test

Table 11. Mean *Alternaria* disease scores* for the different cultivars in the four trials affected in Masaka and Rakai Districts.

Affected trials	M2	M3	R2	R4	Mean
Introduced cultivars					
NASPOT 1	3.0	2.6	1.9	3.3	2.7
NASPOT 4	3.8		0.9	1.5	2.1
Sowola				1.5	1.5
NASPOT 2	1.0	0.6	1.5	2.5	1.4
New Kawogo		1.7		0.0	0.9
1096		0.8			0.8
Tanzania		0.0		1.3	0.7
93-29	1.0		0.5	0.0	0.5
93-493	0.0	0.4	0.4	0.0	0.2
NASPOT 3	0.0	0.0	0.0	0.0	0.0
Wagabolige		0.0		0.0	0.0
NASPOT 5				0.0	0.0
Local cultivars					
Kampala			0.6	0.0	0.3
Old Kawogo	0.0	0.0	0.0	0.0	0.0
Somba busero	0.0	0.0		0.0	0.0
Replication	3	9	8	4	
*P***	<0.001	<0.001	<0.001	<0.001	

*Plots were scored on a 0 to 5 basis, with 0 = no damage and 5 = very severe.

M2 = Masaka on-farm trial planted in the first rains, 2000;
M3 = Masaka on-farm trial planted in the second rains, 2000;
R2 = Rakai on-farm trial planted in the first rains, 2000;
R4 = Rakia on-station trial planted in the first rains, 2000

**** *P* = Probability that cultivars are similar in susceptibility (χ^2 test)**

Table 12. Mean weevil damage scores* of the tubers of the different cultivars in the field trials that were affected in Masaka and Rakai Districts.

Affected trials	M2	R2	R4	Mean
Introduced cultivars				
NASPOT 1	1.8	1.9	0.8	1.5
93-29	2.8	0.8	0.0	1.2
NASPOT 4	1.3	1.0	0.8	1.0
NASPOT 2	0.8	1.3	0.5	0.9
Tanzania			0.8	0.8
New Kawogo			0.8	0.8
Wagabolige			0.8	0.8
Sowola			0.5	0.5
NASPOT 3	0.8	0.5	0.0	0.4
93-493	0.0	1.0	0.0	0.3
NASPOT 5			0.0	0
Local cultivars				
Somba busero	1.5		0.3	0.9
Kampala		1.1	0.0	0.6
Old Kawogo	1.0	0.1	0.0	0.4
Replication	3	8	4	
*P***	<0.001	<0.05	NS	

*Plots were scored on a 0 to 5 basis, with 0 = no damage and 5 = very severe.

M2 = Masaka on-farm trial planted in the first rains, 2000;
R2 = Rakai on-farm trial planted in the first rains, 2000;
R4 = Rakia on-station trial planted in the first rains, 2000

**** *P* = Probability that cultivars are similar in susceptibility (χ^2 test)**

Table 13. The weight (Kg) of marketable tubers harvested (Area harvested = 1 x $2m^2$)

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		1.3	1.6	2.0	1.9	2.1	1.1	0.7	1.0	2.9	0.9	27	0.8	1.6
1999	1	2.9		2.4	3.2	3.7	2.5	3.0	4.0	3.5	4.0	2.1	45	1.0	2.0
1999	2	2.2		3.0	1.3	1.3	2.3	1.1	2.4	1.8	1.8	2.1	45	0.6	1.1
2000	1		6.8	11.1	3.4	5.8	8.3	1.8	7.4	6.8	8.5	5.4	72	1.3	2.6
2000	2	3.1		4.4	0.6	2.1	3.8	1.2	2.6	3.4	3.0	4.0	52	0.9	1.8
All results with Hidaya + K'nyoko controls			5.1	8.2	3.0	4.6	6.4	1.6	5.4	5.0	6.8	4.0	108	1.0	2.1
All results with Kombegi + K'nyoko controls		2.8		3.3	1.7	2.3	2.9	1.8	3.0	3.0	3.0	2.8	160	0.5	1.0
All results combined: K'nyoko controls				5.3	2.4	3.3	4.9	1.8	4.1	3.8	4.7	3.3	242	0.6	1.2

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other ($P<0.05$).

Table 14. The weight (Kg) of non-marketable tubers harvested (Area harvested = 1 x 2m^2)

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		0.2	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.9	0.2	27	0.2	0.4
1999	1	0.7		0.7	0.7	1.2	0.5	1.0	1.0	0.6	1.0	0.7	45	0.3	0.7
1999	2	0.9		0.8	1.0	1.0	1.4	1.4	0.8	0.7	1.1	1.2	45	0.4	0.7
2000	1		4.3	1.0	1.2	1.6	1.3	0.8	1.3	1.5	2.7	1.4	72	1.4	2.8
2000	2	1.6		1.1	0.6	0.8	1.6	1.7	0.8	1.5	2.0	1.4	52	0.5	1.1
All results with Hidaya + K'nyoko controls			3.1	0.8	0.9	1.2	1.0	0.7	1.0	1.1	2.1	1.0	108	1.0	1.9
All results with Kombegi + K'nyoko controls		1.1		0.9	0.8	1.0	1.2	1.4	0.8	1.0	1.4	1.1	160	0.3	0.5
All results combined: K'nyoko controls				0.8	1.1	1.1	1.7	1.2	1.0	1.0	1.8	1.1	242	0.3	0.7

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other ($P<0.05$).

Table 15. The total weight (Kg) of tubers harvested (Area harvested = 1 x $2m^2$)

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		1.5	1.9	2.3	2.2	2.3	1.5	0.9	1.3	3.8	1.1	27	0.9	1.9
1999	1	3.6		3.1	3.9	4.9	3.0	4.0	5.0	4.1	5.0	2.8	45	1.1	2.2
1999	2	3.2		3.7	2.4	2.3	3.7	2.4	3.2	2.5	3.0	3.3	45	0.7	1.4
2000	1		11.1	12.1	4.6	7.4	9.6	2.6	8.7	8.3	11.1	6.7	72	2.0	4.0
2000	2	4.8		5.5	1.2	2.9	5.4	2.9	3.3	4.9	5.0	5.4	52	1.2	2.5
All results with Hidaya + K'nyoko controls			8.2	9.0	4.0	5.8	7.4	2.3	6.3	6.2	8.9	5.0	108	1.5	3.0
All results with Kombegi + K'nyoko controls		3.9		4.2	2.5	3.3	4.1	3.1	3.8	3.9	4.4	3.9	160	0.6	1.3
All results combined: K'nyoko controls				6.1	3.3	4.3	5.4	2.8	4.9	4.8	6.3	4.4	242	0.6	1.2

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other ($P<0.05$).

Table 16. The mean weight (Kg) of tubers harvested per plant

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		0.20	0.20	0.14	0.22	0.30	0.10	0.10	0.10	0.35	0.10	27	0.10	0.20
1999	1	0.34		0.30	0.32	0.34	0.30	0.30	0.40	0.30	0.40	0.30	45	0.10	0.20
1999	2	00.23		0.23	0.20	0.20	0.30	0.20	0.20	0.20	0.20	0.23	45	0.07	0.13
2000	1		0.80	1.00	0.33	0.70	0.90	0.21	0.70	0.60	0.94	0.61	72	0.20	0.32
2000	2	0.30		0.32	0.70	0.20	0.30	0.13	0.20	0.23	0.40	0.30	52	0.10	0.14
All results with Hidaya + K'nyoko controls			0.60	0.70	0.30	0.53	0.70	0.20	0.50	0.44	0.70	0.50	108	0.12	0.24
All results with Kombegi + K'nyoko controls		0.30		0.30	0.20	0.22	0.30	0.20	0.24	0.24	0.31	0.30	160	0.04	0.10
All results combined: K'nyoko controls				0.44	0.23	0.34	0.43	0.20	0.34	0.32	0.50	0.34	242	0.10	0.11

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other ($P<0.05$).

Table 17. The weight (Kg) of foliage harvested (Area harvested = 1 x $2m^2$)

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		5.3	4.2	5.0	3.1	2.1	4.9	2.7	2.9	3.9	5.4	27	1.3	2.6
1999	1	8.0		4.0	4.8	4.4	4.1	3.8	3.3	2.8	3.5	2.3	45	2.2	4.4
1999	2	4.0		2.6	3.3	3.7	4.0	4.3	4.0	2.9	2.9	4.0	45	0.9	1.8
2000	1		6.9	7.4	6.7	9.4	8.0	7.4	6.0	11.2	6.5	7.1	72	2.0	4.0
2000	2	4.9		4.3	7.3	7.0	6.1	4.8	2.9	2.9	7.0	6.6	52	2.0	3.4
All results with Hidaya + K'nyoko controls			6.4	6.4	6.2	7.5	6.2	6.6	4.9	8.7	5.7	6.6	108	1.5	3.0
All results with Kombegi + K'nyoko controls		5.6		3.7	5.2	5.1	4.8	4.4	3.4	2.9	4.6	4.4	160	1.0	1.9
All results combined: K'nyoko controls				4.8	5.6	6.1	5.4	5.3	4.0	5.2	5.0	5.4	244	0.8	1.5

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other (P<0.05).

Table 18. The mean number of weevil-damaged tubers/plot of each cultivar (Area harvested = 1 x 2m^2)

Year Planted	Site *	Kombegi	Hidaya	K'nyoko	Mw'onde	Polista	Sinia A	Sinia B	SP 93/2	SP 93/23	SP 93/34	SPNO	d.f	s.e.d.	l.s.d.
1999	1		1.0	4.8	3.8	7.8	1.3	4.0	5.3	3.0	12.0	5.8	27	2.9	5.9
1999	1	6.0		8.8	9.8	13.2	10.0	11.2	13.7	19.5	25.7	4.3	45	8.1	16.4
1999	2	0.7		0.8	1.5	0.5	2.0	1.2	0.3	1.3	0.8	0.3	45	0.7	1.5
2000	1		1.7	2.8	0.2	1.3	2.6	1.5	5.2	2.9	3.7	4.2	71	1.4	2.7
2000	2	0.0		0.4	0.0	0.0	0.3	0.8	0.1	0.7	0.3	0.6	52	0.4	0.8
All results with Hidaya + K'nyoko controls			1.3	3.4	1.3	3.3	2.2	2.3	5.2	2.9	6.2	4.5	107	1.4	2.7
All results with Kombegi + K'nyoko controls		2.1		3.2	3.5	4.3	3.9	4.1	4.5	6.8	8.5	1.7	160	2.6	5.2
All results combined: K'nyoko controls				3.2	2.6	3.9	3.2	3.3	4.8	5.3	7.6	2.8	243	1.7	3.4

*Site 1 = Kyaka; Site 2 = Maruku

Shaded rows contain results for which the F-ratio test indicates one or more are significantly different from each other (P<0.05).

Table 19. Uses of different crops by the sweet potato farmers interviewed in each district

a) Main crops used for family consumption

Districts	Masaka + Rakai*		Luwero*		Kiboga*	
Crop	% farmers growing	Mean rank	% farmers growing	Mean rank	% farmers growing	Mean rank
Sweet potato	100	2.3	100	1.6	100	2.8
Cassava	94	2.3	90	2.2	93	2.4
Bananas	94	2.0	83	3.3	64	3.1
Maize	72	4.1	73	3.3	82	3.3
Beans	66	4.3	60	3.3	71	3.5
Groundnuts	7	6.0	13	5.0	29	4.9
Potato	6	4.0	0	-	11	3.0
Yams	33	4.0	20	4.3	11	5.0
Cocoyams	22	4.5	0	-	0	-
Pumpkin	0	-	0	-	11	3.0
Millet	0	-	0	-	11	3.0

b) Main crops marketed

Districts	Masaka + Rakai*		Luwero*		Kiboga*	
Crop	% farmers growing	Mean rank	% farmers growing	Mean rank	% farmers growing	Mean rank
Sweet potato	33	2.3	60	1.7	39	2.9
Coffee	78	1.7	43	2.5	10	1.7
Beans	61	2.6	40	2.5	54	2.7
Bananas	39	2.9	20	2.8	29	1.6
Maize	44	2.9	60	1.8	82	1.8
Groundnuts	22	2.5	0	-	21	2.7
Cassava	27	3.2	23	2.3	36	2.4

* Numbers of farmers interviewed were:18 in Masaka + Rakai, 30 in Luwero and 28 in Kiboga Districts

Table 20. Uses and cultivation of sweet potato for the sweet potato farmers interviewed in each district

	Masaka + Rakai*	Luwero*	Kiboga*
Mainly for family use (%)	72	90	89
Mainly for sale (%)	44	17	36
Eaten all year (%)	94	100	93
Mean number of local cvs grown by each farmer	4.4	2.3	4.1
Introduced varieties grown (%)			
NASPOT 1	89	100	86
NASPOT 2	67	57	89
NASPOT 3	83	10	0
NASPOT 4	10	43	75
NASPOT 5	0	10	0
NASPOT 6	0	0	0
Sowola	0	3	50
Tanzania	11	0	0
New Kawogo	6	0	0
93-493	83	0	0
93-29	11	27	0

* Numbers of farmers interviewed were:18 in Masaka + Rakai, 30 in Luwero and 28 in Kiboga Districts

Table 21. The number of times introduced and local cultivars were ranked first by farmers in Masaka and Rakai.

	Introduced cvs				Local cultivars				
Attributes	**NASPOT 1****	**NASPOT 2****	**93-493****	**NASPOT 3****	**Old Kawogo**	**Kampala**	**Somba Busero**	**Kalebe**	**Other local cvs**
Overall	6	3	2	1	2	1	1	0	1
High tuber yield	6	3	2	0	1	2	2	0	1
Large tuber size	6	3	0	0	6	1	0	0	0
Sweet tubers	2	2	1	0	2	1	2	2	3
Drought resistance	1	0	4	1	4	3	0	1	0
Weevil resistance	2	0	1	2	4	2	0	0	0
Early tuber maturity	2	1	2	0	0	0	3	0	1
Long-lasting tubers	1	0	1	1	5	1	0	0	0
Mealy tubers	1	1	0	0	3	0	0	0	1
Extensive foliar growth	1	0	0	1	0	2	1	0	0
Continuous tuber yield	0	0	0	0	1	2	0	0	1
Non-fibrous tubers	0	1	0	0	1	0	0	0	2
Alternaria resistance	0	0	0	2	0	0	0	0	0
Marketability	1	0	0	0	0	0	0	0	1
Acrea resistance	1	0	0	1	0	0	0	0	0
Non-sappy tubers	0	0	0	0	0	1	0	1	0
SPVD resistance	0	0	1	0	0	0	0	0	0
Unexposed tubers	0	0	0	1	1	0	0	0	0
Soft tubers when cooked	0	0	0	0	1	0	0	0	0
Yield on infertile soils	0	0	0	0	0	0	0	0	0
Soft skin on tubers	0	0	0	0	1	0	0	0	0
Smooth tubers	0	0	0	0	1	0	0	0	0
Attractive tuber flesh	0	0	0	0	0	0	1	0	0
Total "1st s"	**30**	**13**	**14**	**10**	**33**	**16**	**10**	**4**	**11**

Table 22. The number of times a cultivar was ranked first by farmers in Kiboga, for the four introduced cultivars, for the three main local cultivars and for “other” local cultivars grown more rarely by the farmers.

	Introduced cvs				Local cvs			
	1*	**2***	**4***	**Sowola**	**Kyebandula**	**Old Kawogo**	**Kakooza**	**“Others”**
Overall rank	14	3	0	2	0	0	0	9
Attribute								
High tuber yield	15	3	0	2	0	0	0	9
Sweet tubers	10	1	0	1	5	0	2	7
Mealy tubers	6	1	1	2	10	0	1	6
Big tubers	8	0	0	0	4	0	0	10
Resistance to drought	4	2	1	0	4	0	1	8
Early maturity	11	2	0	1	0	0	0	6
Continuous tuber yield	3	3	1	0	0	0	0	10
Resistance to weevils	3	0	2	0	4	0	0	6
Attractive tubers	3	0	0	0	2	0	2	1
Non-fibrous tubers	2	1	0	0	2	0	0	0
Long-lasting tubers	1	0	1	1	0	0	0	0
Nice looking at table	1	0	0	0	1	0	1	1
Resistance to *Acrea*	3	0	0	0	0	0	1	0
Marketability	1	0	0	0	2	0	0	1
No loss of taste with time	2	0	0	0	0	0	0	0
Easy to cook	1	0	0	0	0	0	0	1
Non-sappy tubers	0	0	0	0	0	0	0	0
Less 'kigave'	0	0	0	0	0	0	0	0
Straight tubers	0	0	0	0	0	0	0	0
Non exposed tubers	0	0	0	0	0	0	0	1
Extensive foliar growth	0	0	1	0	0	0	0	0
Good yield on poor soils	1	0	0	0	0	0	0	0
Resistance to rodents	0	0	0	0	0	0	0	1
Total	75	13	7	7	34	0	8	68

* NASPOT 1, 2 & 4

Table 23. The number of times a cultivar was ranked first by farmers in Luwero, for the three main introduced cultivars, for the two main local cultivars and for “other” local cultivars grown more rarely by the farmers.

	Introduced cvs			Local cvs		
	1*	2*	4*	Dimbuka	Silk	“Others”
Overall rank	16	2	1	10	0	0
						0
Attribute						0
High tuber yield	16	2	1	10	0	0
Resistance to drought	12	3	2	2	1	5
Big tubers	16	3	0	1	1	4
Mealy tubers	8	2	2	0	7	2
Sweet tubers	14	1	1	1	4	1
Resistance to weevils	8	3	3	2	0	3
Resistance to *Acrea*	5	3	2	1	2	2
Early maturity	5	1	0	10	0	0
Continuous tuber yield	1	3	0	3	2	1
Marketability	4	0	1	0	0	0
Nice flavour	4	1	0	0	0	0
Softness	2	0	0	0	0	2
Good vine establishment	4	0	0	0	1	0
No loss of taste with time	1	0	0	2	0	1
Less fibre	0	0	1	0	0	0
Non-sappy tubers	3	0	1	0	0	0
Extensive foliar growth	1	0	2	1	0	1
Resistance to rodents	0	0	0	1	0	2
Performance on poor soils	1	0	1	1	0	0
Attractive tuber colour	1	0	0	0	0	1
Attractive tuber flesh	0	0	0	0	0	0
Absence of Kigave	0	0	0	0	0	0
Resistant to *Alternaria*	0	0	0	0	1	0
Lasts long in soil	0	0	1	0	0	0
Regrowth after drought	1	0	0	0	0	0
Nice looking vines	0	0	1	0	0	0
Resistant to cracking	0	0	1	0	0	0
Easy to cook	1	0	0	0	0	0
Total	124	24	21	45	19	25

1*, 2*, 4* = NASPOT 1, 2, 4 respectively