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Full Length Research Paper

Viruses and virus- like diseases affecting sweet potato subsistence farming in southern Tanzania

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A survey for sweet potato viruses was conducted in 32 farmer's fields in Mbinga (20 fields) and Songea (12 fields) districts of the Ruvuma region in Southern Tanzania. Plants showing virus- like symptoms were observed in 25 (78%) out of 32 fields examined. Sweet potato virus disease (SPVD) incidence was low in Mbinga district (16.7%) on average and ranged from 3 to 50% while in Songea district incidence averaged 33% and ranged from 3 to 100%. SPVD incidence difference between the two districts was not statistically significant (P > 0.05) except among sweet potato cultivars (P< 0.05). Sweet potato virus disease severity significantly (P < 0.001) varied between the district with Mbinga having the lowest (2.38 ± 0.2) and Songea the highest (3.26 ± 0.12) mean severity score. SPVD severity score also significantly varied among sweet potato cultivars (P < 0.001) with cultivar ''Jeshi'' displaying the most severe symptoms (4.2 ± 0.37 severity score) and 'Wino' and 'Madaresalama expressing the mildest symptoms (2.0 ± 0.00). Twenty foliar samples from infected plants were tested serologically for *Sweet potato chlorotic stunt virus* (SPCSV), *Sweetpotato feathery mottle virus* (SPFMV), *Sweet potato mild mottle virus* (SPMMV), *Sweet potato chlorotic fleck virus* (SPCFV), *Sweet potato calico-like virus* (SPCaLV), *Sweet potato mild speckling virus* (SPMSV), *C-6* (a new flexious rod virus), *Sweet potato latent virus* (SwPLV), *Sweet potato virus* G (SPVG) and *Cucumber mosaic virus* (CMV) using Nitrocelullose Membrane ELISA (NCM-ELISA). SPCFV was the most common virus detected followed by SPCSV. SPVG was detected in seven samples representing the first report of its occurrence in Tanzania. SwPLV, C-6, CMV and SPCaLV were not detected. Whitefly population was low and aphids were rarely found in most of the fields. Orange-fleshed sweet potato cultivars grown in the surveyed areas also displayed SPVD symptoms with high incidence and severity. These results indicate that SPVD situation in Tanzania is not uniform in the major sweet potato growing areas and the significance of this virus diversity needs to be investigated.

Key words: Sweet potato, sweet potato virus disease, NCM-ELISA, incidence, Tanzania

INTRODUCTION

Sweetpotato (*Ipomoea batata* L.) is a major starch staple in Africa with production estimated at 7.5 metric tons, about 6% of the world production (FAO, 1998). In Tanzania it is mainly grown in the Lake Victoria Zone, Southern and Eastern coastal regions (Kapinga et al., 1995). It ranks fourth in food production after maize, cassava, and bean. Sweeet potato is considered by many farmers in Tanzania as a household food security crop that prevents food shortage before the next harvest of maize or other staple food crops (Kapinga et al., 1995). Sweet potato is mainly grown by rural women near their homes to feed their families and its sale can provide women an entry to cash economy (Kapinga et al., 1995). According to Woolfe (1992), sweet potato has one of the highest rates of production per unit area per unit time, making it attractive to farmers with little land. In the Ruvuma region of Tanzania, sweet potato farmers are mainly women and grow sweet potato as mixed cropping with bean, cassava, maize or coffee especially in Mbinga district. Often farmers grow several sweet potato cultivars in a field plot.

Sweet potato production in Tanzania is limited by biotic

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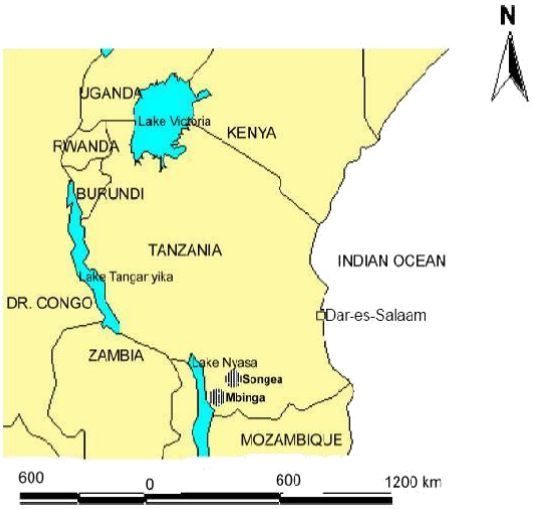

Figure. 1 A sketch map of Tanzania showing surveyed districts (Mbinga and Songea) in Ruvuma region in southern Tanzania

factors of which weevils and viruses are very important (Msabaha, 1977). Viruses alone can cause yield loss of between 56 - 98% (Mukasa et al., 2003). SPVD is the most destructive disease of sweet potato throughout Africa (Geddes, 1990) and the yield losses reported might be underestimated because symptom less plants may not necessarily be virus-free and these latent infections may have a yield decreasing effect. A few viruses have been identified in the Lake Victoria Zone and in the eastern coastal regions (Tairo et al., 2004) during which the aphid-transmitted *Sweet potato feathery mottle virus* (SPFMV) was the most prevalent. Other viruses identified in Tanzania include *Sweet potato mild mottle virus* (SPMMV), *Sweet potato chlorotic stunt virus* (SPCSV) and *Sweet potato chlorotic fleck virus* (SPCFV).The application of serological methods with currently available antisera for several sweet potato viruses offers reliable diagnosis. Little is known on the occurrence of sweet potato viruses in the Ruvuma region in the southern part of Tanzania and the sweet potato cultivars commonly grown by farmers have not been formally documented. The aim of this study was to provide an understanding of occurrence of sweet potato viruses in the Ruvuma region and their possible association with aphid and whitefly, *Bemisia tabaci* population

MATERIALS AND METHODS

Survey and sweet potato sampling

A total of 32 sweet potato farmers fields were examined for sweet potato virus-like disease symptoms in two districts of the Ruvuma region (Figure 1), Mbinga (20 fields) and Songea (12 fields). Also to assess aphid and whitefly population associated with sweet potato virus disease (SPVD). The two districts represent two different agro-ecological zones with Mbinga districts located on the high altitude areas characterised by highland areas commonly referred to as Matengo hills. Songea district lies on lowland area characterised by warm climate and the two districts are at least 160 km apart. These areas were selected based on their importance in sweet potato production. Most of the sweet potato farmers in the surveyed areas were women and they grew sweet potato as mixed cropping subsistence crop with cassava, maize, bean and coffee as was in Mbinga district. Monoculture of sweet potato was also common in some areas and included growing of several cultivars in the same field plot. Cultivar names were identified by the name given to them by the farmers. A total of 15 sweet potato cultivar names were recorded from the surveyed areas and most of them were widely grown in the two districts. Cultivars Jeshi was the most common grown in the two districts. Farmers also were asked to identify (OFSP) cultivars grown by them and a total of eight cultivars were identified.

SPVD incidence, severity and estimation of the number of whitefly and aphids

Sweetpotato fields (2 - 4 moths old) were selected at regular intervals (between 2 - 5 km) along motarable roads traversing each district depending on the availability of suitable sweet potato fields. During sampling, plants were selected along representative diagonal transect line. To assess and estimate SPVD incidence, a number of visibly diseased plants was counted along two diagonals across each field and expressed as the percentage of the total (30 plants) assessed along the lines. Disease severity (usually refers to the degree of expression of symptoms) on individual SPVD-affected plants was assessed visually using arbitrary scale (0-5) where 0 represents no disease symptoms and 5 the most severe symptoms, including leaf distortion, stunting of plants. Assessment of adult whitefly (*Bemisia tabaci*) involved direct counting of adults on ventral side of five youngest apical leaves of the shoots for 1 min because the adults feed preferentially on the youngest immature leaves. This involved disturbing the crop and counting all the adult whiteflies seen, either on the crop or in flight. Due to differences in branching habits of different cultivars the longest three shoots per plant were chosen and the total number of adult whitefly was taken to represent the estimate of the number of adult whitefly per plant. Similarly, shoots were examined for the presence of aphids and if found were counted and the numbers recorded.

Sweet potato sampling

In each field, plants showing virus -like symptoms were picked randomly along the diagonal transect line over the field. Plants expressing distinct symptoms and or very mild or severe symptoms were preferentially sampled. Leaves from plants that showed symptoms that had been sampled earlier in other fields were not collected. In total 20 samples were collected from infected plants and four samples were collected from symptom less plants to serve as negative controls. Leaf samples were transported to Mikocheni Agricultural Research Institute (MARI), Dares-Salaam for virus detection and identification.

Virus detection

Leaf portions (1 cm) was taken from upper, middle and lower leaf parts and used for serological testing of sweet potato viruses with nitrocellulose membranes enzyme-linked immunosorbent assays (NCM-ELISA) as described by Gibb and Padovan (1993). Virus specific polyclonal antibodies to *Sweet potato chlorotic stunt virus* (SPCSV), *Sweetpotato feathery mottle virus* (SPFMV), *Sweet pota-*

Figure 2. Virus-like symptoms on sweetpotato in farmers' fields in Mbinga and Songea districts of the Ruvuma region, Tanzania. (a) Chlorotic flecks, mosaic, leaf yellowing and chlorotic blotches on cv. Wino, (b) vein chlorosis, vein clearing, mottling and branching streaks and leaf distortion on cv. Mazeze, (c) mottling and chlorotic blotches on cv. Jeshi, (d) mottling, leaf yellowing and slight leaf deformation on cv. Jeshi, (e) purple rings and feathering on cv Jeshi nyekundu and (f) severe purpling and stunting on cv. Jeshi

to mild mottle virus (SPMMV), *Sweet potato chlorotic fleck virus* (SPCFV), *Sweet potato calico-like virus* (SPCaLV), *Sweet potato mild speckling virus* (SPMSV), C-6, *Sweet potato latent virus* (Sw-PLV), *Sweet potato 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 provided by the International Potato Center (CIP, Lima, Peru). Visual assessment of the development of a purple colour the samples spots off the nitrocellulose membrane was used to identify virus positive samples (Guitierrez et al., 2003).

Statistical analysis

Means of adult whitefly counts, SPVD severity and incidence between the two districts were compared in analysis of variance (ANOVA) using a computer program (SPSS 9.0; SPSS Inc., Chicago). The program was also used to make a descriptive analysis on frequencies of occurrence of each virus, both in single and mixed infections.

RESULTS

Sweet potato virus-like disease symptoms observed in the fields

The symptoms observed on sweet potato plants included yellow mottling, purpling of leaves, vein clearing, stunting and chlorotic blotches or spots (Figure. 2). Purpling of the lower leaves was the most common observed symptoms especially on cultivar 'Jeshi'. In some locations, purple rings and branching streaks were observed on infected plants that were prominent on main leaf veins (Figure 2). Symptom variation within a single field plot was not apparent except where incidence was high as was the case at Maposeni location in Songea district where affected plants expressed different symptoms that included leaf narrowing, chlorotic blotches, mottling and leaf distortions. In Mbinga district, symptoms were less variable and generally consisted of purpling and chlorotic mottle or blotches.

Prevalence of SPVD, incidence and symptom severity

Sweetpotato virus-like disease symptoms were found in 25 (78%) out of the total 32 sweet potato fields examined. SPVD incidence was relatively lower in Mbinga (16.7 ± 4.25%) and ranged from 0 - 50%. In Songea district, some fields showed high percentage of plants showing virus-like symptoms with incidence that averaged 33.3 ± 9.69% and the infection proportion ranged from 0 - 100%. The difference in SPVD incidence between the two districts however, was not significant ($P > 0.05$). SPVD symptom severity significantly ($P < 0.001$) varied between the two districts with sweet potato-affected plants in Mbinga displaying milder symptoms (2.61 ± 0.23 severity score) than in Songea district (3.26 ± 0.11) (Table 1) . In Mbinga district, disease severity score ranged from 2 to 4 and 2 to 5 in Songea district. SPVD symptom severity also significantly varied among the sweet potato cultivars ($P < 0.001$). The widely grown sweet potato cv. Jeshi expressed the most severe symptoms (up to 4.2 ± 0.37 severity score) (Table 2). Apart from Jeshi the other locally grown OFSP cultivars Mazeze, Njano, and Mayai also displayed moderate to severe symptoms. Other cultivars though rarely grown showed mild symptoms that included Wino, Madaresalama and Arusha.

Abundance of whitefly and aphids on sweet potato fields

The number of adult whitefly/plant differed significantly between the two districts ($P < 0.05$). Whiteflies were observed more (1.25 ± 0.25 adult whiteflies/plant) on sweet potato farmers' fields in Songea than in Mbinga district (0.52 ± 0.25 adult whiteflies/plant) (Table 1). The highest number of whitefly per plant was 4 in Mbinga and 7 in Songea. Interestingly, whitefly numbers also signifi-

Table 1. Effect of agroecological zones (Mbinga and Songea) on SPVD severity, and its vector abundance.

District	SPVD symptom severity score	Whitefly count/plant	Aphid count/plant
Mbinga	2.61 ± 0.23	0.52 ± 0.11	0.02 ± 0.00
Songea	3.26 ± 0.11	1.27 ± 0.23	0.02 ±0.00
Mean	2.76	0.83	0.02
Std	0.82	1.45	0.255

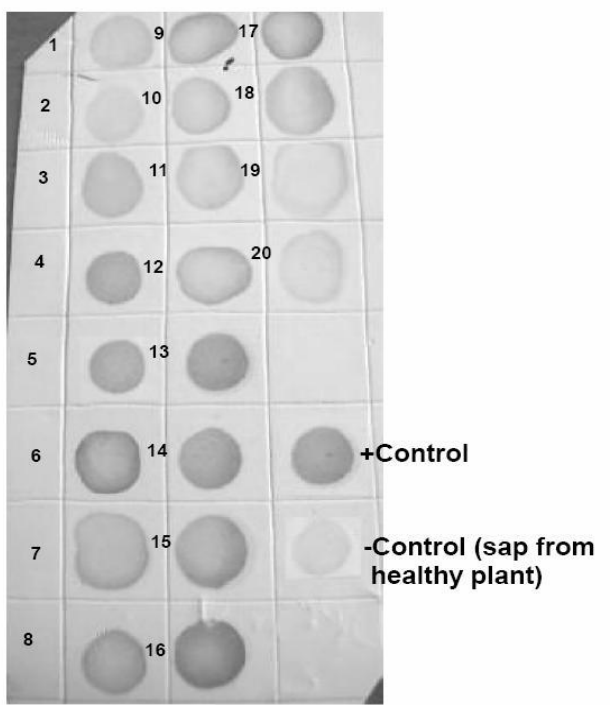

Figure 3. NCM-ELISA detection of SPCFV in sweetpotato samples collected from farmer's fields. NCM strips spotted with sap from virus virus- positive (+ control) and non-infected (-control) plants are included.

cantly varied among the sweet potato cultivars ($P < 0.001$). The OFSP cultivar Mayai supported the highest number of whitefly on average (3.6 ± 0.67) followed by Jeshi (3.3 ± 0.33) (Table 2). Aphids however, were rarely found on sweet potato having observed only in 2 (0.6%) of the total 32 sweetpotato fields examined. One field in Mbinga district recorded one aphid per plant and another field in Songea recorded two.

Identification of sweetpotato viruses

A total of ten samples reacted positively with at least one of the ten virus-specific antisera used for NCM-ELISA. Ten plants were negative to all antisera used and represented virus-like diseases of unidentified etiology (Table 3) . SPCFV was the most common virus detected with 9 of the 10 plants seropositive plants reacted positively to the virus antiserum (Figure. 3). Other seropositive plants were for SPCSV (7 plants), SPVG (7 plants), and SPMSV (4 plants). The aphid- transmitted SPFMV was detected only in 3 plants and SPMMV in 2 plants (Table 3). SPCaLV, C-6, SwPLV and CMV were not detected in any plants tested. Mixed infections were common of SPCFV with SPCSV, or SPVG. Two plants were infected with more than three viruses (SPCSV, SPCFV, SPFMV and SPVG or SPMMV) and were found in the same field in Songea district. Plants with mixed infections of SPCSV and SPCFV showed typical SPVD symptoms characterised by severe mosaic, stunting, leaf distortion and purpling of leaves.

DISCUSSION

The results demonstrate that SPVD was the most prevalent in both Mbinga and Songea districts. SPVD incidence and symptom severity were lower in Mbinga than in Songea district. The low incidence observation in Mbinga district is partly due to the fact that farmers grow sweetpotato crop only in some months of the year (January-May) but not year round as it is the case for Songea. The main crops are maize, beans and cassava in some areas. Rouging of SPVD-affected plants could be used to control spread of SPVD in this district. In addition, low SPVD incidence could be probably because of climate influence. Mbinga district with cool climate lie in high altitude (1000-2000 m a sl) with annual rainfall of over 1400 mm while most of the areas in Songea is lowland (500-1000 m asl) with mean annual rainfall of between 1000- 1400 mm (Berry, 1975). Warm climate has been reported to favour virus disease development by influencing crop growth and virus multiplication (Thresh et al., 2003).

SPCFV and SPVG were detected in both Mbinga and Songea districts, suggesting their widespread occurrence in southern Tanzania. SPCFV was detected in single, most frequently in mixed infections with SPCSV. Earlier studies have indicated SPCSV and SPFMV to be very common in northern and eastern Tanzania (Tairo et al., 2004) and Uganda (Gibson et al., 1997). Our data suggest that SPCFV as well as SPVG present other important viruses of sweetpotato in Tanzania that were not previously reported due to lack of virus-specific antiserum. SPVG presents the first report of its occurrence in

Table 2. Incidence and severity of SPVD and whitefly and aphid population recorded in sweetpotato cultivars grown in farmers fields surveyed in Mbinga and Songea districts of Tanzania 2006

Sample. No	District	Location	Cultivar	Root flesh colour	Incidence (%)	Severity	Whitefly count	Aphid count	Symptom[a]
1	Mbinga	Wukiro	Madaresalama	Pale orange	17.00	2.2 ± 0.2	0	0	Lp
2	Mbinga	Wukiro	Jeshi	Orange	17.00	2.2 ± 0.0	0	0	Lp,
3	Mbinga	Mkoha	Madaresalama	Pale orange	17.00	2.4 ±0.24	1.2 ± 0.58	0	Lp, Mo
4	Mbinga	Mkoha	Wino	White	10.00	2.0 ± 0.0	0	0	Lp
5	Mbinga	Kipapa	Unnamed	White	23.00	3.3 ± 0.28	1.4 ± 0.52	0	Lp, Mo
6	Mbinga	Kimunzi	Local	White	.00	-	-	-	-
7	Mbinga	Kimunzi	Wino	White	.00	-	-	-	-
8	Mbinga	Mbanda	Madaresalama	Pale orange	3.00	2 ± 0	0	0	Lp
9	Mbinga	Mikalanga	Chituli	White	.00	-	-	-	-
10	Mbinga	Mikalanga	Jeshi	Pale orange	50.00	2.4 ± 0.13	0	0	Lp
11	Mbinga	Ilela	Jeshi	Pale orange	.00	-	-	-	-
12	Mbinga	Sepukila	Kagera	Orange	47.00	2.3 ± 0.14	0.33 ± 0.18	0	Lp
13	Mbinga	Sepukila	Arusha	Deep orange	50.00	2.4 ± 0.16	0.66 ± 0.33	0	Lp
14	Mbinga	Sepukila	Jeshi	Pale orange	33.00	2.4 ± 0.16	0.1 ± 0.01	0	LP
15	Mbinga	Mtwara kati	Jeshi	Pale orange	27.00	2.3 ± 0.16	1.6 ± 0.56	0	Lp
16	Mbinga	Rudisha	Wino	White	3.00	2.0 ±0.0	1.0±0	1.0±0	LP, Mo
17	Mbinga	Sepukila	Jeshi	Pale orange	3.00	2.0 ± 0.0	0	0	Lp
18	Mbinga	Sepukila	Jeshi	Pale orange	.00	-	-	-	-
19	Mbinga	Kigonsera	Jeshi	Pale orange	3.00	2.0 ± 0.0	0	0	Lp
20	Mbinga	Kitai	Jeshi	Pale orange	0	-	-	-	-
21	Songea	Lihale	Chituli	White	73.00	3.0 ± 0.21	0	0	M, Mo, LP
22	Songea	Mdunduwalo	Jeshi	Pale orange	10.00	4.2 ± 0.37	0	0	LP, Ln, Ld
23	Songea	Maposeni	Jeshi	Pale orange	10	3.0 ± 0.0	0	0	Lp
24	Songea	Maposeni	Jeshi	Pale orange	100.00	3.6 ± 0.22	3.3 ± 0.33	0.33 ± 0.22	Lp, M, Mo, St, Ln, Fl,Cs
25	Songea	Sinai	Jeshi	Pale orange	17.00	3.6 ± 0.67	0.4 ± 0.04	0	St, LP, Mo
26	Songea	Sinai	Mayai	Deep orange	17.00	3.0 ± 0.31	3.6 ± 0.67	0	LP, St
27	Songea	Changarawe	Jeshi Nyekundu	Orange	10.00	2.7 ± 0.66	1.0 ± 0.1	0	Vch
28	Songea	Changarawe	Jeshi Nyekundu	Orange	20.00	3.3 ± 0.21	0.5 ± 0.05	0	Lp, Lpt
29	Songea	Changarawe	Njano	Deep orange	3.00	3.0 ± 0.0	0	0	Lp
30	Songea	Changarawe	Nyeupe	White	00	-	-	-	-
31	Songea	Changarawe	Jeshi	Pale orange	73	2.57 ± 0.20	0.28 ± 0.18	0	LP
32	Songea	Mpapa	Mazeze	Deep orange	60.00	3.4 ± 0.26	1.62 ± 0.87	0	Chb, Cs, Vb, Ln

Symptoms**:** Chb = chlorotic blotches, Cs = chlorotic spots, Fl = flecks, Lp = purpling of lower leaves, Ln = leaf narrowing, Lpt = line pattern, M = mosaic, Mo = mottling, St = stunting, Vch = veinal chlorosis, Vc = veinal clearing, Vb = vein banding.

Table 3. NCM-ELISA-based analysis results of sweetpotato field samples collected from Mbinga (M) and Songea (S) districts of Ruvuma region

S. No	Location	Cultivar[a]	NCM-ELISA using antibody against									
			SPCSV	SPFMV	SPMMV	SPCFV	SPCaLV	C-6	SPMSV	SwPLV	SPVG	CMV
1	Kipapa/M	Local	-	-	-	-	-	-	-	-	-	-
2	Kipapa/M	Local	-	+	+	++	-	-	+	-	++	-
3	Sepukila/M	Mayai	-	-	-	-	-	-	-	-	-	-
4	Sepukila/M	Arusha	-	-	-	-	-	-	-	-	-	-
5	Lihale/S	Chituli	-	-	-	-	-	-	-	-	-	-
6	Sepukila/M	Chituli	-	-	-	-	-	-	-	-	-	-
7	Mdunduwalo/S	Jeshi	-	-	-	-	-	-	-	-	-	-
8	Mdunduwalo/S	Jeshi	-	-	-	++	-	-	-	-	-	-
9	Rodeshia/M	unnamed	-	-	-	-	-	-	-	-	-	-
10	Maposeni/S	Jeshi	+	-	-	-	-	-	-	-	-	-
11	Maposeni/S	Jeshi	-	-	-	+	-	-	-	-	+	-
12	Sepukila/M	Jeshi	-	-	-	+	-	-	-	-	+	-
13	Sepukila/M	Jeshi	++	-	-	+	-	-	-	-	-	-
14	Kigonsera/M	Jeshi	++	-	-	+	-	-	-	-	+	-
15	Sinai/S	Mayai	++	-	-	++	-	-	+	-	-	-
16	Changarawe/S	Jeshi-Nyekundu	+	-	-	-	-	-	+	-	++	-
17	Changarawe/S	Jeshi-Nyekundu	+	+	+	++	-	-	-	-	+	-
18	Changarawe/S	Jeshi	+	+	-	++	-	-	++	-	+	-
19	Mpapa/S	Jeshi	-	-	-	-	-	-	-	-	-	-
20	Mpapa/S	Mazeze	-	-	-	-	-	-	-	-	-	-
Total			7/20	3/20	2/20	9/20	0/20	0/20	4/20	0/20	7/20	0/20

Key: Visual assessment of colour intensity as - = no apparent colour change, + = weak purple colour, ++++ = very high purple colour intensity [a] Root flesh colour (Table 2).

Tanzania. SPCFV was rarely detected in Uganda (Mukasa et al., 2003) but now most widely in southern Tanzania suggesting that viruses causing SPVD are highly variable in East Africa. The fact that the newly described SPVG was frequently detected in southern Tanzania as well as in some fields recently in Nigeria (Salazar, 2005) and in other countries as Barbados (Salazar and Fuentes 2001) and United States of America (Souto et al., 2003) suggesting that the virus is wide spread in the world. However, SPVG is relatively new virus. In Barbados, plants that were infected by SPVG showed no apparent visual symptoms (Salazar and Fuentes 2001). In this study however, plants from which SPVG was detected displayed apparent leaf mottle, chlorotic bloches or spots as well as vein clearing even if no other virus was found to co-infect the plant. This could be possibly because of genetic differences in the cultivars, environmental conditions, or synergistic effect of other unknown viruses that could not be detected by antisera used in this study. SPCaLV, SwPLV, C-6, and CMV rarely occur on sweetpotato in Africa and were not detected in this study. A relatively large number of plants did not react with any available antisera yet they displayed virus-like symptoms. It can be said that more viruses or virus- like agents than the ten viruses tested seem to infect sweetpotato in southern Tanzania. Symptoms in plants that tested negative to the available antisera were mainly vein-clearing, chlorotic blotches and at times purplish line patterns.

Both SPCSV and SPMMV (Wisler et al., 1998; Hollings et al., 1976) are transmitted by whiteflies which are relatively more abundant in sweetpotato fields than aphids that transmit two viruses, SPCFV and SPFMV without necessary colonizing the crop (Aritua et al., 1998; Fuentos and Salazar, 1992). In this study, whitefly recorded relatively more counts than aphids. However, there was no clear correlation between virus occurrence and whitefly and aphid abundance. It was anticipated that SPCSV with a common vector species could exhibit high frequency of occurrence but was not the case. Instead, aphid-transmitted SPCFV was the most common though aphids were rarely found colonizing sweetpotato. This could be because aphids which transmit it do not necessary have to colonize sweet potato. Transmission is done semi-persistently by aphids carrying sweet potato viruses when they briefly feed on sweetpotato plants, without colonizing the plants. Presumably, the alates of these and other noncolonizing aphid species spread SPFMV while making test visits to crops, as occurs for dissemination of potyviruses in some other crops (Halbert et al., 1981). Similarly aphids were rarely observed on sweetpotato in America (Kennedy and Moyer, 1982) as well as in Uganda (Karyeija et al., 1998) and in north western Tanzania (Ndunguru and Rajabu, 2000).

SPFMV is reported to occur in high frequency in Uganda (Mukasa et al., 2003) and northern and eastern Tanzania (Tairo et al., 2004) but occurred only in low frequency in southern Tanzania. Whether this indicates its absence from the area waits to be confirmed. SPFMV and probably other sweet potato viruses are representtatives of some of the most difficult viruses to work with. SPFMV is at low titer in sweet potato when it infects by itself. Infections can be detected with difficulty by ELISA (Abad and Moyer, 1992; Esbenshade and Moyer, 1982), and aphids acquire SPFMV infrequently (Kennedy and Moyer, 1982) or not at all (Schaefers and Terry, 1976). Distribution of SPFMV along the length of sweetpotato vines is irregular (Abad and Moyer, 1992; Green et al., 1988) and its detection may be difficult. In some cases SPFMV can be detected in some leaves along a vine but not in others and changes in virus concentration throughout the plant over time also cause problem (Beetham and Mason, 1992). The failure to detect SPFMV in infected plants is not only for NCM-ELISA method but also even for molecular methods. Souto et al. (2003) reported inability of RT -PCR to reproducibly detect SPFM in plants known to be infected suggesting that sometimes even symptomatic plants escape detection.

SPVD symptoms ranged from only mild to moderate (2 - 3 mean severity score) in many of the surveyed fields. Few plants displayed severe symptoms particularly those with dual infection of SPCSV and SPCFV or SPFMV. It has been reported SPFM and SPCSV do interact in co-infected plants synergistically causing the severe sweetpotato virus disease that is more damaging to the crop than would be expected if an individual virus was present (Gutierrez et al., 2003). Thus, mild to moderate symptoms observed in this study could be due to lack of synergism caused by infrequency occurrence of SPFMV. However, not all severe symptoms on sweetpotato are due to synergistic effect of mixed infections as was observed in Barbados by Salazar and Fuentes (2001).

We established no direct correlation between abundance of whiteflies and disease incidence and whiteflies differed considerably in abundance on sweetpotato crops and these differences may be important in determining the rates of spread of SPVD in crops. Some sweetpotato cultivars were colonized by more whiteflies than others. Whether this reflects whitefly feeding preferences or cultivar resistance to whitefly is still unknown. This work also suggests that more sweetpotato viruses or virus like agents (unknown at present) potentially contribute to SPVD and further research is needed to identify them and determine their roles.

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