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Full Length Research Paper

Assessing the sweetpotato virus disease and its associated vectors in northwestern Tanzania and central Uganda

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A study was conducted in sweetpotato farmers' fields in Tanzania and Uganda to determine the status of sweetpotato virus disease (SPVD) incidence and its vectors. SPVD incidence was high (66 to 100%) in Tanzania but low (10 - 40%) in Uganda. SPVD symptom expression and severity were highly variable both within and between countries. Whitefly (*Bemisia tabaci*) but not aphids were observed in all the fields and their abundance varied remarkably between locations. In Tanzania, sweetpotato chlorotic stunt virus (SPCSV) was serologically detected in 50% of the samples and sweetpotato feathery mottle (SPFMV) in 45% often in dual infection. Sweetpotato mild mottle virus (SPMMV), sweetpotato mild speckling virus (SPMSV), sweetpotato chlorotic fleck virus (SPCFV) and sweetpotato virus G (SPVG) occurred in low frequency. However, SPCSV was detected in (100%) of the samples collected from Uganda followed by SPFMV (67%). The nature of SPVD incidence, symptom severity, whitefly, and aphid abundance observed in this study suggest the complex nature of SPVD in East Africa. Immediate prospects for controlling SPVD will depend on an enhanced understanding of disease variables and their ecological relationships.

Key words: Sweetpotato, incidence, severity, whitefly, aphids.

INTRODUCTION

Sweetpotato, *Ipomoea batatas* (L.) Lam, is the third most important root crop in the world after potato (*Solanum tuberosum* L.) and cassava *Manihot esculenta* Crantz (FAO, 1998). Sweetpotato is a most important crop in East Africa and in Tanzania, it is mainly produced in the Lake Victoria Zone where it plays a major role in household food security (Bashaasha et al., 1995; Ndunguru, 2000). Overall, sweetpotato ranked second after cassava in the lake zone, eastern zone and Zanzibar (Ishika, 2005). In Uganda, sweetpotato is the second most important root crop after cassava and is grown in virtually all the districts especially in central Uganda (Bashaasha et al., 1995). Farmers in the Lake Victoria basin grow different sweetpotato cultivars such as white, yellow, cream and light to deep orange fleshed ones. Of all these cultivars, the most nutritious ones are the orange-fleshed cultivars that contain beta–carotene (the source of vitamin A).

Sweetpotato production is constrained by relatively few abiotic and biotic factors including lack of clean planting materials, lack of high-yielding cultivars, low soil fertility, lack of resistant cultivars and weevils. However, the main constraint to sweetpotato production in the victoria basin is virus diseases (SPVD) caused by combination of sweetpotato feathery mottle virus (SPFMV) and sweetpotato chlorotic stunt virus (SPCSV), which are transmitted by 2 vectors namely aphids and whitefly, respectively. Sweetpotato virus disease (SPVD) is widespread and regarded as a serious problem in Africa with affected plants commonly yielding less than half of the affected plants (Mukiibi, 1977). SPVD can cause yield reduction of

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56 - 98% (Mukasa et al., 2003, Ndunguru et al., 2007).

For various reasons, SPVD is wide spread in Uganda and is regarded as a serious limiting factor to sweetpotato production (Mukasa et al., 2003). Many sweetpotato cultivars seem to be naturally resistant to SPFMV strains, showing only mild initial symptoms, from which they usually recover and may contain low virus titers. However, co-infection with SPFMV and SPCSV could somehow interfere with the recovery and cause severe SPVD even in the most resistant cultivars.

The aim of this study was to provide a quantitative assessment of SPVD and abundance of its associated vectors (aphid and whitefly) in the Lake Victoria basin of Tanzania and central Uganda districts of Luwero and Wakiso. The information on incidence, severity as well as abundance of sweetpotato virus vectors mainly whitefly and aphids will provide a basis upon which to formulate effective management strategies for sweetpotato virus diseases.

MATERIALS AND METHODS

Location and field sampling

A total of 30 sweetpotato farmer's fields in 10 locations situated in different districts of Mwanza and Kagera regions in the lake victoria basin of Tanzania and 9 in the Luwero and Wakiso districts of central Uganda were sampled.

In each field, 30 plants were examined for SPVD symptoms using a walking pattern for assessment of up to 70% field plants (Feistrizer, 1975). Sweetpotato crops 3 - 4 months old were selected. Plants showing virus-like symptoms were picked randomly along the diagonal transect line over the field. SPVD incidence was calculated as the % of visually diseased plants over the total plants assessed in the transect. SPVD severity was estimated using a scoring scale of 1 - 5 where 1 = mild symptoms and 5 = very severe symptoms after describing the symptoms. Plants expressing distinct symptoms and or very mild or severe symptoms were preferentially sampled. In total, 26 symptomatic and 4 symptomless were collected from each field. Leaf samples were transfered to Mikocheni Agricultural Research Institute (MARI), Dar-es-Salaam in Tanzania and National Agricultural Research laboratory NaRL in Uganda for serological analysis.

To establish the types of infection that is cutting vs secondary infection (whitefly/aphid), plants were judged as having cutting type of infection if they displayed virus symptoms on the lowest leaves (10 leaves above the ground) while plants with secondary infection were those that showed symptoms on the top 10 leaves.

Estimation of whitefly and aphid abundance

Assessment of aphid population involved direct counting of adults on 5 youngest apical leaves of the shoots because the adults feed preferentially on the youngest immature leaves. Due to differences in branching habits of different sweetpotato cultivars, 3 shoots per plant were chosen and the total number of aphids was taken to represent the estimate of the number of aphids per plant. Similarly, shoots were examined for the presence of adult *Bemisia tabaci* and If found were counted and the numbers recorded. In addition, plants were shaken to dislodge the adult whiteflies, which flew and were counted on-flight. Sampling took place between 8.30 and 11.30 h.

Detection of sweetpotato viruses

Three leaf portions (1 cm) were taken from upper, middle and lower leaf parts and used for serological testing of sweetpotato viruses using the nitrocellulose membrane enzyme-linked immunosorbent assay (NCM-ELISA) as described by Gibbs and Padovan (1993). Virus specific polyclonal antibodies to sweetpotato chlorotic stunt virus (SPCSV), sweetpotato feathery mottle virus (SPFMV), sweetpotato mild mottle virus (SPMMV), sweetpotato chlorotic fleck virus (SPCFV), sweetpotato caulimo-like virus (SPCaLV), sweetpotato mild speckling virus (SPMSV), C-6, sweetpotato latent virus (Sw-PLV), sweetpotato virus G (SPVG) and cucumber mosaic virus (CMV) as well as NCM strips spotted with sap from virus-positive and non-infected control plants were kindly provided by the International Potato Center (CIP, Lima, Peru). Visual assessment of the development of a purple colour on the samples spots of the nitrocellulose membrane was used to identify virus positive samples (Gutierrez et al., 2003).

Data analysis

Disease incidence and severity, whitefly and aphid abundance were subjected to analysis of variance (SPSS Inc., 1997), and mean values compared by Duncan multiple range test (DMRT) (SPSS Inc., 1997). A bivariate pearson's correlation analysis was performed to establish the relationship between dependent variables.

RESULTS

SPVD incidence

The locations of sweetpotato farmer's fields sampled during this study are presented in Figure 1. SPVD was observed in all the surveyed locations in Tanzania. Analysis of variance revealed no significant effect of locations ($F_{(4, 15)} = 0.402$, $P = 0.803$) on SPVD incidence. The highest incidence (56%) was recorded at Mwasongwe in Misungwi district followed by Igombe (52%) in Ilemela district and the least (37%) in Kayenze in Magu district (Table 1) in the Mwanza region. SPVD incidence did not vary significantly ($F_{(7, 14)} = 0.1.896$, $P = 0.192$) among the eight sweetpotato cultivars (Mafuta, SPNO, Jitihada, Zapallo, Jewel1, Polista, Sabaina, and Ushashini) (Figure 2).

In Kagera region, SPVD incidence significantly ($F_{(4, 10)} = 14.706$, $P<0.001$) varied between locations with the highest incidence recorded at Byamtemba (81%), Kyaka (92%), and Byeju (94%) in Misenyi district (Table 1). In these locations, SPVD incidence ranged from 66 to 100%. In the areas close to the lake victoria shore, Kahororo and Buitaruka SPVD incidence was low (< 47%). Of the 11 sweetpotato cultivars examined, cultivars Kalebe and Zerida recorded the highest (100%) and Karanda and Damu ya mzee the lowest SPVD incidences (Figure 3).

Sweetpotato virus disease (SPVD) was also observed in all the fields surveyed in Uganda. Analysis of variance revealed no significant ($P = 0.423$) effect of locations on SPVD incidence. In Wakiso district, SPVD incidence was 24 ± 8.71% and differed greatly from each location giving rise to higher standard errors. The highest incidence

Figure 1. A sketch map of Tanzania (Lake Victoria basin) and Uganda (central) showing sites sampled for occurrence of SPVD and assessment of virus vector abundances.

Table 1. SPVD severity, incidence and vector population at different sweetpotato growing locations in the lake victoria basin of Tanzania.

Region	Locations	% SPVD Incidence (%)	SPVD Severity	Mean WF count/plant	Mean Aphid count/plant
Mwanza	region				
	Nyakasanga	43	2.71 ± 0.17a	0.91 ± 0.25b	0.02 ± 0.016a
	Mwasonge	56	3.60 ± 0.17b	0.27 ± 0.12a	0.00a
	Igombe	52	2.68 ± 0.14a	0.58 ± 0.21b	0.33 ± 0.056b
	Kayenze	37	2.96 ± 0.14a	0.20 ± 0.12a	0.28 ± 0.17b
	Ihayabuyaga	48	3.42 ± 0.18b	0.70 ± 0.17a	0.20 ± 0.056b
Kagera	region				
	Byamtemba	81	3.5 ±0.14b	1.5 ± 0.26a	0.2 ±0.055
	Byeju	94	4.2 ± 0.02c	0.47 ± 0.26a	0.00
	Kyaka	92	3.9 ± 0.13c	3.46 ± 0.26b	0.4 ± 0.05
	Kahororo	13	2.5 ± 0.24a	1.1 ± 0.62a	0.00
	Buitairuka	46	3.3 ± 0.17b	0.7 ± 0.23 a	0.00

± Standard error of each mean.
Mean followed by the same letter are not statistically different at the 0.05 level of significance.

(40%) was recorded at Bbulabakulu on sweetpotato cultivar Chipapali (Table 2). In Luwero district, SPVD incidence averaged 17.8 ± 3.05% with highest incidence of only 30% on sweetpotato cultivar Dimbuka which was the most grown (67%) in the Wakiso and Luwero districts.

SPVD severity

In Uganda sweetpotato virus disease symptom severity significantly ($F_{(8, 50)}$=2.881, P<0.05) varied between sweet potato fields. The highest disease severity score was 3.3

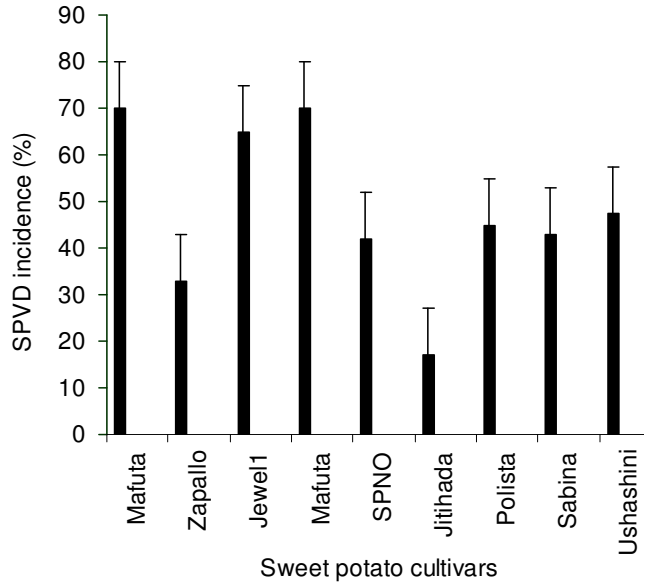

Figure 2. Sweetpotato virus disease incidence in different sweetpotato cultivars surveyed in Mwanza region of Tanzania.

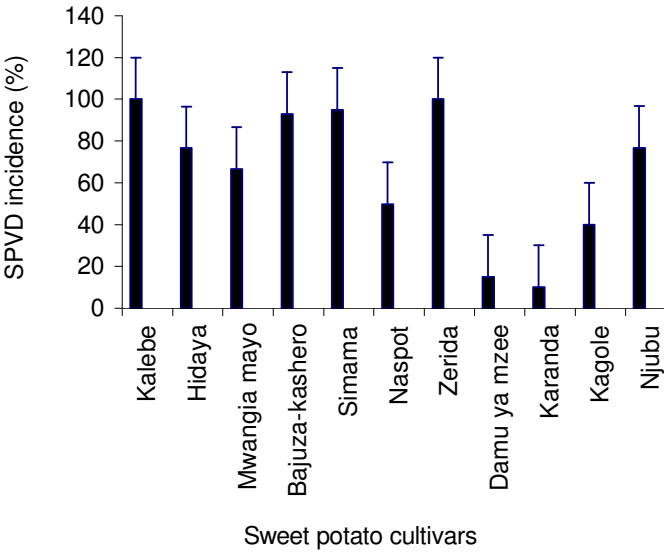

Figure 3. Sweetpotato virus disease incidence in different sweetpotato cultivars surveyed in Kagera region of Tanzania.

± 0.33(± standard error) and was recorded at Bbulabakulu on sweetpotato cv. Dimbuka and in Luwero district on the same cultivar (Table 2). Generally SPVD symptoms varied from mild to moderate with severity score that ranged from 2 to 3.

In the lake victoria of Tanzania sweetpotato virus disease symptom severity significantly ($F_{(4, 184)}$=6.542, P < 0.001) varied between locations. The highest disease severity score (3.6 ± 0.17) was recorded at Mwasongwe in Misungwi district (Table 1). This was followed by Ihayabuyaga in Magu district (average severity score of 3.4 ± 0.18) and the least at Igombe (Table 1). At Nyakasanga, Kayenze and Igombe, disease severity varied from mild to moderate. Disease severity also significantly ($F_{(7, 170)}$ = 3.573, P < 0.001) varied between cultivars. The orange-fleshed sweetpotato cv. Zapallo displayed the most severe SPVD symptoms with severity a score of 4.2 ± 0.27 followed by "Ushashini" (4.1 ± 0.27) (Table 3). In the Kagera region, SPVD-affected plants displayed moderate to very severe symptoms. Plants with the most severe SPVD symptoms were observed at Byeju in Misenyi district followed by Kyaka and Byamtemba (Table 1). Kahororo recorded the lowest SPVD severity score (2.5 ± 0.04) (Table 1).

SPVD symptom expression

Sweetpotato virus disease symptoms in the surveyed areas were highly variable among locations. In some areas of Mwanza region in Tanzania, SPVD symptoms consisted of mosaic, leaf mottle, and plant stunting whereas in other places chlorotic blotches, purpling and rugosis were prominent (Figure 4). Some infected cultivars expressed leaf deformation, stunting, vein clearing or banding and leaf narrowing (fill form) or feathery-like. On sweetpotato cultivar 1990.14.11 leaf curl virus-like symptoms were observed at Nyakasanga (Figure 4). In other fields, SPVD symptoms were less variable and plants expressed prominent purpling of leaves coupled with yellowing and mottling.

Characteristics symptoms of SPVD observed in farmer's fields in the Kagera region generally comprised mainly of severe plant stunting, crinkling and distortion of leaves and purpling of lower leaves. Some sweetpotato cultivars displayed pale mosaic or vein clearing as was the case of cv. Simama. In all the surveyed fields, purpling of the lower and middle leaves coupled with plant stunting was very common.

In Uganda sweetpotato virus disease symptoms were less variable. Generally they comprised leaf yellowing and at times generalized mosaic and or plant stunting. Interestingly, SPVD symptoms varied between locations on the same cultivar possibly suggesting involvement of different sweetpotato virus or a combination of factors.

For example, sweetpotato cultivar Dimbuko while showing generalized yellow mosaic in many areas, at Manyama village, affected plants expressed apparent vein clearing and mild leaf distortion (Figure 5). This was coupled with distinct chlorotic blotches on both young and old leaves.

Detection of sweetpotato viruses

20 representative sweetpotato symptomatic plants in Uganda and Tanzania in the Lake Victoria basin were sampled for virus testing using NCM ELISA. In the lake victoria basin of Tanzania SPCSV was detected in 50% of the samples and SPFMV (45%), often in dual-infection.

Table 2. Sweetpotato virus disease incidence, severity and its associated whitefly and aphid vector population in Central Uganda.

District	Sweetpotato cultivar	SPVD incidene (%)	SPVD symptom severity (0-5)	Whitefly count/plant	Aphid count/plant
Wakiso	Chipapali	40	3.2 ± 0.11[a]	1.7 ± 0.42	0.2 ± 0.14
	Dimbuka	10	3.3 ± 0.33	1.2 ± 0.54	0.0
	Dimbuka	22	2.7 ± 0.21	2.3 ± 1.49	0.0
Luwero	Dimbuka	17	2.3 ± 0.21	3.2 ± 1.13	0.0
	Soroti	20	2.5 ± 0.22	0.0	0.0
	Dimbuka	10	2.3 ± 0.33	0.0	0.0
	Naspot 1	20	3.1± 0.31	0.8 ± 0.8	0.0
	Dimbuka	30	3.1± 0.26	0.7 ± 0.47	0.0
	Dimbuka	10	3.3 ± 0.25	1.8 ± 1.7	0.0
	P value		0.010	0.225	0.744

[a]SE is the standard error of each mean.

Table 3. Mean (± SE) SPVD symptom severity in different sweetpotato cultivars surveyed in the Lake Victoria basin of Tanzania

Region	SP cultivar	Colour	SPVD severity score (1-5 scale)	95% Confidence interval	
				Lower bound	Upper bound
Mwanza	region				
	Mafuta	Orange	3.4 ± 0.221b	2.96	3.83
	SPNO	Cream	2.2 ± 0.221a	1.76	2.63
	Jewel1	Orange	3.7 ± 0.221c	3.29	4.17
	Zapallo	Orange	4.2 ± 0.27c	3.67	4.73
	Polista	Yellow	2.8 ± 0.221a	1.76	3.43
	Sabina	White	2.8 ± 0.35 a	2.14	3.52
	Ushashini	White	4.1 ± 0.27c	3.56	4.63
	Jitihada	Cream	2.2 ± 0.38a	1.44	2.96
Kagera	region				
	Kalebe	white	4.0 ± 0.16c	3.63	4.36
	Hidaya	White	2.7 ± 0.2a	2.30	3.03
	Mwangia mayo	white	3.9 ± 0.28c	3.50	4.23
	Bajuza-Kashero	white	4.3 ± 0.04c	3.96	4.23
	Simama	Cream	3.8 ± 0.19c	3.43	4.16
	Naspot	white	3.0 ± 0.18b	2.63	3.36
	Zerida	White	4.3 ± 0.72c	3.97	4.69
	Damu ya mzee	Orange/ white	3.3 ± 0.44b	2.51	4.15
	Did Mac	white	2.0 ± 0.00a	1.29	2.70
	Karanda	white	2.5 ± 0.59a	1.49	3.50
	Kagole	White	3.1 ± 0.27b	2.67	3.49
	Njubu	White	3.7 ± 0.25c	3.36	4.09

[a]Means followed by the same letters are not statistically significant at the 0.05 level.

SPCFV was serologically detected in 25%, SPMMV, SPMSV and SPVG were rarely detected (Table 4). No sample reacted positively to antiserum specific to SP-caLV, C-6, or CMV (Table 4). In central Uganda, the whitefly-transmitted SPCSV was found in all (100%) of the samples tested followed by SPFMV (65%). The SPCaLV, SPCFV, C-6 virus, SwPLV and CMV were not found to occur in central Uganda. Mixed infections found were

Figure 4. SPVD-affected sweetpotato plants in Mwanza region (a) chlorotic blotches, mosaic and leaf mottle on cultivar SPNO at Nyakasanga, (b) A close-up of SPVD-infected plant cultivar SPNO showing mosaic, vein clearing and slight leaf distortion, (c) Severe veinal chlorosis on SPVD-affected sweetpotato cultivar Mafuta at Nyakasanga, (d) Severe mosaic, stunting growth and leaf purple on sweetpotato cultivar Jewel1 a Mwasongwe, (e) Severe upward leaf curl and mosaic symptoms on sweetpotato cultivar 1990.14.11 at Nyakasanga and (f) Extreme vein clearing and mosaic on sweetpotato cultivar Jitihada.

SPFMV and SPCSV (13 plants), SPFMV and SPMMV (3 plants), as well as SPFMV and SPVG (3 plants) (Table 5).

Whitefly and aphid abundance in sweetpotato fields

In order to obtain quantitative information on insect vectors, which transmit SPCSV and SPFMV, adult whitefly (*B. tabaci*) and aphids were counted on sweetpotato plants showing SPVD symptoms. Whiteflies were observed in all the surveyed fields in both Tanzania and Uganda. Analysis revealed no significant difference ($P>0.05$) in whitefly and aphid abundances between Tanzania and central Uganda. In Tanzania, adult whitefly number was generally low with the highest at Nyakasanga (0.91±0.25 whiteflies/plant) in the Mwanza region (Table 1). This was followed by Ihayabuyaga (0.70 ± 0.17 whiteflies per plant) and the least number was recorded at Kayenze (Table 1). Number of aphids per plant however significantly varied between locations. The highest number of aphids was recorded at Igombe followed by Kayenze with 0.33 ± 0.56 and 0.28±0.17 aphids per plant respectively. Influence of sweetpotato cultivars on insect vector abundances was not significant ($P>0.05$). Both sweetpotato cultivar “Polis-

Table 4. NCM-ELISA-based analysis results of sweetpotato field samples collected from Mwanza and Kagera regions of Tanzania.

	NCM-ELISA using antibody against									
Cultivar	**SPCSV**	**SPFMV**	**SPMMV**	**SPCFV**	**SPCaLV**	**C-6**	**SPMSV**	**SwPLV**	**SPVG**	**CMV**
Mafuta	+++	-	-	-	-	-	-	-	-	-
SPNO	-	-	++	-	-	-	-	-	-	-
Jewel1	++	-	-	-	-	-	-	-	-	-
Zapallo	-	-	-	++	-	-	-	-	-	-
Polista	+	++	-	-	-	-	-	-	-	-
Sabina	+	++	-	-	-	-	-	-	-	-
Ushashini	+	-	-	-	-	-	+	-	-	-
Jitihada	+++	++	-	++	-	-	-	-	-	-
Kalebe	-	+++	-	++	-	-	-	-	-	-
Hidaya	-	-	++	+++	-	-	-	-	-	-
Mwangia mayo	-	-	-	-	-	-	++	-	-	-
Bajuza-Kashero	-	+++	-	-	-	-	-	-	-	-
Simama	-	+	-	-	-	-	-	-	-	-
Naspot	++	+	-	-	-	-	-	-	+	-
Zerida	++	-	-	-	-	-	-	-	++	-
Damu ya mzee	+++	-	-	-	-	-	-	-	++	-
Did Mac	-	-	+	-	-	-	-	-	-	-
Karanda	-	-	-	+++	-	-	-	-	-	-
Kagole	-	+++	-	-	-	-	-	-	-	-
Njubu	+	+++	-	-	-	-	-	-	+	-
Total	10/20	9/20	3/20	5/20	0/20	0/20	2/20	0/20	4/20	0/20

Key: Visual assessment of colour intensity as - = no apparent colour change, + = weak purple colour, ++++ = very high purple colour intensity.

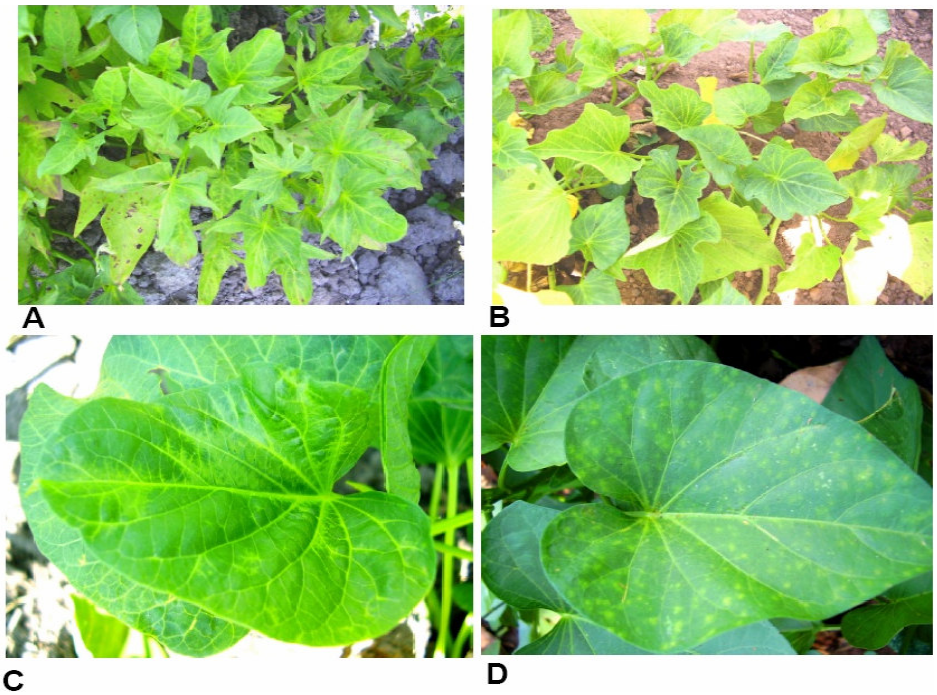

Figure 5. SPVD symptoms in farmer's fields on sweetpotato in Luwero and Wakiso districts of Central Uganda (a), leaf yellowing, narrowing and mosaic on sweetpotato cv. Chipapali, (b) leaf yellowing and mottling on sweetpotato cv Dimbuka, (c) Vein clearing and chlorotic blotches on sweetpotato leaf of cv. (d) Dimbuka and excessive chlorotic blotches and spots observed on affected sweetpotato cv. Dimbuka.

Table 5. NCM-ELISA-based analysis results of sweetpotato field samples collected from Luwero and Wakiso in central Uganda

	NCM-ELISA using antibody against									
Cultivar	**SPCSV**	**SPFMV**	**SPMMV**	**SPCFV**	**SPCaLV**	**C-6**	**SPMSV**	**SwPLV**	**SPVG**	**CMV**
Chipapali	++	-	-	-	-	-	-	-	-	-
Dimbuka	++	-	-	-	-	-	-	-	-	-
Soroti	++	-	-	-	-	-	-	-	-	-
Soroti	+	++	+	-	-	-	-	-	+	-
Soroti	++	++	-	-	-	-	-	-	-	-
Dimbuka	++	++	++	-	-	-	-	-	-	-
Dimbuka	+++	+++	-	-	-	-	-	-	++	-
Dimbuka	+	-	-	-	-	-	-	-	-	-
Dimbuka	+	+	-	-	-	-	-	-	+++	-
Dimbuka	+	++	-	-	-	-	-	-	-	-
Naspot 1	++	+	-	-	-	-	-	-	-	-
Naspot 1	++	-	-	-	-	-	-	-	-	-
Naspot 1	++	+	-	-	-	-	-	-	-	-
Dimbuka	++	+++	-	-	-	-	+++	-	-	-
Dimbuka	++	+	-	-	-	-	-	-	-	-
Dimbuka	+++	++	-	-	-	-	-	-	-	-
Soroti	+++	+	++	-	-	-	-	-	-	-
Soroti	++	++	-	-	-	-	-	-	-	-
Dimbuka	+++	-	-	-	-	-	-	-	-	-
Dimbuka	++	-	-	-	-	-	-	-	-	-
Total	20/20	13/20	3/20	0/20	0/20	0/20	1/20	0/20	3/20	**0/20**

Key: Visual assessment of colour intensity as - = no apparent colour change, + = weak purple colour, ++++ = very high purple colour intensity. The ELISA results should be processed and be presented in a simple easy to follow way. The results as they are now are raw.

ta" and "Ushashini" supported the largest number (1.46 ± 0.28) of whitefly. No whiteflies were observed on cultivar "Mafuta".

The number of aphids per plant was not significantly influenced by sweetpotato cultivars ($F_{(7,170)}$=0.911, P= 0.404).

In Kagera region adult whiteflies and aphids per plant reached the highest at Kyaka as well as number of adult aphids (Table 1) but were not observed in the other locations.

In central Uganda whitefly abundance did not significantly ($F_{(8, 50)}$ = 1.387, P = 0.225) vary between locations and only 2 fields did not record whiteflies. Of the 2 districts, whitefly number was higher in Luwero (3.2 ± 1.13 whiteflies/plant) than in Wakiso (Table 2). Aphids on sweetpotato were observed only in one field (0.2 ± 0.14 aphids per plant) (Table 2).

SPVD type of infection

In most SPVD- affected fields, virus symptoms could be observed on the lowest leaves of the affected plants suggesting sources of virus infection to be planting of infected sweetpotato vines. For example, in the Kagera region, plants with vine infection was the most commonly observed as was the case at Byeju, Byamtemba and Kyaka where over 80% of the plants with SPVD had cutting infection type.

In Uganda, in contrast SPVD was mainly of secondary infection that involved vectors. Farmers expressed knowledge of SPVD and admitted to practice rouging of infected plants whenever possible. However, in Wakiso district, plants with cutting infection were the most commonly observed and farmers showed little knowledge of SPVD.

Relationship between response variables

Results of the correlation analysis of SPVD severity to whitefly and aphid abundance showed that the number of adult whiteflies per plant did not significantly correlate with SPVD severity suggesting that high number of adult whiteflies per plant is not necessarily associated with severe symptoms on sweetpotato but rather severity is a result of host-virus interaction and possibly other factors. In Uganda however no negative correlation was observed.

DISCUSSION

Sweetpotato virus disease (SPVD) was observed in all surveyed sweetpotato fields in the north western Tanzania and central Uganda, which represents the major

sweetpotato growing areas suggesting its wide spread nature in east Africa. In this study, SPCSV was the most commonly detected virus in central Uganda and was found frequently in dual infection with SPFMV as reported earlier (Mukasa et al., 2003). Other viruses serologically detected during this study included SPMSV, SPMMV and SPVG, a previously unreported virus but molecular diagnostic methods such as the polymerase chain reaction (PCR) will be needed to confirm this. In the Lake Victoria basin of Tanzania SPCSV was the most detected virus as well as SPFMV, which occurred in dual infection. SPCFV, SPMMV and SPVG were less prevalent and their impact on SPVD pathogenicity could not be immediately established. C-6, SwPLV and CMV were not detected in samples from Tanzania. Generally SPVD incidence was low in central Uganda and high in the lake victoria basin especially in the Kagera region of Tanzania. Previous surveys of sweetpotato fields in Uganda (Mukasa et al., 2003) revealed low SPVD incidence that did not exceed 20%. In this study, incidence in central Uganda ranged from zero to 40%. Compared to Tanzania, SPVD incidence in Uganda was low as well as number of aphids and whitefly, rouging of infected plants may form an effective way of minimizing SPVD incidence and its damage to sweetpotato production. Interactions of SPCSV with other potyviruses (e.g. SPMSV, SPVG) instead of SPFMV or the presence of a third different virus (e.g. SPCFV, SPMMV) in SPVD may be producing not only SPVD-like symptoms with different severity (Untiveros, Fuentes and Salazar, 2006) but also affecting the resistance/tolerance of varieties in the lake victoria basin and may have contributed to the high incidence observed in this study. Increased SPVD may also be due to occasional use of infected planting materials from the previous crops as was observed in Tanzania partly because of lack of clean planting materials and little or lack of knowledge of SPVD. Compared to previous reports (Mukasa, 2004), SPCFV was detected in a relatively high frequency suggesting that the virus is probably acquiring new pest status, a topic to warrant further investigation.

Many of the sweetpotato landraces that predominate in farmers' fields in many parts of East Africa are susceptible to SPVD and express obvious symptoms when infected by one or more sweetpotato viruses. Symptom expression is influenced by several factors including virus species/strain (Gibson, 1994); host response (Mukasa, 2004), plant age at infection (Fargette et al., 1988), temperature (Gibson, 1994) and Sseruwagi et al., 2003). Mild and severe strains of sweetpotato viruses have been detected in plants expressing mild and severe symptoms, respectively (Mukasa et al., 2003) and the severe symptoms that were prevalent in Tanzania and Uganda were due to dual infections of SPFMV and SPCSV (Tairo et al., 2004; Mukasa et al., 2003; Ndunguru and Kapinga, 2007). In partially resistant cultivars, symptoms may be localized and, sometimes absent on the young shoots. This complicates the assessment of sweetpotato viruses as plants that have recovered are usually excluded when selecting leaf samples for virus diagnosis.

This study has also confirmed previous findings which reported low number of aphid counts on sweetpotato (Mukasa, 2004; Ndunguru and Kapinga, 2007) suggesting that aphid transmission of sweetpotato viruses occurs when they briefly feed on sweetpotato plants as they search for overwintering hosts. High SPVD incidence also correlated with high population of whitefly in the lake victoria basin. In southern Tanzania low whitefly and aphid population also correlated with low SPVD incidence (Ndunguru and Kapinga, 2007).

SPVD symptoms varied between cultivars but generally comprised of either severe leaf purpling, narrowing, plant stunts and vein clearing. These symptoms have been reported previously by Gibson et al. (1998) in Uganda and recently in southern Tanzania by Ndunguru and Kapinga (2007).

Leaf purpling symptoms were very rare in the surveyed fields in the 2 districts of central Uganda and typical leaf narrowing (strap-like) commonly occurring in sweetpotato with divided leaves. Elsewhere purpling symptoms have been associated with the presence of SPCSV (Gibson et al., 1998). Since sweetpotato is a daily household food for rural and urban populations in Uganda and Tanzania (Bashaasha et al., 1995; Ishika, 2005), the findings of this paper has shown sweetpotato viruses previously known to occur in less frequency in Uganda and Tanzania have gained high incidence. This observation together with prevalence of SPVD in the farmer's fields presents the most formidable threat to sweetpotato production and action must be taken to cab the disease.

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