

Prevalence of Sweetpotato Virus Vectors in Lake Victoria Basin of Tanzania: A Challenge to Disease Management Techniques

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Abstract: A series of experiments were conducted from 2003 to 2005 to determine the major mechanism through which sweet potato virus disease (SPVD) is spread in farmers' fields in the Lake Victoria basin of Tanzania. Farmers' ability to select SPVD-free vines for planting was tested followed by phytosanitary (selection and rouging infected plants) experiments conducted at six different sites in farmer fields in Bukoba and Muleba districts during short rain and long rain seasons in 2003 and 2004. In addition, the effectiveness of using SPVD-free (tissue culture developed and virus-indexed) was tested for three seasons from 2004 to 2005. It was established that farmers have skills to effectively select against SPVD-infected planting vines particularly those with apparent SPVD symptoms. SPFMV and SPCSV vectors largely contributed to new incidences of SPVD compared to the vines-based infections. SPFMV and SPCSV co-existed. The use of virus-free vines in such vector-prevalent environment was found to be fruitless efforts. It was concluded that, the use of cultivars with multiple resistance to sweet potato viruses could be the only feasible management strategies for SPVD in the Lake Victoria Basin.

Key words: Disease management, sweet potato, sweet potato viruses, Tanzania, vectors.

1. Introduction

Sweet potato, *Ipomea batatas* (L.) Lam. is the third most important root crop after potato (*Solanum tuberosum* L.) and cassava (*Manihot esculenta* Crantz) [1]. It is widely grown in Africa for family food and income generation [2, 3]. In Tanzania, the crop is particularly grown by women around the homestead [4, 5]. It is increasingly an income earning crop for farmers close to urban centres [6] and the main food crop for many households in Lake Victoria basin [5, 7]. The Lake Victoria basin is located in the North-western part of Tanzania, a high rainfall area around Lake Victoria bordering Burundi, Rwanda and Uganda. In Bukoba and Muleba districts in the region where rainfall occurs during major part of the year, the

crop is grown throughout the year. The importance of sweet potato as a food security crop to many homesteads is attributed to low input requirements of the crop, short time to maturity and the ability of the crop to grow well in marginal lands [8].

Despite the importance of sweet potato and its suitability to most areas, weevils and sweet potato virus disease (SPVD) constrains its productivity [7, 9]. While weevil may accounts for about 56% of the yield loss per plant of an affected [10], SPVD claims up to 56%-98% of the yield loss per plant [11, 12]. SPVD is caused by dual infection with the whitefly-borne *Sweet potato Chlorotic stunt virus* (SPCSV, Genus *Crinivirus*, family *Closteroviridae*) and the aphid-borne *Sweet potato feathery mottle virus* (SPFMV, genus *Ipomovirus*, family *Potyviridae*) [13]. It occurs by either planting vine from diseased plants (primary infection) or through vectors (secondary

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infection) such as *Bemisia tabaci* Gennadius and *Myzus persicae* Sulz. The characteristic symptoms of SPVD are leaf chlorosis, vein clearing, stunted growth which leads to reduced tuber yield [12]. In susceptible cultivars, the symptoms are usually vivid and easy to diagnose by visual assessment [14]. However, at some instances, SPVD diagnostics might be complicated prompting needs for additional detection techniques. Thus, serology is preferred because it is relatively cheaper, robust and quick.

In Tanzania the disease is serious in some parts of Bukoba and Muleba districts. Most of high yielding local cultivars that are preferred by farmers are susceptible to the disease. A series of surveys conducted in 2003 and 2004 in these two districts indicated more than 40% SPVD incidences (G. Rwegasira, unpublished data). It was not known whether such levels of incidences are caused by the cutting-based infection or the vectors. This had led to difficulties in designing effective management strategies. Objectives of the current study were: (1) to assess farmers' knowledge on SPVD and their ability to select disease free planting materials, (2) to determine which of the two infection mechanisms (infected cuttings and vectors) plays a major role in new incidence of SPVD, and (3) to examine the effectiveness of using SPVD-free planting material as SPVD management strategy.

2. Materials and Methods

2.1 Assessment of Farmers' Knowledge on SPVD

A study to test farmers' knowledge of SPVD was carried out in farmers' fields in May 2003, at six sites namely Bugabo, Kanyigo, Kanazi, Kyema, Kyaka and Ngenge in Bukoba and Muleba districts. One variety, "Kigambire'nyoko" that existed in all study sites was chosen to maintain uniformity. It is a local variety, high yielding but susceptible to SPVD, usually showing clear symptoms of the disease when infected. At each site, a sweet potato crop aged 3-4 months was sampled at random. The researchers surveyed each

plot and assessed SPVD incidence and severity score. Thereafter, farmers were asked each to collect 30 vines that they would consider fit for establishing a good crop from the previously assessed plot. The collection was done at each site to assess farmers' awareness of SPVD and their ability to select healthy planting materials. The collected vines were later counter-checked for SPVD symptoms by the researcher, grouped as to whether were SPVD-free or diseased and recounted. The number of SPVD-symptomatic vines in farmers' collection was compared with the overall mean for the plots at each site.

2.2 Determination of the Sources for New SPVD Infection

2.2.1 Experimental Sites

Six experimental sites were selected on-farm from Bukoba and Muleba districts, in which SPVD prevalence were found to be relatively high during surveys. Readiness of farmers to be involved in the study and provide a working land for experiments was also prioritized. Out of six, the four sites (Bugabo, Kanyigo, Kanazi, Kyema) were located within 2-5 km off-shore of Lake Victoria. These sites are dominated by sandy and alluvial sandy soils with pronounced topography on high ridges and plateaus. Annual rainfall averages around 2,000 mm coupled with high relative humidity ($\geq 80\%$) and average maximum temperatures of about 27 °C. Rainfall is well distributed throughout the year with bimodal peak from September to December and February to May. The other two sites (Kyaka and Ngenge) are dominated by heavy clay to loamy-clay soils, mean annual rainfall of 750 mm, relative humidity of $\leq 70\%$ and mean annual maximum temperature of 28 °C. These sites are dry for the most part of the year and are at least 50 km from the lakeshore.

2.2.2 Experimental Design

A randomized complete block design was used to test the phytosanitary-based SPVD management

techniques. Selection of healthy vines and roguing & non-roguing of diseased plants were tested. In a rouging experiment, SPVD-symptomless vines var. Kigambire'nyoko chosen by farmers were planted in a 5, 6 m long ridges plots (approx. 5 m × 6 m) at 0.3 m × 0.45 m spacing, replicated three times. One month after planting, all the vines that sprouted with SPVD symptoms were rogued and destroyed to retain the SPVD-free crop. In a non-roguing experiment similar sized plots were established but no rouging of SPVD-symptomatic vines was done after sprouting. SPVD incidences and severity were recorded at one month interval starting the second month until harvesting at 5 months after planting. Scouting for vectors, whitefly and aphids was done at a two-week interval from planting to harvesting time on 5-terminal leaves of each five randomly selected plants in each ridge at morning hours from 07:00 to 09:00 hour. Due to lack of advanced sampling facilities, the visual counting (scouting) was used by carefully turning over the leaves and counting insects on the abaxial surfaces. The experiments were conducted for two consecutive seasons, from March to August 2003 and repeated from January to May 2004.

2.3 SPVD Incidences and Virus Detection in Virus-Indexed Sweet Potato

A pending experiment was conducted on-station at Maruku Research Institute (31°46' E, 1°45' S and 1,209 m.a.s.l.) using tissue cultured, virus-free but SPVD-susceptible sweet potato cultivars. These were mostly orange-fleshed cultivars imported from Lima under CIP's VITAA project and had been virus indexed at Kenya Plant Health Inspectorate Services (KEPHIS). The vines were initially planted for monitoring and multiplication at Maruku open quarantine facility in January 2004. After one season, the multiplied planting materials were planted each in four ridges with 1 m × 5 m size at 0.3 m × 0.45 m spacing in an evaluation trial. One local SPVD-free but susceptible var. Kigambire'nyoko was included as

a control. SPVD incidence data and other agronomic parameters were recorded monthly for two consecutive seasons from September to December 2004 (season 1) and January to May 2005 (season 2). Finally serological tests were done on all the cultivars using monoclonal antibodies to SPFMV and SPCSV. An approximately 10 mm leaf portions were samples from the middle and lower parts of the leaf and used for serological testing of the viruses by the nitro-cellulose membrane enzyme-linked immunosorbent assay (NCM-ELISA) technique as described by Gibb and Padovan [15]. Dr. R. Kapinga of the International Potato Center (CIP), regional office in Kampala, Uganda kindly provided the ELISA testing kit. Samples developing purple colour were scored positive.

3. Results and Discussion

3.1 Farmers Knowledge, SPVD Incidences in Farmers' Fields and Experimental Plots

As shown in Fig. 1, the mean SPVD incidences in farmers' fields varied, ranging from 7% at Bugabo to 60% at Kyaka with average severity score of 3.2 (data not shown). Although Bugabo, Kanazi and Kanyigo are all near to Lake Victoria, SPVD incidences varied greatly. The disease was particularly rampant in farmers' fields at Kyaka which is more than 50 km away from the Lake Victoria shore but closer to Uganda-Tanzania border area of Mutukula. The number of SPVD-affected vines in farmers' collections was relatively low (3%-10%) compared to the actual field incidence previously established by the researcher. These data suggest that most farmers do not collect planting vines from plants with obvious SPVD symptoms. The suspicion is based on the fact that even the few SPVD-affected vines that were picked from their collections as planting materials were at initial stages on symptoms development which requires an expert eye to delineate them.

Data from the rogued experimental plots (Table 1) indicated that Bugabo had the lowest SPVD mean

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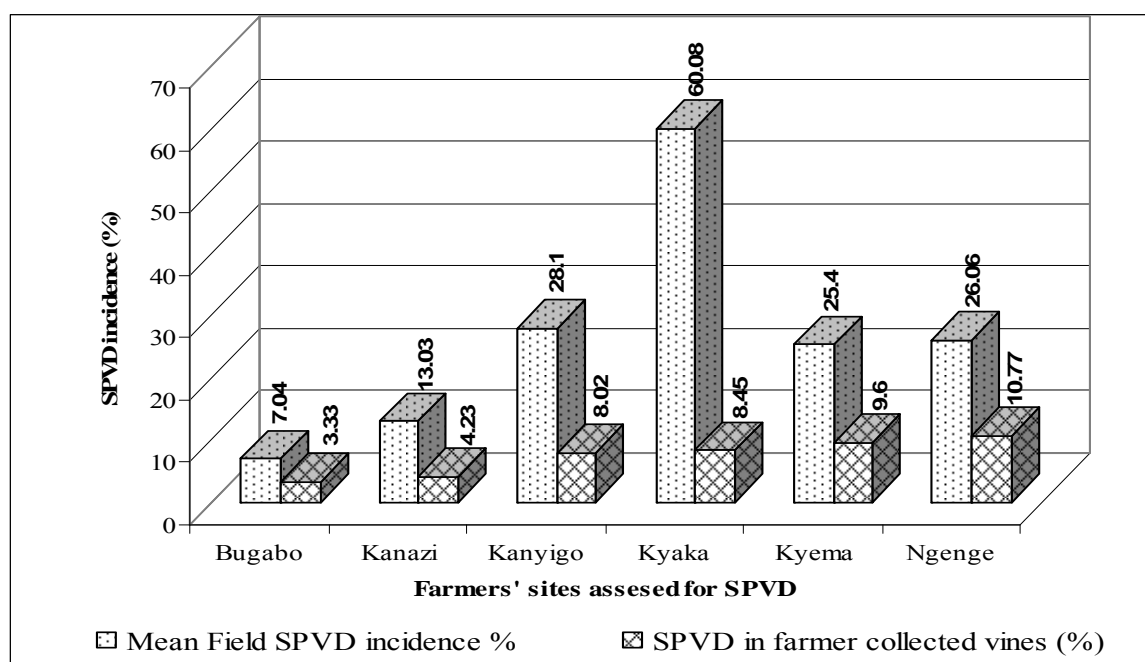


Fig. 1 Relationship between SPVD incidences in vines collected by farmers and the actual field incidence.

Table 1 Incidence of SPVD and mean whitefly and aphid counts in experimental plots.

Site	Plant/plot	SPVD infected	SPVD incidence (%)	W/fly	Aphids
Bugabo	102.8 ± 8.03	5.6 ± 1.91	5.4 ± 1.97 ^a	2.6 ± 0.92 ^a	0.4 ± 0.4 ^a
Kanazi	87.8 ± 7.75	7.2 ± 1.32	8.2 ± 1.3 ^a	1.0 ± 0.54 ^a	2.0 ± 0.84 ^c
Kanyigo	88 ± 5.36	21 ± 1.89	23.8 ± 1.5 ^b	4.0 ± 1.09 ^b	0.8 ± 0.58 ^b
Kyaka	70 ± 3.65	38.6 ± 4.43	55.0 ± 4.86 ^c	8.0 ± 1.70 ^c	3.2 ± 0.86 ^c
Kyema	74.4 ± 4.32	14.2 ± 3.35	19.69 ± 4.78 ^b	1.2 ± 0.73 ^a	1.2 ± 0.58 ^b
Ngenge	62.6 ± 4.13	11.2 ± 1.28	18.2 ± 2.35 ^b	1.6 ± 0.67 ^a	0.2 ± 0.2 ^a

Values followed by same letter within a column are not statistically significant ($P < 0.05$).

Mean value ± standard error.

incidence (5.4%) and the highest record was at Kyaka (55%). Sites with high SPVD incidences (Kyaka, Kanyigo and Kyema) had similarly high vector (whitefly and aphids) population. The general trend suggests that SPVD incidences were proportion to the number of vectors scouted from each site. Therefore, virus vectors could be the major contributors to new incidences of SPVD in the study area.

The survey results suggested that SPVD occurred throughout the areas studied. All locations had low SPVD incidences (< 25%) except at Kyaka, which had relatively high incidences of the disease (60%). Since Kyaka area is near to the border between Tanzania and Uganda and SPVD has been rampantly reported in South-western Uganda [13]. The sources of infection could be originating from the neighboring

Uganda areas. Although none of farmers had been trained about the disease, many of them would avoid cutting vines from a plant showing SPVD symptoms. Careful farmers tended to avoid vines showing strange symptoms although they could not tell the causes for such symptoms. Despite the fact that farmers' ability to effectively choose healthy vines depended on how explicit the SPVD symptoms were on the respective cultivar, the contribution of cuttings to new infection was low based on incidence recorded in the fields soon after sprouting. Similar trend was observed in the rogued and non-rogued plots where by no difference was observed between the number of newly infected plants. Thus the contribution of infected vines to new incidences of SPVD was negligible suggesting the presence of an alternative source of infection which

was more effective.

3.2 Number of Vectors Recorded in Relation to Roguing Practice

New SPVD incidence in plots where roguing was not done, one month after planting to get rid of vine-based infection did not differ from where roguing was done (Fig. 2). The parameter shows that whether or not roguing is done, there is no certainty of avoiding new infection. The number of vectors (whiteflies and aphids) found on sweet potato leaves varied among the locations. The distribution was random and did not follow any specific trend. However, more whiteflies were recorded during the rainy season in January 2004 than the rest of the months whereas more aphids were recorder during a low rainfall season of June to August 2003. Despite the variation, vectors were generally present in low numbers at all sites.

The number of vectors (whitefly and aphids) recorded, implicated them as a possible causes of new SPVD incidences. Although relatively low in numbers, the fact that vector counts were not done on daily basis reduced the probabilities that optimum counts were made. Also the fact that SPCSV and SPFMV are transmitted in semi-persistent manner [16] do not obligate continuous presence of the vectors on plants to get the virus transmitted. Therefore whiteflies and aphids could be mainly responsible for the new incidences and subsequent spread of SPVD in the Lake Victoria Basin.

3.3 SPVD Symptoms and Serological Testing for SPFMV and SPCSV Incidences in Virus Indexed Materials¹

There was no SPVD recorded during the first season (Table 2). The complete absence of the disease

was similarly noted at all the initial stages at the open quarantine and multiplication plots. High incidence of SPVD was recorded in the second season starting January to May, 2005. The serological test showed that both virus SPFMV and SPCSV were present in the samples with the former being more prevalent than the later. Strong expression of SPVD symptoms was noted in instances where the two viruses co-existed. Where SPFMV existed alone, no apparent symptoms were recorded in most cases. The virus detection in the samples was further complemented by observable symptoms on the sampled leaves.

All the virus-indexed materials were free from SPVD at the observation and multiplication stage in the open quarantine. However, a few plants became infected during the first season of experimentation although at a low incidence level (5%) in var. Zapallo. During the second season, most of the plants were affected by SPVD. Sixteen out of twenty test cultivars manifested apparent SPVD foliar symptoms (Fig. 3). The disease incidences rose to 100% in a few very susceptible cultivars such as Kandee and Beanregard at the end of the second season.

The virus-indexed sweet potato vines remained disease free for almost one year at the open quarantine and multiplication plots that were set in isolation from the rest of sweet potato fields. This confirmed the usefulness of tissue culture technology in eliminating viruses from infected tissue [17]. The fact that SPVD was first recorded at the trial site located near other sweet potato fields and incidences were higher over the second season is an indication that vectors were responsible for the new SPVD incidences. Further justification was from random sampling occasionally done which recorded both aphids and whiteflies in the experimental plots (Data not shown). The serological test indicated co-existence of SPFMV and SPCSV confirmed the synergistic phenomenon reported by Gibson et al. [18]. Lack of symptoms expression in samples where SPFMV was recorded alone concurs with findings by Aritua et al. [19] that in East Africa,

¹ * incidence obtained based on visual assessment of SPVD symptoms on the affected plants

The score for NCM-ELISA test was based on the development of purple colour on test paper upon application of the leaf sap; + stands for virus-infected sample and – stands for virus-free sample.

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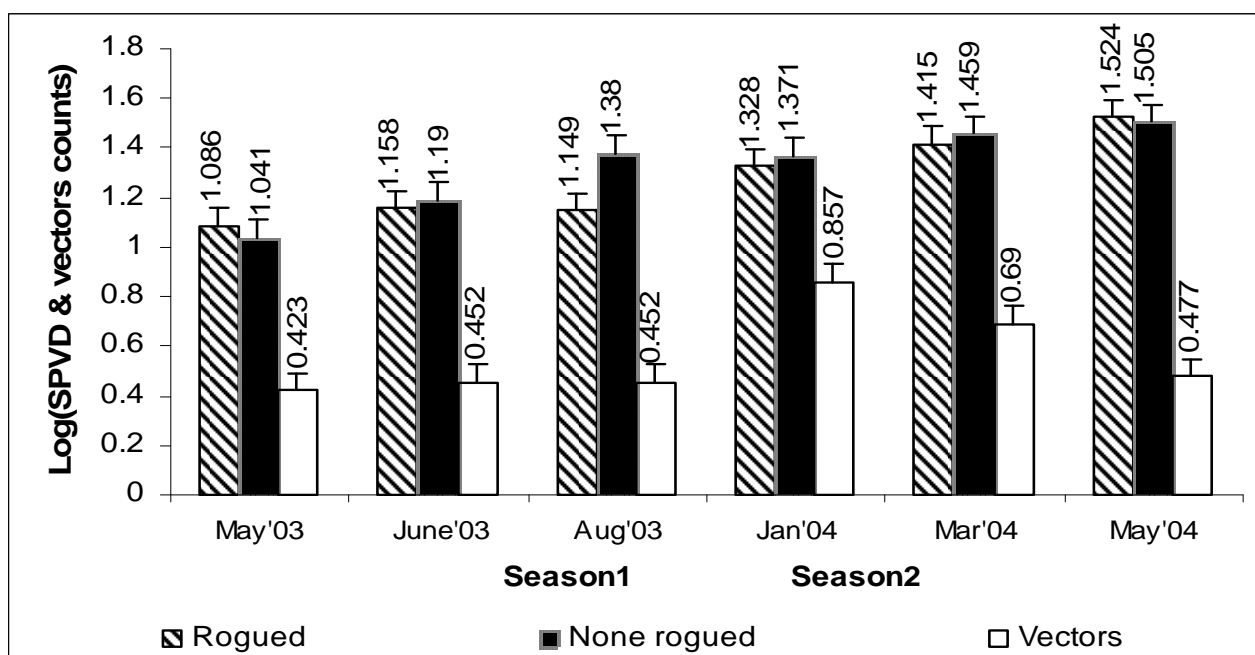


Fig. 2 Comparison of the number of newly SPVD-affected plants and scouted vectors.²

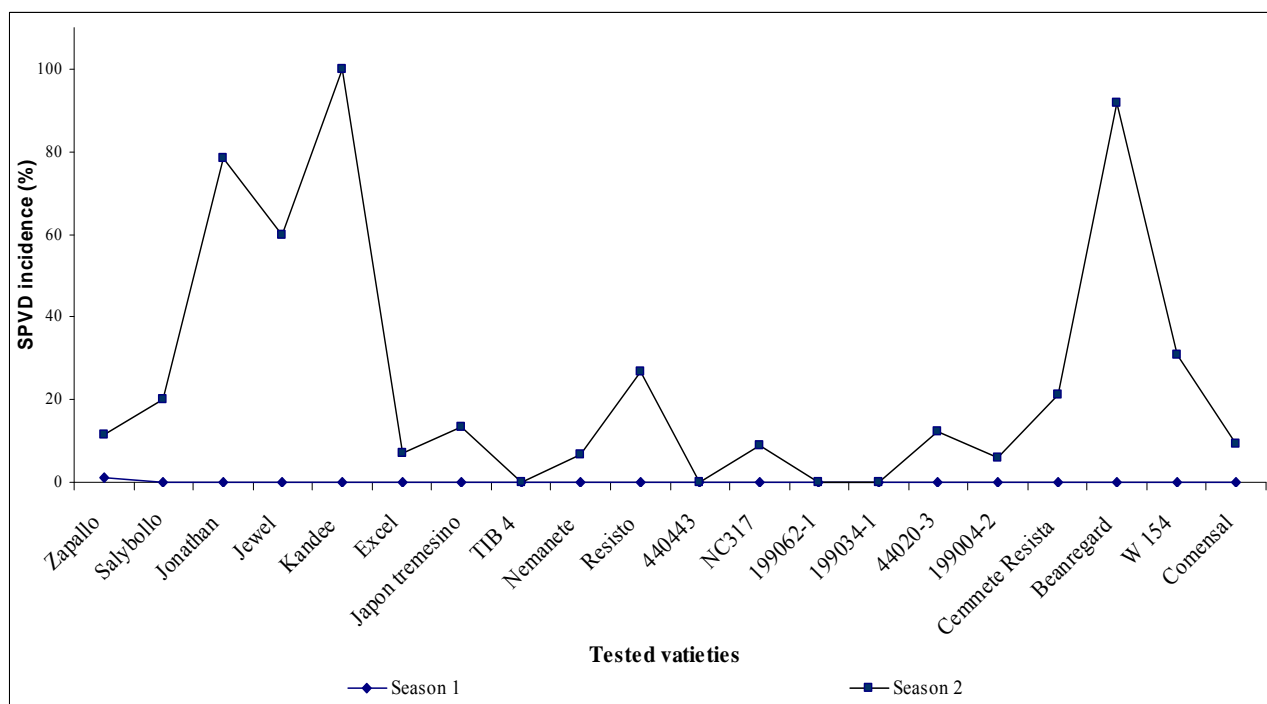


Fig. 3 New mean incidences of SPVD in tissue culture (virus indexed) cuttings.³

² The mean counts were log-transformed because of their irregularities. The mean count for SPVD-affected plants in each plot was only based on observable symptoms. Thus the count is only indicative of SPVD incidence since did not take into consideration those plants that were at latent stage of infection. The number of vectors was also indicative because it was based on observable adult insects (whitefly and aphids) and the counting was done at two weeks interval. Only the vectors counts for the respective months have been shown in Fig. 2.

³ SPVD incidences were assessed based on symptoms expression on the foliar part of the crop. Plants were assessed individually in each plot and thereafter the plot average computed against the total plant population to obtain the overall incidence for each variety.

Table 2 SPVD incidences as NCM-ELISA test and the symptoms manifested on foliar parts of the plant.

Variety/cultivar	Year 1		Year 2		#NCM-ELISA		Collected sample
	Number of plants assessed	*SPVD Incidence (%)	Number of plants assessed	*SPVD incidence (%)	SPFMV	SPCSV	
Zapallo	10	1.0	44	11.36	+	+	Leaf chlorosis, vein clearing, stunting
Salybollo	12	0	40	20.0	+	+	Leaf chlorosis, purple-edge spot in lamina
Jonathan	15	0	28	78.6	+	+	Vein clearing, severe stunting
Jewel	10	0	30	60.0	+	+	Purpling
Kandee	11	0	30	100	+	+	Chlorosis, vein clearing, severe stunting
Excel	10	0	28	7.14	+	-	Reduced leaf size
Japon tremesino	10	0	30	13.3	+	+	Retarded growth, purple-edge spot
TIB 4	12	0	28	0.0	+	-	No apparent symptoms
Nemanete	10	0	30	6.67	+	-	Mild chlorosis
Resisto	10	0	26	27.0	+	-	No apparent symptoms
440443	8	0	30	0.0	-	-	No apparent symptoms
NC317	10	0	33	9.0	+	+	Leaf chlorosis, vein clearing
199062-1	9	0	36	0.0	-	-	No apparent symptoms
199034-1	8	0	34	0.0	-	+	Stunting
44020-3	12	0	33	12.12	+	+	Reduced leaf size, purple-edge spots in lamina
199004-2	10	0	34	6.0	+	+	Leaf chlorosis, vein clearing
Cemmete Resista	7	0	38	21.05	+	+	Yellowing, reduced leaf size
Beauregard	13	0	36	91.67	+	+	Chlorosis, vein clearing, severe stunting
W 154	11	0	26	30.77	+	+	Leaf chlorosis, vein clearing
Comensal	10	0	32	9.38	+	+	purple-edge spot
Kigambire'nyoko	12	0	35	8.20	+	+	Chlorosis, vein clearing

SPFMV-infected plants may exhibit neither root nor foliage symptoms.

4. Conclusion

SPVD is prevalent in most farmers' fields in the Lake Victoria region particularly in Kyaka area. Farmers carefully select healthy plating materials despite the limited knowledge about SPVD. SPVD infected vines have limited contribution to the new incidences. The strong symptoms of the disease exhibited by infected plants are caused by a synergistic effect of SPFMV and SPCSV. Vectors play a major role on the new incidences of SPVD in the study area. Therefore the management strategies for the disease should emphasize on measures to avoid or manage the vectors alongside the use of varieties with multiple resistance to viruses.

References

- [1] FAOSTAT, 2008, available online at: <http://faostat.fao.org/faostat/servlet/xteservlet3>.
- [2] E.E. Carey, R.O. Mwanga, S. Fuentes, et al., Sweet potato viruses in Uganda and Kenya: results of a survey, in: Proce. Sixth Trien. Symp. of the Intern. Soc. of Trop. Root Crops-Africa Branch (ISTRC-AB), Oct. 22-28, 1995, Lilongwe, Malawi, 1998, pp. 457-461.
- [3] T. Stather, Technical Manual for Sweet Potato Integrated Pest and Production Management Farmer Field Schools in East Africa, 2003, p. 88.
- [4] R.E. Kapinga, P.T. Ewell, S.C. Jeremiah, et al., Sweet potato in Tanzanian farming and food systems: implications for research, CIP, Sub-Saharan Africa Region, Nairobi, Kenya, Ministry of Agriculture, Dar-Es-Salaam, Tanzania, 1995, p. 47.
- [5] F. Tairo, A. Kullaya, J.P.T. Valkonen, Incidence of viruses infecting sweetpotato in Tanzania, Plant Dis. 88 (2004) 916-920.
- [6] G.M. Rwegasira, E.F. Marandu, R.W. Gibson, et al., Control of sweetpotato virus disease through farmer field school approach in Kagera region, Tanzania, in: R. Kapinga, R. Kingamkono, M. Msabaha, J. Ndunguru, B. Lemaga, G. Tusiime (Eds.), Proceedings of the 13th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC), November 10th-14th, 2003, AICC, Arusha, Tanzania, 2007, pp. 292-297.
- [7] G.M. Rwegasira, E.F. Marandu, Working with farmers to control sweet potato virus disease in the Lake Zone of Tanzania. Annual Report for the Second Phase of the Project in the Lake Zone of Tanzania, An output of CPP funded project number R8243 through NRI/IITA-LZARDI, 2004, p. 22.
- [8] J. Ndunguru, C.A. Rajabu, Incidence of sweetpotato virus disease under different sweet potato cropping systems in

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- the Lake Zone of Tanzania, African Potato Association (APS) Conference Proc., Vol. 5, 2000, pp. 405-408.
- [9] A.M. Geddes, The relative importance of crop pests in sub-Saharan Africa, Bulletin No. 36, Natural Resources Institute (NRI), Chatham, GB, 1990.
- [10] CIP (International Potato Center) Annual Report, Science for People and the Planet, Apartado 1558, Lima 12, Peru, 2003, p. 103, available online at: www.cipotato.org.
- [11] R.W. Gibson, I. Mpembe, T. Alicai, et al., Symptoms, aetiology and serological analysis of sweet potato virus disease in Uganda, *Plant Pathol.* 47 (1998) 95-102.
- [12] R.F. Karyeija, R.W. Gibson, J.P.T. Valkonen, The significance of sweet potato feathery mottle virus in subsistence sweet potato production in Africa, *Plant Dis.* 82 (1998) 4-15.
- [13] S.B. Mukasa, P.R. Rubaihayo, J.P.T. Valkonen, Incidence of viruses and viruslike diseases of sweet potato in Uganda, *Plant Dis.* 87 (2003) 329-335.
- [14] G.M. Rwegasira, E.F. Marandu, Working with farmers to control sweet potato virus disease in the Lake Zone of Tanzania, Annual Report for the Second Phase of the Project in the Lake Zone of Tanzania, An output of CPP funded project number R8243 through NRI/IITA-LZARDI, 2004, p. 22.
- [15] K.S. Gibb, A.C. Padovan, Detection of sweet-potato feathery mottle potyvirus in sweet-potato grown in northern Australia using an efficient and simple assay, *International J. Pest Manage.* 39 (1993) 223-228.
- [16] R.C. Larsen, M. Laakso, J.W. Moyer, Isolation and vector relationships of a whitefly-transmitted component of the sweet potato virus disease (SPVD) complex from Nigeria, *Phytopath.* 81 (1991) 1157.
- [17] E.F. George, *Plant Propagation by Tissue Culture, Part 1. The Technology*, 2nd ed., Exogenetics Ltd, 1993, p. 574.
- [18] R.W. Gibson, S.C. Jeremiah, V. Aritua, et al., Sweet potato virus disease in sub-Saharan Africa: evidence that neglect of seedlings in the traditional farming system hinders the development of superior resistant landraces, *Phytopath.* 148 (2000) 441-447.
- [19] V. Aritua, E. Adipala, E.E. Carey, et al., The incidence of sweet potato virus disease and virus resistance of sweet potato grown in Uganda, *Ann. Appl. Biol.* 132 (1998) 399-411.