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Control strategies for sweet potato virus disease in Africa

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Abstract

Sweet potato virus disease (SPVD), caused by dual infection with the whitefly-borne *Sweet potato chlorotic stunt virus* and the aphid-borne *Sweet potato feathery mottle virus*, is the most serious disease of sweet potato in Africa. SPVD has been known there since at least the 1940s although it took several decades to elucidate its aetiology. It occurs throughout Africa and is particularly prevalent in the Great Lakes region. Production of sweet potato is largely by resource-poor farmers, growing mostly local landraces and for home consumption: control strategies need to be appropriate to these circumstances. Most high yielding and/or early maturing landraces in Uganda are susceptible to SPVD and most resistant landraces are low-yielding, forcing farmers to compromise between large

and/or early yields, and food security. Two strategies were therefore tested to avoid the disadvantages associated with such compromises. These were deploying high-yielding SPVD-resistant cultivars and phytosanitation practices to enable susceptible landraces to be grown safely. In on-farm trials in Masaka and Rakai Districts of Uganda, some SPVD-resistant cultivars bred at Namulonge Agricultural and Animal Research Station (NAARI), in Wakiso District, out-yielded local landraces. Other trials at NAARI and at nearby farms showed that roguing diseased cuttings within one month of planting and isolation from diseased crops, even by such short distances as 15m, can considerably decrease spread of SPVD to susceptible cultivars. This indicates that phytosanitation can protect desirable susceptible cultivars even if only local adopted. This dual approach of deploying resistant varieties and phytosanitation provides farmers with a valuable increase in their choice of control strategy for SPVD.

Keywords: Sweet potato; Plant virus control; Resistant cultivars; Phytosanitation; Sweet potato virus disease; Africa.

1. Introduction

Sweet potato is a major starch staple in Africa: sweet potato virus disease (SPVD) is its most important disease there (Geddes, 1990) and perhaps worldwide (Carey et al., 1999). Despite the apparently broad meaning of its name, SPVD has been associated specifically with symptoms caused by a combination of two viruses: *Sweet potato chlorotic stunt virus* (SPCSV) (*Crinivirus; Closteroviridae*) and *Sweet potato feathery mottle virus* (SPFMV) (*Potyvirus; Potyviridae*) (Gibson et al., 1998b). The symptoms include an often severe stunting of the plant and stunting, distortion and either a chlorotic mottle or vein clearing of the leaves. The first reports of SPVD appeared in the 1930s from Congo Belge (now Democratic Republic of Congo) (reported by Stayaert; see Sheffield, 1953). Hansford (1944) subsequently observed it in neighbouring Uganda and Sheffield (1953) in Ruanda-Urundi (now Rwanda and Burundi), Uganda, Kenya and Tanganyika (now part of Tanzania). Since then, SPVD has been reported in Ghana (Clerk, 1960), Nigeria (Schaefers and Terry, 1976), Cameroon (Ngeve and Boukamp,

1991), Madagascar, Zambia (Gibson et al., 1998a), Togo, Liberia, Sierra Leone, São Tomé, Ivory Coast (Thottappilly and Rossel, 1988), Benin and Gabon (Lenné, 1991).

Sheffield (1957, 1958) isolated two viruses from SPVD-affected sweet potato originating from Kenya, Tanganyika Territory (now part of Tanzania) and Uganda. 'Virus A' was aphid-borne and is now considered to be SPFMV (Karyeija et al., 1998). The other, 'virus B', was whitefly-borne. It may be SPCSV (Cohen *et al.*, 1992) but virus B was also transmitted by sap inoculation and to diverse hosts (Sheffield, 1958). These properties are not characteristic of SPCSV (Cohen et al., 1992) but are characteristic of *Sweet potato mild mottle virus* (SPMMV) (*Ipomovirus; Potyviridae*), another whitefly-borne virus commonly infecting sweet potato in East Africa (Hollings and Stone, 1976). SPCSV, SPMMV and SPFMV may be found together in sweet potato plants with typical SPVD symptoms (Gibson et al., 1998). If such plants had been used by Sheffield (1958) for isolation of virus B by whitefly transmission, the wide host range, sap transmission, apparent diversity of isolates and role in the induction of SPVD of virus B might then have resulted from the combined properties of both SPCSV and SPMMV. That SPVD derives from dual infection with SPFMV and SPCSV was first demonstrated unequivocably in West Africa (Schaefers and Terry, 1976) and later in East Africa (Gibson et al., 1998).

SPFMV alone generally causes no symptoms in sweet potato in East Africa (Gibson et al., 1997), whereas SPCSV stunts its growth and causes yellowing or purpling of lower leaves (Gibson et al., 1998b). In plants infected with both viruses, SPCSV synergises the multiplication of SPFMV, the titre of both coat protein (Gibson et al., 1998b) and viral RNA (Karyeija et al., 2000) of the SPFMV increasing several hundredfolds with co-infection, leading to the development of SPVD. SPFMV is transmitted by several aphid species in the non-persistent manner (Stubbs and McLean, 1958) and, in East Africa, by aphid species that do not colonize sweet potato (Wambugu, 1991; Aritua et al., 1998). SPCSV is transmitted semi-persistently by the whitefly *Bemisia tabaci* (Schaefers and Terry, 1976; Larsen et al., 1991). In East Africa, infection by SPCSV alone is generally limited, whereas SPFMV is either latent in many plants or

spread rapidly by itinerant alate aphids. Consequently, SPVD quickly follows any initial symptoms of SPCSV, prevalence of SPVD is closely related to abundance of whiteflies (Aritua et al., 1998; 1999) and control of SPVD essentially involves limiting the spread of SPCSV.

Uganda produces more sweet potato than any other country in Africa. The crop is grown mostly by poorly-educated women farmers for daily family food and for small-scale trading (Bashaasha et al., 1995) and it is vital to the alleviation of poverty (Scott et al., 1999). Hansford (1944) published the first description of SPVD there; the disease is particularly common in the south of Uganda around the shore of Lake Victoria and in the north-west along the Rift Valley (Aritua et al., 1998). Farmers mostly grow landraces (Bashaasha et al., 1995). Cultivars bred on-station have been released only recently (Mwanga *et al.,* 2001). Planting material is obtained by taking leafy shoot cuttings from mature crops. Farmers generally select planting material preferentially from symptomless parents so most crops start more-or-less SPVD-free. Crops are generally grown in small plots that are interspersed amongst other crops, so-called "patch intercropping". Where rainfall permits, for example, in the south of Uganda around the shore of Lake Victoria, sweet potato is grown continuously throughout the year, and mature and newly-planted crops overlapping. Individual SPVD-affected sweet potato plants have been recorded to yield only 2 - 40% that of unaffected plants (Karyeija et al., 1998). However, sweet potato has a sprawling indeterminate growth habit enabling unaffected plants to compensate for the loss or stunting of neighbouring plants and it seems doubtful that yield of a crop is much curtailed until >50% of plants are affected (Aldrich, 1963). Such high incidences are rarely observed because, in areas where the whitefly vectors of SPCSV are common, farmers grow SPVD-resistant landraces (Aritua et al., 1998). These tend to be less productive or produce storage roots of a lower quality than some SPVD-susceptible landraces (Gibson et al., 2000). Widespread use of less productive SPVD-resistant landraces may be the most damaging consequence of SPVD.

The main challenge of SPVD, therefore, is not so much to reduce its incidence but to enable farmers to grow qualitatively and/or quantitatively more productive cultivars

with little or no increase in the incidence of SPVD. An initial project had identified the areas in Uganda where SPVD is particularly damaging; they included Masaka and Rakai Districts (Aritua et al, 1998). High-yielding, SPVD-resistant cultivars have been released recently by the Ugandan national Potato Programme (Mwanga et al., 2001) and the project therefore tested these in districts where SPVD was prevalent. Previous work had also identified that most spread of SPVD into newly-planted crops derives from older crops within a radius of only about 100m (Aritua et al., 1999), probably because SPCSV is transmitted only semi-persistently (Larsen et al., 1991) and because *B. tabaci* adults fly mostly short-distances (Byrne et al., 1996). This also presented the possibility that farmers might be able to exploit isolation and grow high-yielding local landraces, despite any relative susceptible to SPVD, by controlling SPVD using local phytosanitation. This paper therefore describes recent research on control of SPVD, testing the resistant cultivars on-farm and testing phytosanitation on-station and on-farm.

2. Methods

2.1. *Resistant cultivars*

Sweet potato cultivars released in Uganda by the national Potato Programme and sweet potato clones which had already exhibited promising characteristics were tested using two approaches in Masaka and Rakai Districts of Uganda. These comprised:

- **On-station trials**. Replicated trials tested a diversity of sweet potato cultivars and other superior station-bred clones. Storage root yield and insect or pathogen damage were evaluated for each plant genotype.
- **On-farm trials**. Single-replicate trials tested about six sweet potato cultivars and other on-station bred clones on-farm under the agronomic practices of the farmer. Two local landraces chosen by each farmer as the best were always included as controls. Insect and pathogen damage were evaluated for each plant genotype by scientists and the palatability of the storage roots by farmers.

On-station trials. On-station trials in Masaka were planted at Masaka District Farm Institute, Kamenyamiggo, and trials in Rakai were planted at the Kabira Sub-District Demonstration Farm. The cultivars, other clones bred on-station and the local check landraces used in each test are listed in Table 1. Planting materials of the cultivars and other clones bred on-station were obtained from Namulonge Agricultural and Animal Research Institute (NAARI); planting materials of the local check cultivars were obtained from local farmers. Trials were planted in the second rains of 1999 and the first rains of 2000. Plots were arranged in a randomised block design with three or four replications, plots of each cultivar comprising at least 2.5m length of two ridges (1m spacing) with cuttings planted at about 0.3m intervals. Trials were monitored monthly for pests and diseases: SPVD-affected plants found at the first monitoring were removed and not included in the final count on the assumption that these had grown from infected cuttings. Plots were harvested after about 6 months. Total and marketable yields of storage roots were recorded.

On-farm trials. On-farm trials in Masaka and Rakai were done with 10 - 12 farmers each growing cycle in Kyanamukaka and Kabira Sub-counties, respectively and were planted in the first rains of 1999 and both the first and second rains of 2000. Generally, the same farmers participated throughout the series of trials. Single plots of each of the introduced test cultivars (see Table 1 for genotypes) plus the two popular local cultivars chosen by each participating farmer were planted at random in one block in each farmer's field (farmers had only sufficient spare land to allow one replicate at each farm). Farmers made traditional heaps of soil using hoes. Each heap usually occupied about $1m^2$ and was planted with four cuttings though some heaps were much bigger and planted with more cuttings where this was the local practice. Clusters of about eight such heaps planted with one cultivar comprised a plot. All farmers chose cv. Old Kawogo as one of their local cultivar checks. Farmers in Masaka all chose cv. Somba Busero as their other local cultivar, whereas farmers in Rakai all chose cv. Kampala. Planting material of the introduced cultivars was mostly derived from NAARI 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, cvs 93-29 and NASPOT 4

were excluded because of their relatively poor performance and cvs New Kawogo, Wagabolige, Tanzania and 1096 were included as a result of their relatively good performance in the formal replicated cultivar trials. Planting material of each local cultivar was supplied by each farmer.

Plots were monitored monthly for occurrence of pests and diseases; SPVD-affected cuttings found at the first monitoring were removed and not included in the final count. Total and marketable yields of storage roots, and any weevil damage, were recorded. Some of the trials were affected by pilfering (this was a particular problem for the 2000 first rains trials as the rains largely failed, leading to widespread food shortages). Such trials were not included in yield analyses. The yields of both formal cultivar evaluation trials and on-farm trials were compared (Table 1) using analysis of variance (Genstat 5: Release 4.1). There was considerable variation in total yields between on-farm trials even during the same growing season, apparently because of differences in soil fertility and rainfall on individual farms (rainfall in Uganda often falls in heavy localised thunderstorms). To limit this source of variation, yield results for the released cultivars on individual on-farm trials were adjusted, making the mean yield for the landraces equal to one, and then re-analysed (Table 3).

2.2 *Phytosanitation trials*

Roguing An experiment testing the effect of roguing was done in Luwero District on farms near to NAARI, planted using traditional mounds. Each plot was *c.* 5 x 5m (5 mounds x 5 mounds), comprising about 100 plants. A single guard row of mounds separated plots on each of the four sides. All mounds were planted with four cuttings of the relatively SPVD-susceptible cv. Tanzania collected from symptomless field plants, except for four cuttings taken from SPVD-affected plants and planted at random in each plot. Treatments comprised:

1. Removing all SPVD-affected cuttings (both introduced and naturally occurring ones), one month after planting (MAP).

2. Removing all SPVD-affected cuttings both 1 MAP and in each subsequent month.
3. No SPVD-affected plants were removed.

Trials were planted in a randomised block design twice at each of two farms, the first time with 3 and the next with 5 replicates.

Isolation from SPVD-affected plots The experiment was planted at NAARI farm, again using traditional mounds 1m apart. Initially, it comprised a central plot, 5 x 5m (*c.* 100 plants) planted with SPVD-affected cuttings. Some 4 –5 mths later, when the SPVD-affected plants were fully established, disease-free cuttings of cv Tanzania were planted in eight plots, each 5 x 5m, and arranged to the east, west, north and south of the diseased plot, either adjacent to the diseased plot or 15m away. The ground between plots was cultivated to suppress weeds. The numbers of SPVD-affected plants in each of the eight test plots were counted monthly for six months from planting. The same experiment was done twice. The few SPVD-affected plants appearing one month after planting (MAP) were assumed to have derived from SPVD-affected cuttings and were discounted.

3. Results

3.1 *Resistant cultivars*

Yields: on-station trials. There were no significant ($P>0.05$) differences in the total (Table 1) or marketable (Table 2) yields of the different cultivars tested in the on-station trial in 1999 in Masaka District (Table 1). However, in the 1999 planted trial in Rakai, cvs NASPOT 1 and Tanzania yielded significantly ($P<0.05$) more than the best yielding landrace (Old Kawogo). The severe drought in 2000 led to poor yields with no significant differences between entries in the trial planted in Rakai and the failure of the trial in Masaka.

Yields: on-farm trials. In on-farm trials at Masaka and Rakai, NASPOT 1 had greatest total (Table 1) and marketable (Table 2) yields in most cropping cycles, though it yielded significantly more ($P<0.05$) than the local cultivars only at Rakai in the second rains of 2000. Cv. 93-493 also yielded significantly more (total yield only)($P<0.05$) than landrace checks in the trial at Rakai planted in the second rains of 1999. There was considerable variation in yield between cropping cycles. Thus, trials planted in the first rains of 2000 yielded poorly at both Rakai and Masaka, probably largely because of inadequate rain that season. There was also considerable variation in yield between farms within each location, probably resulting from differences in soil fertility and the incidence of localised thunderstorms. Yield results for each of the introduced cultivars were therefore adjusted proportionally to the mean yield of the local cultivars on each farm. Furthermore, Masaka and Rakai Districts adjoin and have relatively similar agroecologies. Based on these adjusted values and combining the results for the trials in both locations (Table 3), NASPOT 1 generally yielded twice or more the marketable yield of the local landrace checks in most cropping cycles ($P<0.05$). Other introduced cultivars, notably NASPOT 2, NASPOT 3 and 93-493, sometimes also gave significantly ($P<0.05$) more total or marketable yield than the local cultivars.

Incidence of SPVD Several of the introduced cultivars including NASPOT 1 had similar numbers to or fewer SPVD-affected plants than the local cultivars (Table 4).

Evaluation of cultivars by farmers At harvest, tubers were steamed and tasted by farmers in 'blind' tasting trials. Generally, cvs NASPOT 1 and Tanzania were ranked highest, exceeding the rank of the local cultivars. The farmers also selected spare planting material from the trials. The most widely adopted introduced cultivars were NASPOT 1, NASPOT 2, NASPOT 3 and 93-493. Most of the farmers also gave cuttings to their friends, neighbours and family and most claimed to be growing *c*. 0.4 ha (*c*. 1 acre) more of sweet potato as a result of having the new cultivars.

3.2. *Phytosanitation trials*

Roguing SPVD spread more rapidly in the unrogued plots than in either the plots rogued throughout or the plots rogued only at 1 MAP (Fig 1.). By 5 MAP, an average of 14 plants/plot (*c.* 100 plants/plot) had become affected by SPVD in unrogued plots whereas an average of only 7 to 8 plants had become affected in either of the rogued treatments ($P<0.001$). The roguing treatments had no significant effect ($P>0.05$) on either marketable or total storage root yields. Roguing after 1 MAP did not provide any additional decrease in SPVD spread.

Isolation from SPVD-affected plots Within 4 – 5 mths of planting, SPVD had spread to 3 -4 times as many plants in the plots planted adjacent to the SPVD-affected plants as to those in plots 15 m away (Fig. 2) ($P<0.001$). Some of the tubers were stolen so yields were not available.

4. Discussion

Although SPVD-resistant landraces are present in East Africa, most have various inadequacies but above all, poor and late yield (Aritua et al., 1998). The rarity of superior SPVD-resistant landraces is thought to result from the slow evolution of sweet potato in traditional farming systems. Few sweet potato seedlings occur naturally in farmers' fields and most farmers, at least in Uganda and Tanzania, either ignore the few that do grow or even destroy them (Gibson et al., 2000).

On-farm trials in the Masaka and Rakai Districts of Uganda demonstrated that cultivars bred at NAARI (Mwanga et al., 2001) outperformed local landraces that were popular there. They did this both in yield and resistance to SPVD. NASPOT 1 was outstanding, having about twice the storage root yield of the landraces tested. This presents farmers in Uganda with an opportunity to double the yield/hectare of sweet potato from its current low level of *c.*30% of world average yields (FAOSTAT, 2002). This research also confirms indirectly that the rarity of superior SPVD-resistant local

cultivars is indeed because of inefficiencies in traditional breeding systems (Gibson et al., 2000) rather than because there are technical barriers such as adverse genetic linkages between yield and resistance. Farmers liked NASPOT 1 even though it has some deficiencies, for example, susceptibility to *Alternaria*. Because sweet potato is grown predominantly by resource-poor farmers for home consumption, they need to be involved at an early stage of the selection process in order to ensure their needs are addressed, thereby ensuring that most released cultivars are adopted.

The success of the isolation and roguing trials in restricting spread of SPVD both highlight the importance of avoiding nearby sources of infection, confirming that spread of SPVD is mainly local (Aritua et al., 1999). This is presumably a result of SPCSV being transmitted only semi-persistently (Larsen et al., 1991) and by *B. tabaci* adults making mostly short-distance flights (Byrne et al., 1996). The success of just 15m isolation was perhaps the more dramatic result though consistent with results with other crops (Thresh, 1976). This suggests that other related methods such as increasing field size, adoption of compact plots, synchronisation of planting etc may also be effective. Despite these initial successes, neither method of phytosanitation has yet been tested by farmers so the challenge of identifying method(s) appropriate to local sweet potato production systems remains. However, they hold the promise that farmers may be able to make more and better use of familiar, relatively SPVD-susceptible but otherwise high quality landraces. Although farmers may need to make some changes to their production system, no adjustments need to be made by consumers. Another advantage of using crop hygiene to control SPVD is that it is likely also to assist in the control of sweet potato weevils (*Cylas* spp.), the main insect pest of sweet potato in Africa (Geddes, 1990) and many other areas of the World.

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Fig. 1. Numbers of SPVD-affected plants in rogued and not rogued plots (+/- standard error of mean)

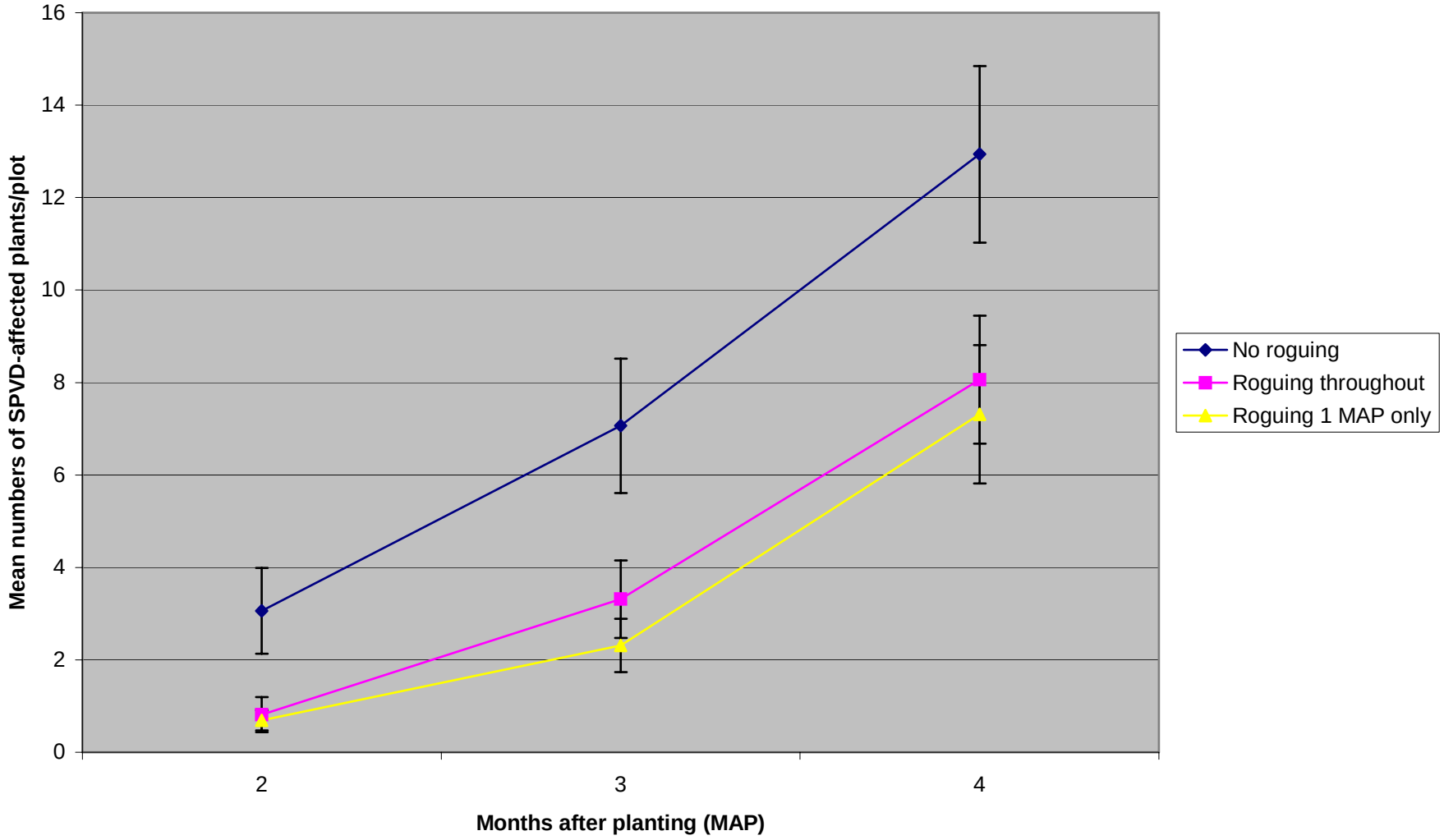

Fig. 2. Spread of SPVD to plots adjacent to or 15m from an SPVD-affected plot (+/- standard error of mean)

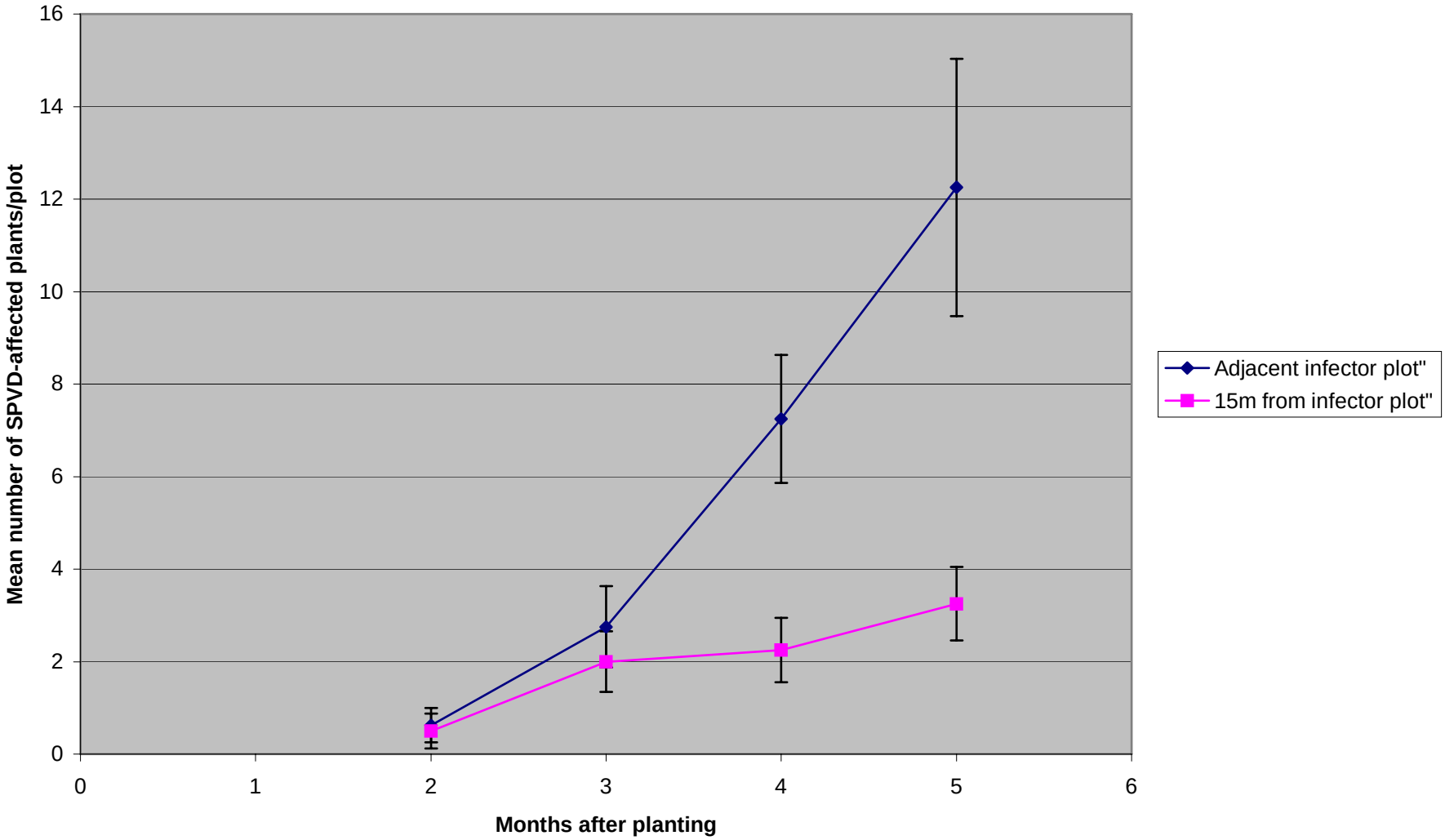

Table 1. Total yields (tonnes/ha equivalent) of on-farm and on-station trials in Masaka (M) and Rakai (R) Districts.

Trials	M1	M2	M3	M4	R1	R2	R3	R4	R5	Mean
Cultivars										
a) Introduced										
29								26.1		26.1
NASPOT 1	50	19.6	12.9		40.2	13.2	18.6	37.4	4.4	23.0
93-493	38.4	7.7	9.9	37.2	48.6	10.3	16	5.8	8.3	21.9
319				25.6				17.7		21.7
NASPOT 6				24.8				16.1		20.5
Wagabolige			13.7	34.7			12	36.3	5.3	20.4
NASPOT 3	43.9	8.2	12.2		43	11.1	14.8	28	5.8	20.3
93-29	38.6	1.7			36.5	6.5		28.5	6.9	19.9
NASPOT 2	41.5	11.9	6.9		36.7	9.3	11.4	29	12.3	19.2
1096			9.9	31.8			15.2			19.0
Tanzania			11.8	27.2			14.8	38	2.6	18.9
New Kawogo			12.6	24.8			11.9	31.8	9.8	18.2
Sowola				17.3				29.1	5.3	17.2
Bwanjule				23.3				24.6	0	16.0
NASPOT 4	32.2	4.1			30	8.5	18.1		5.1	15.9
NASPOT 5				11.1				27	2.5	13.5
b) Local										
Old Kawogo	36.6	9.6	8.1		31.8	9.9	12.7	21.3	7.9	16.6
Somba busero	31.3	9.3	13							16.2
Kampala					18.2	9.5	8.8	19.1	6.6	12.4
Replication	7	3	9	3	8	8	11	4	4	
SE of mean	4.7	4.6	2.1	3.6	4.4	1.5	1.7	4.5	3.1	
LSD *(P = 0.05)*	13.5	14.6	5.9	10.7	12.6	4.3	4.8	12.8	8.9	

1 = on-farm trial planted in the second rains, 1999;
2 = on-farm trial planted in the first rains, 2000;
3 = on-farm trial planted in the second rains, 2000;
4 = on-station trial planted in the second rains, 1999;
5 = on-station trial planted in the first rains, 2000.

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

Trials	M1	M2	M3	M4	R1	R2	R3	R4	R5	Mean
Cultivars										
a) Introduced										
29								22.1		22.1
NASPOT 1	39.5	15.1	11.4		35.9	9.1	14.3	33.1	2.5	20.1
319				23.7				14.8		19.3
NASPOT 6				22.2				13.7		18.0
93-493	29.5	5.1	6.5	32	37.6	6.3	11.8	22.8	4.6	17.4
Wagabolige			11.6	26.3			9.2	33.9	2.5	16.7
NASPOT 3	37.5	3.3	9.2		34.1	6.7	10.6	25.8	2.7	16.2
New Kawogo			11	22.9			9.4	30.2	6.9	16.1
Tanzania			8.1	22.2			9.8	34.5	1.1	15.2
1096			5.7	27			11.2			14.6
NASPOT 2	32.6	7.4	4.6		30		8.4	25	1	14.2
Bwanjule				19.4				22.3	0	13.9
93-29	30.7	0			31	3.6	0	25.1	4.8	13.6
Sowola				15.4				19.9	2.9	12.7
29								24	0	12.0
NASPOT 4	22.4	1.6			18.3	2.8	0	14.5	2.1	8.8
NASPOT 5				4.5						4.5
b) Local										
Old Kawogo	33.6	2.3	6.6		26.4	7.7	10.1	20	5.8	14.1
Somba Busero	25.7	6.3	8.5							13.5
Kampala					15.3	5.5	6.8	16.3	3.6	9.5
Replication	7	3	9	3	8	8	11	4	4	
SE of mean	4.6	5.0	1.9	3.9	3.3	1.3	1.3	4.5	1.4	
LSD *(P = 0.05)*	13.2	16.0	5.4	11.6	9.4	3.7	3.7	12.8	4.0	

1 = on-farm trial planted in the second rains, 1999;
2 = on-farm trial planted in the first rains, 2000;
3 = on-farm trial planted in the second rains, 2000;
4 = on-station trial planted in the second rains, 1999;
5 = on-station trial planted in the first rains, 2000.

Table 3. 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	
Replication	15	11	20
SE of mean	0.20	0.20	0.23
LSD *(P = 0.05)*	0.57	0.56	0.65

b) 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	
Replication	15	11	20
SE of mean	0.23	0.33	0.24
LSD *(P = 0.05)*	0.64	0.92	0.66

Table 4. SPVD incidence (%) in on-farm and on-station trials in Masaka (M) and Rakai (R) Districts.

Trial	M1	M3	M4	M5	R1	R3	R4	Mean
Introduced cultivars								
319			0	0			0	0
NASPOT 3	0	2.5		0	0.3	4.4	0	1.2
New Kawogo	0.4	3.2	0	2		3.6	0.6	1.6
Bwanjule			0	4.6			0.8	1.8
Wagabolige		7.3	0	0.6	0			2.0
NASPOT 5			3.6	3.1			0	2.2
93-493	0.7	3.8	3.6	6.4	1.4	1.3	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	6.1
Tanzania		15.9	2.4	2.6		12.2	3.8	7.4
1096		26.4	0			14.8		13.7
Local cultivars								
Old Kawogo	0.4	10		1	1.7	9.4	0.6	3.9
Somba Busero	4.3	7						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	

1 = on-farm trial planted in the second rains, 1999;
2 = on-farm trial planted in the first rains, 2000;
3 = on-farm trial planted in the second rains, 2000;
4 = on-station trial planted in the second rains, 1999;
5 = on-station trial planted in the first rains, 2000.