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Impact of *Sugarcane yellow leaf virus* on sugarcane yield and juice quality in Réunion Island

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Abstract

Sugarcane yellow leaf virus (SCYLV) was first detected in sugarcane of Réunion Island in 1997. A field experiment was undertaken to assess the potential impact of this virus on sugarcane production. The agronomic characteristics of SCYLV-infected plants were compared to those of virus-free plants of three sugarcane cultivars (R570, R577 and R579) which occupy more than 90% of the cultivated sugarcane area on Réunion Island. In the plant crop, significant losses in stalk weight (28%) and in sugar content (11%) were detected for cultivar R577, but not for either of the two other cultivars. In the first ratoon crop, yield reduction was detected for cultivar R577 (37%), but also for cultivar R579 (19%). Cultivar R577 also showed significant losses in sugar content (12%) due to reduced amount and quality of extracted cane juice. No yield reduction was found for cultivar R570, although stalk height and diameter were reduced in SCYLV-infected canes of this cultivar in the first ratoon crop. Leaf yellowing was observed at harvest of plant and ratoon crops when sugarcane was no longer irrigated, and 10–59% of symptomatic stalks could be attributed to the presence of SCYLV. The most severe yellowing symptoms were related to infection of sugarcane by the virus.

Introduction

Yellow leaf syndrome (YLS) was first reported in Hawaii and in Brazil in the late 1980s and early 1990s (Schenck, 2001; Vega et al., 1997). The most prominent symptom of the disease is a yellowing of the midrib on the abaxial surface of the leaf, which may extend into the lamina, although similar symptoms may be related to other biotic or abiotic factors (Lockhart and Cronjé, 2000). Leaf tips become yellow, then necrotic, and necrosis may spread down the blade until the whole leaf is affected. An unclassified member of the *Luteoviridae* called *Sugarcane yellow leaf virus* (SCYLV) was identified as one of the causal agents of YLS (Moonan et al., 2000; Smith et al., 2000). Following the development of reliable serological and molecular diagnostic techniques (Comstock et al., 1998; Schenck et al., 1997), SCYLV was found to be widespread in most sugarcane producing countries, although it is rare in southern Africa where symptoms of YLS are common (Cronjé and Bailey, 1999). There is strong evidence that phytoplasmas are also associated with YLS in several countries, including Cuba, Mauritius and South Africa (Aljanabi et al., 2001; Cronjé et al., 1998; Peralta et al., 2000). SCYLV was first detected in Réunion in 1997, but sugarcane leaf yellowing had been observed on the island since 1980, particularly in cultivar S17 (Rassaby et al., 1999).

Yield losses of up to 40–60% were recorded in Brazil for cultivar SP71-6163 (Burnquist and Vega, 1996; Vega et al., 1997) but these data were revised and losses of 20% were finally reported (Lockhart and Cronjé, 2000; Matsuoka and Meneghin, 1999). In Louisiana, 6–14% losses in sugar were shown for cultivar LCP82-89 depending on the crop cycle (Grisham et al., 2000; 2001). Growth differences were found between SCYLV-infected and virus-free plants of sugarcane cultivar H87-4094 in Hawaii, even before symptoms were visible (Lehrer et al., 2000). Physiological studies conducted on the same cultivar showed that SCYLV-infected leaves exhibit a higher carbohydrate level, a lowered chlorophyll *a/b* ratio and a smaller photosynthetic capacity. Export of assimilate in virus-infected plants is therefore reduced compared to virus-free plants (Lehrer et al., 2001).

The objective of this study was to analyse the impact of SCYLV on sugarcane yield and juice quality of the three main cultivars grown in Réunion Island, and to determine associated disease symptoms. SCYLV-infected and virus-free sugarcane plants were compared in a field trial for two crop cycles, plant crop and first ratoon crop. Several parameters such as agronomic characteristics and sugar content were measured.

Materials and methods

Plant material and experimental design

The field experiment was set up at the CIRAD experimental station at La Mare, Réunion Island: elevation = 65 m above sea level, latitude = 160,350 m and longitude = 75,070 m (IGN-Institut National Géographique – projection system for Réunion Island), and soil = ferrallitic soil (= oxisol according to USDA taxonomy) on old volcanic effusive material. Three sugarcane cultivars were used: R570, R577 and R579. Cuttings were prepared with stalks obtained from 11- to 12-month-old commercial fields. The presence or absence of SCYLV in stalks was determined by tissue blot immunoassay (TBIA) with a freshly cut surface of each stalk extremity. Two two-bud cuttings were planted per plant location, and the spacing was 0.75 m between plants on the row and 1.5 m between rows. The experimental field was set up in October 1999 using a two factor randomized block design, and was surrounded by commercial sugarcane fields. Each plot of the six blocks contained two subplots of nine plants each. Each subplot was surrounded by a border row of the same plants. Stalks of the 18 plants per plot originated from either SCYLV-infected or SCYLV-free cuttings. The experimental plots were regularly watered by drip irrigation and fertilized at planting with NPK15/12/24 fertilizer (1000 kg ha^{-1}). Watering was stopped six weeks before harvest to favour ripening of sugarcane. Harvest of the plant crop and harvest of the first ratoon crop occurred in October 2000 and 2001, respectively.

To avoid transmission by aphids of SCYLV to virus-free plants, insecticides were sprayed on sugarcane foliage of both virus-infected and virus-free plots. Spraying was performed every two weeks for the first six months of growth in the plant and ratoon crop. Three different products were alternately applied: Decis® (deltamethrin 25%) 6.25 g ha^{-1}, Karaté® (lambda-cyhalothrin 5%) 1 litre ha^{-1} and Pirimor G® (pyrimicarb 50%) 125 g ha^{-1}. The infection status of plants in SCYLV-infected and non-infected plots was verified just before harvest by TBIA.

SCYLV detection

The top visible dewlap leaf was used for SCYLV detection in plants three and 11 months after planting. TBIA was performed as described by Schenck et al. (1997), except that nitrocellulose membranes and Fast Blue BB salt (Sigma®) were used. TBIA membranes were observed with a stereomicroscope (×100) to determine positive reactions which appeared as dark blue spots coincident with the vascular bundles. Five leaves from each of the 18 plants were tested in each plot. A plant was considered infected by SCYLV when at least one vascular bundle of one leaf showed a positive reaction.

Symptom rating

Symptoms were recorded on all leaves of each stalk. A score ranging from 0 to 4 and corresponding to the severity of symptoms was assigned to each leaf: 0 = no symptoms, 1 = slight yellowing of the central part of the midrib, 2 = pale yellow colour all along the midrib, 3 = strong yellow colour all along the midrib, and 4 = yellow coloured midrib and yellow or pink coloured lamina. These data were used to attribute a mean disease severity to each stalk.

Measured parameters

The number of stalks per stool was determined at harvest when sugarcane was 12 months old.

A measuring tape was used to measure stalk height (distance between soil level and the last visible dewlap) of all stalks in each block. The diameter of the rounded side of an internode that appeared average, and that was located halfway up the stalk, was measured for all stalks with a calliper square. All stalks were cut by hand at soil level with a machete. Leaves were removed and stalks were weighed using bathroom scales. For further analyses, four samples of 20 millable stalks each were randomly taken in each experimental unit (one cultivar and one infection status). Sugar content was determined (Hoarau, 1969). Three values were used to determine sugar content in sugarcane juice: (1) refractometric Brix that was measured with a refractometer and represents the amount of total dissolved solids, (2) Pol that was measured with a polarimeter and that represents the amount of sucrose among total dissolved solids (these two values were recalculated in comparison to cane mass after correction of measuring temperatures), (3) sucrose % cane, that is, in theory, the percentage of sucrose in sugarcane on a fresh weight basis. Purity of sugarcane juice was determined by calculating the Pol/Brix ratio and fibre content of stalks by weighing the residues obtained after juice extraction.

Statistical analyses of data

Computer programs of SAS (SAS Institute Inc., Cary, USA) were used for data analyses. Data for each parameter were examined by analysis of variance (Student's t-test) using the mean value for stools measured in each of the six blocks or the mean value of the four samples of 20 millable stalks per block.

Results

Infection status of sugarcane after planting

Three months after planting and just before harvest, the infection status of all sugarcane stools (including border rows) was examined. Results were similar at both sampling dates and a few stools considered virus-free were infected with SCYLV and vice-versa. The virus was detected in 6%, 6% and 17% of stools originating from virus-free cuttings at planting of cultivars R577, R579 and R570. In contrast, for each of the three cultivars, SCYLV was not detected in 3% of stools originating from virus-infected cuttings.

Impact of SCYLV on agronomic characteristics of sugarcane

Ten parameters representing agronomic and yield components were measured for the three cultivars and for two consecutive crop cycles. In the plant crop, no significant differences were found between healthy and virus-infected canes of cultivars R570 and R579, for any of the parameters measured (Table 1): yield (tons ha^{-1}), number of stalks per stool, stalk height, stalk diameter, stalk weight, sucrose % cane, Brix, Pol, juice purity and fibre content of the stalk. In contrast, healthy and virus-infected canes of cultivar R577 were different for 7 out of the 10 measured parameters. In canes of this cultivar, the presence of SCYLV was associated with reductions of 28% in stalk height, 7% in stalk diameter and 28% in stalk weight. Sugar content of stalks was also reduced (11%) as shown by lower Brix and Pol values and higher fibre content in SCYLV-infected stalks. No significant differences were found between healthy and virus-infected canes of cultivar R577 regarding yield (tonnage), the number of stalks per stool and juice purity.

In the first ratoon crop, differences were found between healthy and virus-infected canes of all three cultivars, but the number of parameters affected varied according to the cultivar (Table 2). Only stalk height and stalk diameter were reduced (9% and 7%, respectively) in cultivar R570 infected by SCYLV. Yield, stalk height and stalk diameter were reduced (19%, 7% and 4%, respectively) in cultivar R579; impact of the virus on the stalk number per stool was also close to significance in this cultivar ($P = 0.0557$). Differences between healthy and virus-infected canes of cultivar R577 were measured for 8 out of 10 parameters. In the first ratoon crop of this cultivar, the presence of SCYLV was associated with reductions of 37% in sugarcane yield, 18% in stalk height, 13% in stalk diameter, and 46% in stalk weight. Sugar content of stalks was also reduced (12%) as shown by lower Brix, Pol and juice purity values. No significant differences were found between healthy and virus-infected canes of cultivar R577 regarding the number of stalks per stool and fibre content.

Symptoms

No YLS symptoms were observed during the first 10.5 months of sugarcane growth for any of the cultivars. It was only after the irrigation was stopped

Table 1. Effect of SCYLV on agronomic characteristics and production parameters of three sugarcane cultivars in the plant crop[a]

Parameter	Cultivar											
	R570				R577				R579			
	Healthy	Infected	Δi–h[b]	P	Healthy	Infected	Δi–h[b]	P	Healthy	Infected	Δi–h[b]	P
Yield (t/ha^{-1})	85.22	68.52	−16.70	0.1466	89.21	68.19	−21.02	0.0721	104.46	110.75	+6.29	0.5756
Number of stalks per stool	7.90	7.65	−0.25	0.7274	9.95	9.38	−0.57	0.4347	9.19	8.61	−0.58	0.4241
Stalk height (cm)	160.21	156.32	−3.89	0.4404	165.55	119.56	**−45.99 (−27.8%)**	0.0001	164.89	159.69	−5.20	0.3054
Stalk diameter (mm)	26.13	26.64	+0.51	0.2325	25.93	24.00	**−1.93 (−7.4%)**	0.0002	29.50	28.76	−0.74	0.0873
Stalk weight (kg)	1.21	1.05	−0.16	0.1516	1.06	0.76	**−0.30 (−28.3%)**	0.0124	1.29	1.49	+0.20	0.0810
Sucrose (% cane)	10.46	9.85	−0.61	0.1643	10.59	9.47	**−1.12 (−10.6%)**	0.0158	10.60	10.30	−0.30	0.4880
Brix (%)	18.65	17.92	−0.73	0.1433	18.56	17.37	**−1.19 (−6.4%)**	0.0225	18.49	18.36	−0.13	0.7969
Pol (%)	16.69	15.85	−0.84	0.1266	16.70	15.44	**−1.26 (−7.5%)**	0.0278	16.53	16.25	−0.28	0.5974
Juice purity (Pol/Brix)	89.57	88.37	−1.20	0.1073	89.88	89.01	−0.87	0.2374	89.39	88.82	−0.57	0.4361
Fibre content (%)	13.77	13.63	−0.14	0.6011	13.07	14.10	**+1.03 (+7.9%)**	0.0013	12.35	12.81	+0.46	0.1149

[a]Two factor randomized block design with six replications of 18 plants per plot; data significant at $P = 0.05$ are indicated in bold.
[b]Difference between infected (i) and healthy (h) canes.

(six weeks before harvest) that symptoms of leaf yellowing started to appear. SCYLV-infected and virus-free sugarcane stalks of all three cultivars exhibited symptoms, but the incidence and severity varied according to infection status and cultivar (Tables 3 and 4). In the plant crop, 25–42% of virus-free stalks showed leaf yellowing, whereas 52–98% of SCYLV-infected stalks were symptomatic (Table 3). In first ratoon crop, 65–77% of virus-free stalks showed leaf yellowing, whereas 92–100% of SCYLV-infected stalks were symptomatic (Table 4). Almost all (1000 out of 1016) virus-infected stalks of cultivar R577 exhibited symptoms in the plant crop and all (974) showed symptoms in the first ratoon crop.

Additionally, the percentage of infected stalks increased with the severity of symptoms in all three cultivars (Table 5). Symptoms recorded on most virus-free stalks were scored 0 (no leaf yellowing) or 1 (slight yellowing of the central part of the leaf midrib) in the plant crop, and 0–2 (pale yellow colour all along the leaf midrib) in the first ratoon crop. Severe leaf yellowing (scores 3 and 4) was observed almost solely on SCYLV-infected stalks, whatever the cultivar and crop cycle. In the plant crop, 1/857 (0.1%), 335/1016 (33%) and 45/942 (5%) SCYLV-infected stalks of cultivars R570, R577 and R579, respectively, showed severe leaf yellowing (scores 3 and 4). In the first ratoon crop, these values were 264/844 (31%), 826/974 (85%) and 421/919 (46%) for cultivar R570, R577 and R579, respectively.

Discussion

Although the presence or absence of SCYLV was verified in all stalks before preparing the cuttings for planting, not all plants expected to be virus-free from these cuttings were virus-free. Similarly, not all plants expected to be infected with the virus from these cuttings were infected. Two hypotheses may explain the appearance of SCYLV in some ‘healthy’ plants: transmission of SCYLV by viruliferous aphids from virus-infected to healthy plants, even though insecticides were regularly applied; or presence of virus populations below the detection threshold of TBIA in stalks used for preparing the cuttings (Comstock et al., 1998). The negative detection of SCYLV in ‘infected’

Table 2. Effect of SCYLV on agronomic characteristics and production parameters of three sugarcane cultivars in the first ratoon crop[a]

Parameter	Cultivar											
	R570				R577				R579			
	Healthy	Infected	Δi–h[b]	P	Healthy	Infected	Δi–h[b]	P	Healthy	Infected	Δi–h[b]	P
Yield (t/ha)	84.72	69.26	−15.46	0.1325	82.14	51.46	**−30.68 (−37.4%)**	0.0056	120.30	97.56	**−22.74 (−18.9%)**	0.0321
Number of stalks per stool	8.71	7.40	−1.31	0.0756	7.67	8.84	+1.17	0.1092	9.78	8.36	−1.42	0.0557
Stalk height (cm)	290.81	265.48	**−25.33 (−8.7%)**	0.0001	258.06	211.09	**−46.97 (−18.2%)**	0.0001	284.08	263.51	**−20.57 (−7.2%)**	0.0005
Stalk diameter (mm)	28.62	26.48	**−2.14 (−7.5%)**	0.0001	25.73	22.35	**−3.38 (−13.1%)**	0.0001	27.83	26.68	**−1.15 (−4.1%)**	0.0108
Stalk weight (kg)	1.10	1.05	−0.05	0.6853	1.21	0.65	**−0.56 (−46.3%)**	0.0001	1.43	1.30	−0.13	0.3082
Sucrose (% cane)	12.92	13.02	+0.10	0.7340	12.74	11.15	**−1.59 (−12.5%)**	0.0001	12.98	12.81	−0.17	0.5694
Brix (%)	22.23	22.21	−0.02	0.9335	21.96	20.10	**−1.86 (−8.5%)**	0.0001	22.00	21.87	−0.13	0.6935
Pol (%)	20.65	20.71	+0.06	0.8713	20.43	18.36	**−2.07 (−10.1%)**	0.0001	20.35	20.26	−0.09	0.8003
Juice purity (Pol/Brix)	92.83	93.29	+0.46	0.2778	93.02	91.41	**−1.61 (−1.7%)**	0.0011	92.49	92.63	+0.14	0.7479
Fibre content (%)	15.94	15.64	−0.30	0.5250	15.96	16.46	+0.50	0.3021	14.71	15.14	+0.43	0.3752

[a]Two factor randomized block design with six replications of 18 plants per plot; data significant at $P = 0.05$ are indicated in bold.
[b]Difference between infected (i) and healthy (h) canes.

Table 3. Effect of SCYLV on appearance of yellowing symptoms in three sugarcane cultivars in the plant crop

Cultivar	Total number of SCYLV-free stalks	Number of SCYLV-free stalks		Total number of SCYLV-infected stalks	Number of SCYLV-infected stalks	
		Without yellowing	With yellowing		Without yellowing	With yellowing
R570	805	466 (58%)	339 (42%)	857	409 (48%)	448 (52%)
R577	1068	656 (61%)	412 (39%)	1016	16 (2%)	1000 (98%)
R579	1013	756 (75%)	257 (25%)	942	448 (48%)	494 (52%)

Table 4. Effect of SCYLV on appearance of yellowing symptoms in three sugarcane cultivars in the first ratoon crop

Cultivar	Total number of SCYLV-free stalks	Number of SCYLV-free stalks		Total number of SCYLV-infected stalks	Number of SCYLV-infected stalks	
		Without yellowing	With yellowing		Without yellowing	With yellowing
R570	865	305 (35%)	560 (65%)	844	70 (8%)	774 (92%)
R577	784	276 (35%)	508 (65%)	974	0 (0%)	974 (100%)
R579	1033	239 (23%)	794 (77%)	919	21 (2%)	898 (98%)

plants may be explained by virus populations below detection threshold of the serological technique, but also by uneven distribution of the virus in infected stalks. Although the number of plants with modified infection status was low, these plants were not taken into consideration to determine the impact of SCYLV on yield and juice quality, but were replaced by plants from the border rows.

Table 5. Percentage of SCYLV-infected stalks according to symptom severity in three sugarcane cultivars in the plant and first ratoon crops

Cultivar	Crop cycle	Number of infected stalks/total number of stalks with symptom severity scored[a]				
		0	1	2	3	4
R570	Plant crop	409/875 (47%)	385/714 (54%)	62/72 (86%)	1/1 (100%)	0
R570	First ratoon crop	70/375 (19%)	244/728 (34%)	266/340 (78%)	227/229 (99%)	37/37 (100%)
R577	Plant crop	16/672 (2%)	224/545 (41%)	441/512 (86%)	257/267 (96%)	78/88 (89%)
R577	First ratoon crop	0/276 (0%)	24/432 (6%)	124/220 (56%)	443/447 (99%)	383/383 (100%)
R579	Plant crop	448/1204 (37%)	346/599 (58%)	103/107 (96%)	43/43 (100%)	2/2 (100%)
R579	First ratoon crop	21/260 (8%)	188/763 (25%)	289/488 (59%)	340/360 (94%)	81/81 (100%)

[a]0 = no symptoms, 1 = slight yellowing of the central part of the midrib, 2 = pale yellow colour all along the midrib, 3 = strong yellow colour all along the midrib, and 4 = yellow coloured midrib and yellow or pink coloured lamina.

Impact of SCYLV on sugarcane stalk weight was measured in the trial since the first crop cycle of cultivar R577. Significant losses in tonnage were not detected at $P = 0.05$ because of high heterogeneity between plots (data not shown). Values of several other yield characteristics (stalk height and diameter, sugar content in stalks,. . .) were, however, significantly lower in virus-infected canes than in virus-free plants. In contrast, no impact of SCYLV on yield was shown in the plant crop for the two other cultivars, R570 and R579. Cultivar R577 is usually not cultivated in the area (La Mare) where the yield trial was conducted and, therefore, unusual and excessive impact could be due to sub-optimal growth. However, the yield of cultivar R577 in this trial was greater than that of cultivar R570, which is the most widely grown cultivar on Réunion Island.

A greater impact of SCYLV on yield of cultivar R577 was found in the first ratoon crop compared to the plant crop: 46% reduction of stalk weight (vs. 28% in the plant crop), 13% reduction of stalk diameter (vs. 7% in the plant crop), and significant reduction in tonnage (37%). However, the number of stalks per stool was not affected in either crop. The stalk height reduction was lower in the first ratoon crop when expressed as a percentage (18% vs. 28% in the plant crop), but the impact was similar when expressed in cm (46 and 47 cm in plant and ratoon crop, respectively). Juice purity was only significantly lower in virus-infected canes of cultivar R577 in first ratoon crop, whereas a higher fibre content in infected stalks was only detected in the plant crop.

Although no impact of SCYLV was detected in cultivars R570 and R579 in the plant crop, several yield components of these two cultivars in the first ratoon crop were significantly lower in virus-infected than in virus-free plants: stalk height and diameter in cultivar R570; tonnage of cane, stalk height and diameter in cultivar R579. However, these yield reductions were not as high as those observed in cultivar R577. It can, therefore, be concluded that the impact of SCYLV and tolerance of sugarcane to the virus vary according to sugarcane cultivar. Similar results were found for other members of the *Luteoviridae* family: *Potato leafroll virus* (PLRV) on potato and *Barley yellow dwarf virus* (BYDV) on barley can cause severe yield losses, and the reaction to these viruses varied according to cultivars (Loughnane, 1941; Smith and Hallsworth, 1990).

In this trial, the greatest impact of SCYLV on yield (tonnage of cane) was 37% in the first ratoon crop, but stalk weight reduction of 28% was already detected in the plant crop of cultivar R577. Yield losses of 6%, 11% and 14% in the plant crop, first and second ratoon, were found in a similar yield trial conducted in Louisiana with cultivar LCP82-89 which is susceptible to YLS (Grisham et al., 2000; 2001). Cane quality components (% Brix, % Sucrose, % Fibre and % Purity) did not differ between SCYLV-infected and non-infected plants of cultivar LCP82-89, but stalk number and tonnage were reduced in virus-infected plants. In contrast, SCYLV had a positive impact on several leaf components: % Brix, % Sucrose and % Purity were higher in juice from virus-infected green leaf tissue compared to healthy leaf tissue (Grisham et al., 2001). Similar observations were made with the Sugarcane yellows phytoplasma (ScYP) which is also associated with one form of YLS: % Brix is always equal or superior to 8 in ScYP-infected leaves (Peralta et al., 2000). Leaf components were not investigated but, in contrast to results obtained in Louisiana with cultivar LCP82-89, SCYLV affected both cane quantity and cane quality of cultivar R577.

Sugarcane yield losses due to SCYLV have been reported in several countries (Lockhart and Cronjé, 2000; Schenck, 2001), and the present results indicate

that sugarcane cultivars grown in Réunion Island also suffer from the pathogen. The experiment described herein was carried out over a two-year period, but the results showed variation in these years. Similar variation was shown to occur in a YLS trial conducted over three years in Louisiana where cultivar LCP 82–89 suffered the greatest losses (23% sugar per unit area) in the second-ratoon crop (Grisham et al., 2002). Additional trials should, therefore, be conducted to show reproducibility of the results in a given location and also in different locations of Réunion Island.

No YLS symptoms were observed on leaves of cultivars R570, R577 and R579 for several months in both crop cycles. This phenomenon can be considered as normal because YLS symptoms usually appear, or are more severe, at plant maturity or after the occurrence of environmental stresses (Comstock et al., 1994 ; Schenck et al., 1997). Indeed, it was only after cessation of irrigation that the first disease symptoms were observed. Leaf yellowing was observed on SCYLV-infected plants but also on virus-free plants. Previous studies showed that incidence of yellowing symptoms in sugarcane was not correlated with the presence of SCYLV (Aljanabi et al., 2001; Smith et al., 2001). Indeed, leaf yellowing in sugarcane is not specific to SCYLV and several biotic and abiotic factors can cause these symptoms: nutrient deficiencies or nutrient excess (Borth et al., 1994), flowering and borers (Matsuoka and Meneghin, 1999), cold season or water excess (Comstock et al., 1994), and ScYP infection (Smith et al., 2001). In Louisiana, growth of sugarcane cultivar LCP 82–89 was reduced in SCYLV-infected plants but these plants did not exhibit leaf yellowing (Grisham et al., 2001). However, in this trial, some of the leaf yellowing was clearly associated with the presence of SCYLV. The percentages of stalks showing leaf yellowing were greater (10–59%), and symptoms more severe, in virus-infected plants compared with healthy plants. Higher numbers of stalks with yellowing were also noted in the first ratoon crop than in the plant crop. This was probably due to the severe dry season that occurred during the ratoon crop. Additionally, even if YLS symptoms are not specific to this disease, severity of leaf yellowing varied between cultivars, and cultivar R577 showed the most severe symptoms.

Because leaf yellowing symptoms were observed in both virus-infected and virus-free plants, it cannot be excluded that other pathogens may have been present in the sugarcane plots and interfered with sugarcane growth and/or severity of leaf yellowing. Joint infection of *Beet western yellows virus* (BWYV) and *Lettuce mosaic virus* (LMV) in lettuce resulted in a significantly greater yield loss than that caused by BWYV or CMV infection alone (Walkey and Payne, 1990). When sugarcane is affected simultaneously by mosaic and another disease, growth and yield are more reduced than when plants are affected by each disease separately (Koike and Gillaspie, 1989). Synergistic effects due to presence of SCYLV and other biotic or abiotic factors might also explain the increase in severity of leaf yellowing with the increase in SCYLV incidence observed here. Additional studies are therefore needed to determine if leaf yellowing observed in the control sugarcane plants was only due to a physiological stress (water shortage) at harvest or to other factors.

SCYLV spreads primarily within the sugarcane crop by clonal propagation and by aphid vectors rather than from external sources (Lockhart and Cronjé, 2000). The use of resistant cultivars and clean planting material represents, therefore, the most effective means of control when SCYLV is established in a sugarcane-producing area. Clean plants can be obtained by meristem culture (Chatenet et al., 2001; Fitch et al., 2001), and virus-resistant or tolerant cultivars could be produced by conventional breeding or transgene introgression (Lockhart and Cronjé, 2000). In view of results reported in the present study, R570, the major cultivar currently grown commercially on Réunion Island is relatively tolerant to SCYLV. Only low impact was found when all plants of this cultivar were infected and, in a survey undertaken in 1998, R570 was the least SCYLV-infected cultivar on the island (Rassaby et al., 1999). Impact of the pathogen on cultivar R579 could be limited, especially if healthy planting material is used and the cultivar grown in locations where infection by aphids is low. On the other hand, the susceptible clone R577 should not be planted in Réunion Island until other control strategies based on essential features of YLS epidemiology are developed.

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