Chapter 1.13

Factors Associated with Damage to Sweetpotato Crops by Sweetpotato Virus Disease

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Introduction

Sweetpotato virus disease (SPVD) is the most destructive disease of sweetpotato (*Ipomoea batatas* [L]) in Africa (Geddes, 1990). It is caused by a combined infection of the aphid-borne *Sweetpotato feathery mottle virus* (SPFMV) and the whitefly-borne *Sweetpotato chlorotic stunt virus* (SPCSV) (Schaefers and Terry, 1976; Gibson et al., 1998b). Infection with SPFMV alone causes no obvious symptoms in African sweetpotato varieties (Gibson et al., 1997), while infection with SPCSV alone causes only moderate stunting, yellowing or purpling of middle and lower leaves and some yield loss (Gibson et al., 1998b). By contrast, SPVD causes severe plant stunting and small, distorted leaves with either chlorotic mosaic or vein clearing (Schaefers and Terry, 1976). The yield of affected plants generally is reduced by more than 50% (Mukiibi, 1977; Hahn, 1979; Ngeve and Boukamp, 1991). It appears that SPCSV has a synergistic effect on SPFMV (Rossel and Thottappilly, 1987; Aritua et al., 1998a): field plants that are infected with SPCSV quickly develop SPVD, either through an activation of a latent SPFMV infection or through increased susceptibility to aphid-borne spread of the virus. In this manner, infection with SPCSV is the trigger for SPVD and damage by the disease has long been linked with high populations of its vector, the whitefly *Bemisia tabaci* (Gennadius) (Sheffield, 1957).

SPCSV is transmitted semi-persistently by *B. tabaci*; feeds lasting a few hours are required for both efficient acquisition and inoculation (Cohen et al., 1992). *B. tabaci* that colonize sweetpotato in Africa cannot readily colonize cassava (*Manihot esculenta* Crantz) and vice-versa (Burban et al., 1992; Legg, 1996). As a result, there may be no direct link between whitefly numbers on sweetpotato and whitefly numbers on cassava, or between transmission of SPCSV and of *African cassava mosaic virus*, even where sweetpotato and cassava are intercropped. Thus, the epidemic of cassava mosaic disease and *B. tabaci* in cassava crops in East Africa seems to have had little effect on the incidence of SPVD. This is particularly fortunate because sweetpotato often provides the most readily available alternative crop to cassava.

Sweetpotato is an important crop for subsistence farmers throughout

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Uganda, generally being grown continuously throughout the year. Planting occurs whenever soil moisture is adequate and so is concentrated during, although not exclusively limited to, the rains, which in most areas of Uganda occur from March to June and from September to November. Crops are usually maintained for at least 6 months, cropping frequently being extended for up to 1 year by piecemeal harvesting, using a stick to tease out individual mature tubers (Bashaasha et al., 1995).

SPVD has been reported to be prevalent at moderate altitudes, 50 to 600 m above sea level, in East Africa (Sheffield, 1953). However, in Uganda, it was rare in the eastern districts of Soroti, Tororo and Busia but reached damaging levels of incidence in central Mpigi District, as well as in the southern districts of Masaka and Rakai, even though all locations were at a similar mid-altitude (Aritua et al., 1998b). The main aim of this project therefore was to understand the underlying causes of the different incidences, so as to provide a sound base from which to develop management practices. Recent work (Gibson et al., 1997; Aritua et al., 1998b) identified three factors as being associated with low SPVD incidence:

(1) Whiteflies were rare on sweetpotato in some localities (for example, the eastern districts of Uganda);

(2) The predominant sweetpotato variety is resistant; and

(3) Farmers select planting material from symptomless parents.

Our work therefore focused on links between SPVD incidence and (a) whitefly numbers, (b) varietal resistance and (c) farmers' plant health management practices.

Methods and Results

Monthly surveys of whiteflies and SPVD were carried out at 10 farmers' fields around each of six towns in Uganda (Soroti, Busia, Iganga, Namulonge, Kanoni and Masaka), from January 1998 to April 1999. All the sites are at about the same altitude and lie roughly along a south-east/north-west axis. Sweetpotato fields, 4 to 8 months old, were chosen while travelling along a rural road or path around each town, stopping at intervals of about 1 km or at the first field observed thereafter, different plantings being sampled each month. Whitefly numbers in each field were assessed by counting the number of whitefly adults observed while turning over leaves for a 1-minute period. Ten different parts of each crop were sampled in this manner. A more detailed account of the sampling method is provided in Aritua et al. (1998b). SPVD was assessed by counting the proportion of affected plants among 30 plants selected at random along a V-shaped track through each field.

Whiteflies were relatively few at Soroti and Busia except in February 1998 (Figure 1) and, in accord with this, SPVD was also rare there (Figure 2). Similarly, there were slightly more of both whiteflies and SPVD at Iganga. Although farmers' fields at Namulonge, Kanoni and Masaka all had relatively large and similar numbers of whiteflies, SPVD at Namulonge averaged only 2% and at Masaka, 6%, reaching 18% at Kanoni. Whitefly numbers were relatively high at all sites from January to April (inclusive). At those sites where SPVD was common, its incidence remained relatively low until February, consistent with there being a latent period of about 1 month (Gibson et al., 1998a) between infection by the whiteflies and

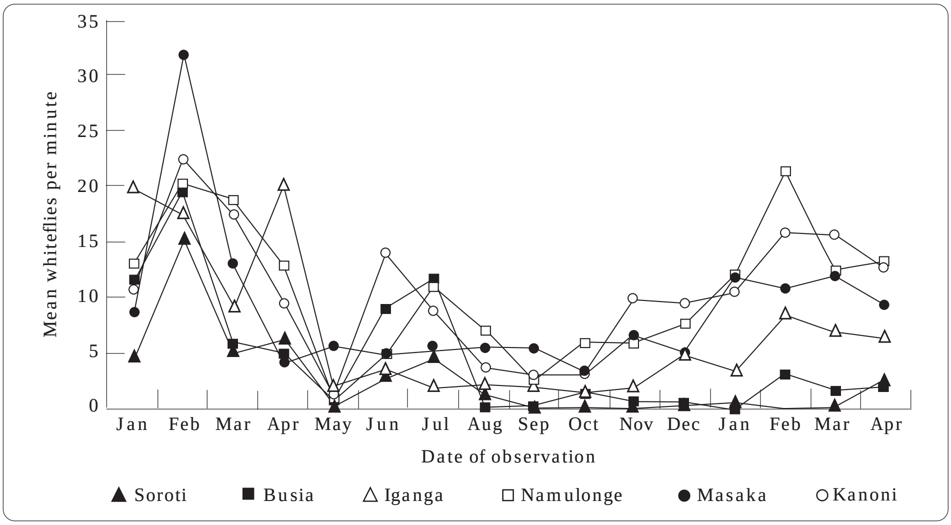

Figure 1. Mean whitefly numbers in six districts of Uganda (January 1998-April 1999). Each data point represents the mean for 10 fields.

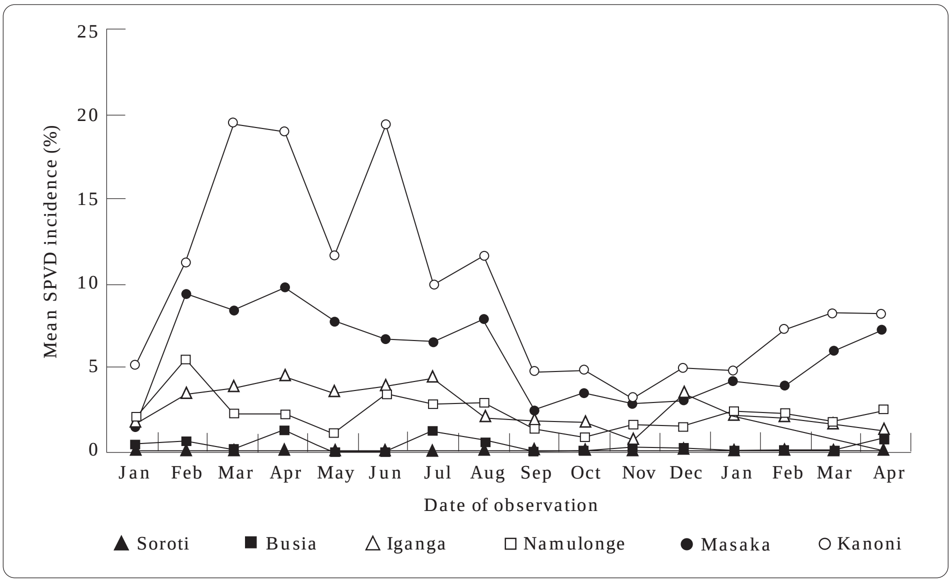

Figure 2. Sweetpotato virus disease (SPVD) incidence in farmers' fields in six districts of Uganda (January 1998-April 1999).

appearance of SPVD. The incidence of SPVD then remained relatively high until August, partly perhaps as a result of continuing infection but probably also because of the survival of affected plants.

From the point of view of understanding the relationship between vector dynamics and disease incidence over time, sampling farmers' fields had the disadvantages that they were not necessarily planted with the same cultivars and that the planting material already might have been infected and, to a varying degree, with SPVD. In order to eliminate these variables, three on-farm trials were planted at each of the three most contrasting sites, Soroti, Namulonge and Kanoni, using planting material from Namulonge Agricultural and Animal Production Research Institute (NAARI) farm, with one series of plantings in the second rains of 1997 (Aritua et al., 1999) and another in the second rains of 1998. Whitefly numbers and SPVD incidence were monitored monthly, from January to June, using the same procedures as in the surveys of farmers' fields. In both series, the results were very similar to those obtained by monitoring farmers' fields:

(1) No SPVD and few whiteflies (results not shown) were found at Soroti;

(2) Whiteflies were abundant at both Namulonge and Kanoni (Table 1);

(3) But SPVD increased in incidence rapidly only at Kanoni (Figure 3); and

(4) There was no correlation between whitefly numbers and final SPVD incidence (Table 1).

An index of the level of local inoculum for each site at Namulonge and Kanoni was also calculated from "area of each field of sweetpotato within 100 m of each trial" × "incidence of SPVD in it"¸ "distance to the trial plot". Results are tabulated (Table 1) for the first series of trials in which there was more virus spread. The value for local inoculum correlated closely with SPVD incidence at both sites, suggesting that the greater spread of SPVD at Kanoni was due to the greater incidence of SPVD in nearby farmers' fields. Examination of records of farmers' crops in the two localities also revealed that a highly SPVD-resistant variety called New Kawogo predominated at Namulonge and the surrounding villages and this may explain why SPVD was rare in the farmers' fields there. At Kanoni, more susceptible varieties predominated in farmers' fields (Aritua et al., 1999).

Links between SPVD incidence, crop data and farmers' management

Table 1. Relationship between sweetpotato virus disease (SPVD) incidence and (1) whitefly counts, (2) local inoculum and (3) whitefly numbers × local inoculum.

Farm	SPVD incidence[a]	Whiteflies[b]	Local inoculum[c]	Whiteflies × inoculum
Namulonge A	4.0	11.4	0	0
Namulonge B	1.5	13.2	100	1320.0
Namulonge C	0	14.0	120	1680.0
Kanoni D	18.5	10.5	1043	10951.5
Kanoni E	36.0	13.4	2298	30793.2
Kanoni F	23.5	9.4	1519	14278.6
Correlation[d]	-	-0.284	0.990	0.969
P	-	N.S.	< 0.001	< 0.001

a. SPVD incidence (%): final assessment (June) in each on-farm trial.
b. Whiteflies: mean monthly (January-June) whitefly counts from each on-farm trial.
c. Local inoculum: index calculated from SPVD incidence × area of field ÷ distance from field for fields within 100-m radius of trial plots.
d. Correlation of SPVD incidence with data in corresponding column.

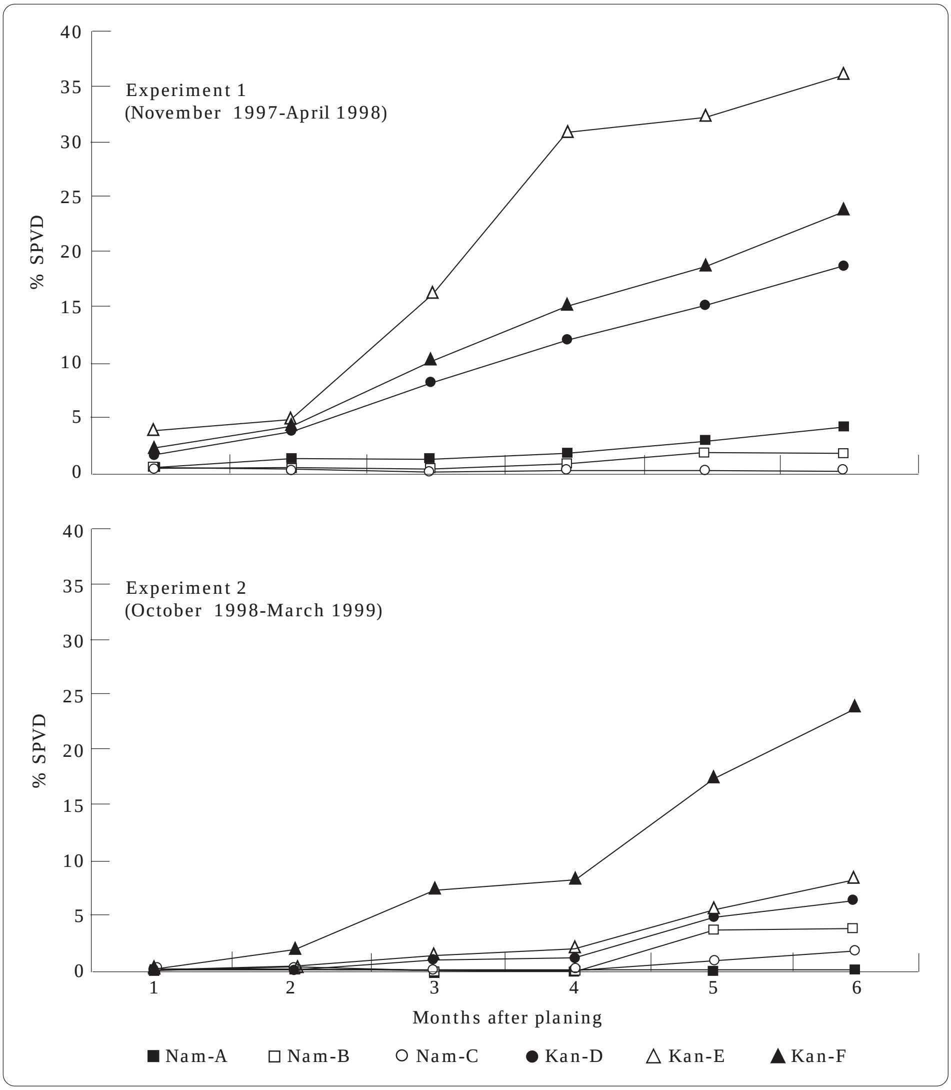

Figure 3. Progress of sweet potato virus disease (SPVD) in initially disease-free sweetpotato planted during the second rains of 1997 (Experiment 1) and the second rains of 1998 (Experiment 2) at farms at Namulonge (Nam-A, Nam-B, Nam-C) and Kanoni (Kan-D, Kan-E, Kan-F).

practices also were examined by farm surveys and farmer interviews in 1998-99 (for methods, see Gibson et al., 2000), focusing particularly on localities where SPVD was unusually prevalent, notably Bukoba and Karagwe sub-districts of Kagera District in Tanzania, and Rukungiri and Mpigi Districts in Uganda (Table 2).

Most farmers, particularly those in Tanzania not exposed as yet to the bitter lessons of the cassava mosaic epidemic (which began in Uganda), did not realize that SPVD involved a virus spread by whiteflies, many considering it to be caused by too much sun. Even so, most farmers attempted to control SPVD, predominantly through the use

Table 2. Importance to farmers of different measures that they already are using to manage sweetpotato virus disease (SPVD) (adapted from Gibson et al., 2000).

Locality	Percentage of farmers[a] giving the rank indicated to a control measure									No. of farmers	
	Symptomless planting material			Roguing			Resistant cultivars			Controlling SPVD[b]	Interviewed
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd		
Tanzania[c]											
Bukoba	100	0	0	0	33	0	0	0	0	15 (75)	20
Karagwe	80	0	0	20	10	0	0	0	0	10 (36)	28
Uganda											
Rukungiri	82	14	0	11	50	7	7	14	18	44 (88)	50
Mpigi	88	10	0	2	10	27	10	54	7	41 (82)	50
Soroti	100	0	0	0	17	17	0	17	0	6 (12)	50
Overall	87	9	0	7	28	13	6	25	9	116 (60)	198

a. Among those claiming to use specific measures to control SPVD.
b. Number of farmers (in parentheses, percentage of farmers among those interviews) claiming to use specific control measures for SPVD.
c. Farmers in other districts in Tanzania were not questioned on this subject.

of plant health management tactics (Table 2). In particular, most farmers carefully selected their planting material from unaffected parent plants. A few also removed (rogued) diseased plants from young crops. However, farmers often planted new crops close to old diseased crops, even though incidence of SPVD and the distance between crops were significantly ($P < 0.05$) and negatively correlated. Farmers also appeared to make no attempt to remove diseased plants from old and abandoned crops even when they were close to newly planted fields. This is consistent with farmers lacking knowledge that SPVD is caused by an insect-transmitted virus.

Although most farmers knew of SPVD-resistant varieties, few ranked resistance as a valuable management practice (Table 2), apparently because most resistant varieties had a poor and/or late yield. Despite this, they ranked new varieties with superior yield characteristics and resistance as their top requirement.

Conclusions

Our results confirm that SPVD varies considerably in incidence among sites and that part of the variation in incidence is associated with differences in the numbers of *B. tabaci* infesting the crop. Thus, the explanation for the rarity of SPVD in Soroti and Busia seems to be that whiteflies are rare throughout much of the year (Figure 1) but this still leaves unanswered the question of why fewer whiteflies should be present in Soroti and Busia than in Mpigi District. Our investigation was too limited to identify positively the reason(s) for this. However, a major difference between Soroti and Busia Districts and Mpigi District is that the first rains in Soroti and Busia Districts occur later and the second rains earlier than in Mpigi District. This leads to a more prolonged dry season between the second and the first rains in Soroti and Busia, during which time most vegetation dries out, natural bushfires are common and the resulting natural vegetation predominantly consists of low-growing bushes and grasslands. Rainfall being more evenly spread throughout the year in Mpigi, vegetation continues to grow year-round and such fires rarely occur. As a result, sweetpotato crops in this region often occur in locations sheltered by tall trees and other vegetation.

High incidences of SPVD were associated with:

(1) Large average numbers of whiteflies found on the sweetpotato crop during the year;

(2) High peak whitefly populations, which occurred during the hot dry season (January-March); and

(3) Relatively large amounts of SPVD-affected plants nearby.

The importance of local inoculum was shown directly by our on-farm field trials but was indicated also by survey data showing that SPVD incidence increased as sweetpotato cropping intensity increased. A requirement for local inoculum is consistent with SPCSV being only semi-persistently transmitted and with *B. tabaci* being a relatively weak flier. Using pesticides to reduce the population of the whitefly vector is highly unlikely to be a useful tactic in SPVD management since, even setting aside environmental risks, human health concerns and the tendency of whiteflies to develop resistance to insecticides, the crop has too low a value to justify the investment in insecticides. Choice of appropriate varieties is unlikely to be effective in reducing vector populations because earlier work has not identified major differences in the numbers of whiteflies on different sweetpotato varieties (Aritua et al., 1998a). However, local inoculum could be reduced by:

(1) Planting disease-free cuttings (already used by most farmers);

(2) Roguing plants that develop symptoms (used by a few farmers early in the season);

(3) Removal of crop debris (both roots and foliage as both re-grow readily and are often diseased) from old fields (not currently used);

(4) Separation of new crops from old diseased ones (not currently used); and

(5) Increased use of resistant varieties (favoured only in localities where acceptable resistant varieties were available).

Our work also suggests that it may be particularly important to apply plant health management tactics during the hot dry season because this is when the whitefly vectors are most abundant. However, it is important to emphasize that, although they may seem obvious, none of these strategies have been tested yet in field trials, to ensure that they are effective and adoptable by farmers, and so cannot be officially recommended. Furthermore, our farmer interviews indicated that most farmers do not have a sound understanding of the cause and source of SPVD. Some of these control practices might therefore appear to farmers to be inappropriate. Consequently, both participatory research and training programs will be essential if plant health management strategies are to be developed and widely adopted.

Farmers in areas severely affected by SPVD gave highest priority to the need for superior, virus-resistant varieties (Table 3). Our work showed that resistant varieties are valuable not only because they suffer less SPVD damage but also because their widespread cultivation reduces incidence of SPVD in remaining stands

Table 3. Aspects of sweetpotato virus disease (SPVD) management on which farmers in severely affected localities would most like to receive assistance (adapted from Gibson et al., 2000).

Locality	Percentage of farmers[a] giving a particular rank to the indicated management tactic									No. of farmers	
	Superior, resistant cultivars			Technical information			Chemical control			Requesting[b]	Interviewed
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd		
Bukoba	100	0	0	0	0	0	0	0	0	14 (70)	20
Rukungiri	60	21	0	23	6	2	17	15	0	48 (96)	50
Overall	69	16	0	18	5	2	13	11	0	62 (89)	70

a. Among those requesting specific measures to manage SPVD.
b. Number of farmers (in parentheses, percentage among those interviewed) requesting assistance with management of SPVD.

of susceptible varieties. Although farmers also gave a low ranking to the use of their currently available resistant varieties (Table 2), this was because most farmers perceived their resistant landraces to have major flaws. The higher yielding, resistant varieties such as those selected at NAARI in Uganda and at the Agricultural Research Institute in Ukiriguru, Tanzania, taking account of farmer preferences, should overcome this obstacle.

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