EFFECT OF SUGARCANE YELLOW LEAF VIRUS ON SUGARCANE YIELD AND JUICE QUALITY

By

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Abstract

In 1996, sugarcane plants infected with sugarcane yellow leaf virus (SCYLV), reported to cause yellow leaf syndrome (YLS), were discovered in Louisiana. Field experiments were established to assess the potential impact of the disease on the Louisiana sugarcane industry. In the first experiment, yield and juice quality of SCYLV-infected and non-infected plants of cultivar LCP82-89 were compared. Sugar yields per unit area were reduced 11% and 14% in the first ratoon and second ratoon crops respectively. Stalk number and tonnage were reduced in SCYLV-infected plants. Cane quality components, % brix, % sucrose, % fibre and % purity, did not differ between infected and non-infected plants. However, % brix, % sucrose, and % purity were higher in juice from virus-infected green leaf tissue compared with healthy leaf tissue. In a second experiment, juice from leaves and stalks of infected and non-infected plants collected from plant cane, first ratoon, and second ratoon crops of cultivars LCP82-89 and LHo83-153 was analysed. Cane quality components did not differ in either cultivar. In juice from SCYLV-infected leaves, % sucrose was higher in LCP82-89 and % purity and starch concentrations were higher in both cultivars, while differences in total polysaccharides and oligosaccharides were not detected. Dextran content was inconsistent. The uppermost green leaves are normally removed from the stalk during mechanical harvesting; however, they may not be removed if the cane is lodged. Leaves delivered to the mill containing elevated levels of starch might reduce processing efficiency.

Introduction

Yellow leaf syndrome of sugarcane has been reported from Brazil, Australia, South Africa, Zimbabwe, the Florida, Hawaii, Louisiana, and Texas industries of the United States and many other sugarcane-producing regions. The causal agent of the syndrome may be either a luteovirus transmitted by aphids and termed the sugarcane yellow leaf virus (SCYLV) (Vega *et al.*, 1997), or a phytoplasma (Cronjé, *et al.*, 1998; Cronjé and Bailey, 1999), transmitted by leafhoppers. The symptoms caused by the two pathogens appear to be identical. However, both pathogens can often be detected in plants without symptoms.

Typically, the symptoms of YLS first appear on leaves three through six, where leaf one is the uppermost leaf with a visible dewlap. The lower surface of the midrib becomes a distinct yellow while the upper surface of the midrib may be unchanged or turn yellow, pink or reddish. The symptoms are most common on mature plants. In some cultivars, the yellowing spreads laterally from the midrib into the lamina and the leaves begin to die from the tip; in others, a general yellowing of the leaves occurs. Brix readings two to three times higher than normal have been found in juice extracted from the midribs of YLS-affected plants (Comstock *et al.*, 1994). Reduced plant growth and yield losses have been reported from Brazil (Vega *et al.*, 1997).

Comstock, *et al.* (1994, 1998) reported that 76 commercial and advanced candidate sugarcane cultivars from Louisiana growing at the USDA-ARS Sugarcane Field Station at Canal Point, Florida tested positive for SCYLV. These clones are used as parents in the Louisiana cultivar development program that begins with crosses made at Canal Point. Seed from these crosses is sent to Louisiana for planting and selection. Six of the seven sugarcane cultivars recommended for planting in Louisiana were found infected. The other minor cultivar was not included in the screening. Many breeding canes showing symptoms of YLS failed to flower.

Following the observations of YLS in Florida and Texas, we began conducting visual surveys of sugarcane in Louisiana for YLS symptoms in 1993. In 1996, we analysed sugarcane plants from several sources for the presence of SCYLV and found a low incidence of infected plants, although no symptoms were observed. In the fall of 1998, plants with YLS symptoms were observed in commercial fields. Infection by SCYLV was subsequently confirmed by reverse transcription polymerase chain reaction (RT-PCR). Two experiments were conducted to compare the yield and juice quality of SCYLV-infected and non-infected sugarcane in Louisiana.

KEYWORDS: Sugarcane, Yellow Leaf Syndrome, SCYLV, YLS.

Materials and methods

Experiment 1

Two adjacent plantings of sugarcane cultivar LCP82-89, one SCYLV-infected and the other uninfected, were used as a source of seedcane for the two treatments. A completely randomised design with 11 replications was used. Plots were 3 rows (5.4 m) wide and 5.5 m long. The disease status of plants in SCYLV-infected and non-infected plots was verified annually by RT-PCR. The experiment was planted on 9 October 1996 and the plant, first ratoon and second ratoon crops were harvested on 15 December 1997, 12 November 1998 and 17 November 1999 respectively.

Prior to harvest in plant cane, first ratoon, and second ratoon crops, six randomly selected stalks from each plot were collected for mill analysis (Legendre, 1992). Senescent leaves were stripped from the stalks and discarded. The green leaves were separated from the mature stalks. Juice from the green leaves and stalks was analysed separately. Green leaves were not analysed in the second-ratoon crop.

Cane from each plot was cut with a mechanical harvester and the mass determined in the plant-cane and first-ratoon crops. Because of severe damage to the experiment by tropical storms, normal harvesting of the second-ratoon crop was not possible. In this crop, 10 stalks were collected at random from each plot, weighed, and treated as above for mill analysis. Cane and sugar yields were then estimated using earlier millable stalk counts and mean weights of hand harvested stalks.

Experiment 2

Plots were established with plants grown from single-budded setts cut from stalks of LCP82-89 and LHo83-153 and tested as either SCYLV-infected or uninfected. Plants were started in the greenhouse in the fall of 1997 and transplanted to the field on 12 May 1998. A completely randomised design with three replications was used. Plots were 3 rows (5.4 m) wide and 5 m long, 36 plants per plot. The disease status of plants in SCYLV infected and uninfected plots was verified annually by RT-PCR. The plant, first ratoon and second ratoon crops were harvested on 12 December 1998, 6 December 1999 and 11 November 2000, respectively.

Twenty-one randomly selected stalks were harvested by hand from each plot in the plant cane and first ratoon crops. The green leaves and stalks were separated for analysis, as described above. The fresh masses of green leaves and stalks were recorded. Juice extracted from the green leaves and stalks was analysed for % brix, % sucrose, % purity, and levels of total polysaccharides, dextran, starch (Godshall *et al.*, 1990) and oligosaccharides (Eggleston and Clark, 1997).

In the second ratoon crop, the stalks were separated into four sections rather than two. The upper portion of each stalk was divided into two sections, the green leaves and the uppermost part of the stalk containing the growing point and immature stalk. The lower portion was divided into two sections, the basal six internodes and the remaining portion of the stalk. Juice was extracted from each section and analysed as described above. The cane in each plot was harvested mechanically and yields of cane and sugar were determined in the first ratoon and second ratoon crops.

Results and discussion

No spread of SCYLV was detected in either experiment except in one check plot of experiment 2, where one of 10 samples tested positive. No characteristic YLS symptoms developed in any plot of either experiment.

In experiment 1, yield and juice quality of stalks did not differ between SCYLV-infected and uninfected plots in the plant cane crop (Table 1). Cane and sugar yields were reduced in the SCYLV-infected plots in the first-ratoon and second-ratoon crops by 11 and 14 percent, respectively. The component of yield that appears to have been most reduced by virus infection was stalk population. The juice quality of the stalks was not affected.

In experiment 2, cane and sugar yields were higher in uninfected plots of LCP82-89, particularly in the second ratoon crop, but these were not significant at $P = 0.05$. No differences in the yield of LHo83-153 were recorded (Table 2).

A number of the quality components of the juice extracted from leaves differed between infected and uninfected plants (Tables 1 and 3). Increases in % sucrose and soluble solids were recorded in SCYLV-infected leaf tissue.

Table 1—Effect of SCYLV on yield and juice quality of sugarcane cultivar LCP82-89 (Experiment 1).

Component		Plant cane		First ratoon		Second ratoon	
		SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve
Leaves	Brix (%)	8.7	7.6**	13.2	8.1**		
	Sucrose (%)	2.5	1.8**	3.5	2.0**		
	Fibre (%)	21.3	20.6	29.9	19.9		
	Purity (%)	36.0	29.4**	51.3	30.3**		
	Sugar (t/ha)	5.0	1.0**	5.0	1.3**		
Stalks	Brix (%)	20.1	20.1	20.1	20.2	16.5	16.6
	Sucrose (%)	15.7	15.8	15.9	16.0	14.7	14.8
	Fibre (%)	11.8	11.9	12.1	12.7	11.7	12.0
	Purity (%)	88.8	89.2	90.0	90.3	88.6	88.7
	Stalks/ha ($\times 10^{-3}$)	80.47	86.20*	86.87	95.96*		
	Cane (t/ha)	75	77	74	83*	74	86
	Sugar (t/ha)	8.55	9.01	8.51	9.55*	7.82	9.11*

* or ** = differences between infected and control plants significant at P = 0.05 or 0.01 respectively.

Table 2—Effect of SCYLV on cane and sugar yield of sugarcane cultivars LCP82-89 and LHo83-153, Experiment 2.

Cultivar	Component	First ratoon		Second ratoon	
		SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve
LCP82-89	Cane (t/ha)	78	81	69	83
	Sugar (t/ha)	11.47	12.00	8.89	11.10
LHo83-153	Cane (t/ha)	78	77	74	75
	Sugar (t/ha)	11.21	11.28	9.88	9.55

There were no significant differences.

Table 3—Effect of SCYLV on juice quality of sugarcane cultivars LCP82-89 and LHo83-153, Experiment 2.

Cultivar	Tissue	Component	Plant cane		First ratoon		Second ratoon	
			SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve
LCP82-89	Leaves	Brix (%)	7.6	6.5	9.5	8.2	8.2	7.0**
	Imm stalk						8.0	7.1**
	Leaves	Sucrose (%)	2.3	1.4*	3.9	2.2*	2.7	1.7**
	Imm stalk						2.9	2.7
	Stalk	Brix (%)	19.8	19.6	21.1	21.3	18.0	18.5*
	Lower stalk						21.4	22.0*
	Stalks	Sucrose (%)	17.9	18.0	19.5	19.8	15.0	15.7*
	Lower stalk						20.0	20.6
LHo83-153	Leaves	Brix (%)	7.0	6.3	8.1	8.1	7.5	6.7**
	Imm stalk						6.9	6.0**
	Leaves	Sucrose (%)	1.8	1.0	3.8	4.1	2.0	1.1*
	Imm stalk						2.0	1.2*
	Stalk	Brix (%)	20.1	20.6	21.1	21.2	18.7	18.0**
	Lower stalk						21.0	20.8
	Stalk	Sucrose (%)	18.5	19.2	19.9	19.9	16.8	15.6**
	Lower stalk						19.7	19.5

In the plant and first ratoon crops, the stalks were divided into mature stalk (stalk) and green leaves (leaves), which included some immature stalk. In the second ratoon, the green leaves (leaves) were separated from the immature stalk (imm stalk) and the lower six internodes (lower) were separated from the mature stalk (stalk).

* or ** = differences between infected and control plants significant at P = 0.05 or 0.01 respectively.

In an attempt to determine more specifically which components had changed because of infection by SCYLV, virus-infected and uninfected leaves were analysed for total polysaccharides, dextran, starch and oligosaccharides. Total polysaccharides and dextran did not differ between virus-infected and uninfected leaves, but there was a higher starch content in infected leaf tissue of all crops of LCP82-89 and the second ratoon crop of LHo83-153 (Table 4). No differences in the concentrations of these components were detected in juice from stalks of SCYLV-infected and uninfected plants. Differences in oligosaccharide content were not observed (data not shown).

Conclusions

Evidence is presented that yield may be reduced in SCYLV-infected sugarcane even when symptoms of YLS are not evident. Increased soluble solids (brix), including starch, were recorded in leaf tissue. This is a concern in sugar milling operations since it may result in a loss of recoverable sucrose and an increase in molasses. With mechanical harvesters, the leaves and immature stalk tissues are often not properly separated from the stalks and enter the milling process. The introduction of billet harvesters into the Louisiana sugarcane industry and an increase in the harvesting of unburned cane has resulted in more green leaf tissue being delivered to the mills. The results of this study suggest that leaves of SCYLV-infected plants may have a direct impact on cane and juice quality, and may affect boiling house efficiency.

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Table 4—Effect of SCYLV on concentrations of polysaccharides, dextran and starch in juice from sugarcane stalks and leaves, Experiment 2.

Cultivar	Tissue	Constituent (ppm)	Plant cane		First ratoon		Second ratoon	
			SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve	SCYLV +ve	SCYLV –ve
LCP82-89	Leaves	Total polysaccharides	18 921	19 614	20 772	21 987	25824	23 177
	Imm st						15 093	14 877
	Leaves	Dextran	3 581	3 712	4 090	4 711	1 831	2 365
	Imm st						2 360	3 198*
	Leaves	Starch	4 477	2 772**	1 951	1 489**	4 777	1 840**
	Imm st						3 039	1 396**
	Stalks	Total polysaccharides	1 338	1 342	2 413	2 484	1 868	1 902
	Lower						1 388	1 599
	Stalks	Dextran	488	473	990	963	540	847
	Lower						486	782
	Stalks	Starch	555	572	555	698	427	650
	Lower						314	485
LHo83-153	Leaves	Total polysaccharides	21 554	22 944	27 494	27 812	28 924	30 144
	Imm st						16 894	17 914
	Leaves	Dextran	2 617	3 676	3 709	3 035	1 054	1 285
	Imm st						2 261	2 530
	Leaves	Starch	3 869	3 290	1 975	1 677	3 350	1 626**
	Imm st						2 921	1 677*
	Stalks	Total polysaccharides	1 478	1 663	3 254	3 722	3 653	3 367
	Lower						2 043	2 252
	Stalks	Dextran	297	276	1 108	1 303	1 327	1 527
	Lower						541	703
	Stalks	Starch	1 486	1 563	1 795	1 843	1 958	2 257
	Lower						1 021	1 122

In the plant and first ratoon crops, the stalks were divided into mature stalk (stalk) and green leaves (leaves), which included some immature stalk. In the second ratoon, the green leaves (leaves) were separated from the immature stalk (imm stalk) and the lower six internodes (lower) were separated from the mature stalk (stalk).

* or ** = differences between infected and control plants significant at P = 0.05 or 0.01 respectively.

REFERENCES

Comstock, J.C., Irey, M.S., Lockhart, B.E.L. and Wang, Z.K. (1998). Incidence of yellow leaf syndrome in CP cultivars based on polymerase chain reaction and serological techniques. Sugar Cane, 1998 (4): 21–4.

Comstock, J.C., Irvine, J.E. and Miller, J.D. (1994). Yellow leaf syndrome appears on the United States mainland. Sugar J., 1994 (March): 33–5.

Cronjé, C.P.R., Bailey, R.A. and McFarlane, K. (1998). Update on the occurrence of yellow leaf syndrome in the South African sugar industry and evidence for the causal agent. Proc. S. Afr. Sug. Technol. Ass., 72: 81–4.

Cronjé, C.P.R. and Bailey, R.A. (1999). Association of phytoplasmas with yellow leaf syndrome of sugarcane. Proc. Int. Soc. Sugar Cane Technol., 23: 373–80.

Eggleston, G. and Clark, M.A. (1997). Applications of HPAE-PAD in the sugar industry. Seminars in Food Analysis, 2: 119–27.

Godshall, M.A., Clarke, M.A. and Dooley, C.D. (1990). Starch: process problems and analytical developments. Proc. Conf. on Sugar Processing Res., San Francisco, 1990: 244–64.

Legendre, B.L. (1992). The core/press method of predicting the sugar yield from cane for use in payment. Sugar J., 54 (9): 2–7.

Vega, J., Scagliusi, S.M.M. and Ulian, E.C. (1997). Sugarcane yellow leaf disease in Brazil: evidence of association with a luteovirus. Plant Dis., 81: 21–26.

L'EFFET DU VIRUS ASSOCIÉ AU SYNDROME DE LA FEUILLE JAUNE DE LA CANNE À SUCRE SUR LE RENDEMENT EN CANNE ET LA QUALITÉ DU JUS

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Résumé

En 1996, des plants de canne à sucre infectés par le virus associé au syndrome de la feuille jaune de la canne à sucre (SCYLV) furent observés pour la première fois en Louisiane. Des essais aux champs furent établis pour déterminer l'impact de la maladie sur l'industrie sucrière de Louisiane. Dans le premier essai, le rendement et la qualité du jus dans des cannes infectées et saines de la variété LCP82-89 furent comparés. Le rendement en sucre par unité de surface était réduit de 11% et 14% dans les première et deuxième repousses respectivement. Le nombre de tiges et le poids étaient inférieurs dans les cannes infectées par le SCYLV. Il n'y avait pas de différence entre cannes infectées et saines en ce qu'il s'agit des caractères associés à la qualité, % brix, % saccharose, % fibre et % pureté. Néanmoins, le % brix, % saccharose et % pureté étaient plus élevés dans la sève provenant des feuilles vertes de cannes infectées par rapport à celles provenant de cannes saines.

Dans un deuxième essai, la sève provenant des feuilles et des tiges de plantes infectées et saines des variétés LCP82-89 et LHo83-153 fut analysée en vierge, première et deuxième repousse. Aucune différence ne fut décelée dans les composantes de la qualité de la canne dans les deux variétés. Dans la sève des feuilles infectées par le virus SCYLV, la teneur en saccharose était plus élevée dans la variété LCP82-89 alors que le degré de pureté et l'amidon étaient plus élevés dans les deux variétés. Aucune différence ne fut décelée au niveau des polysaccharides et oligosaccharides pour les deux variétés. Le contenu en dextranes n'était d'aucune signification. Les premières feuilles vertes en haut de la tige sont en général enlevées durant la récolte mécanique; néanmoins, elles pourraient ne pas l'être si la canne est sujette à la verse. Les feuilles avec une teneur élevée en amidon, délivrées à l'usine, pourraient réduire l'efficience de l'usinage.

Mots clés: canne à sucre, syndrome de la feuille jaune, SCYLV, YLS.

EFECTO DEL VIRUS DE LA HOJA AMARILLA DE LA CAÑA EN LA PRODUCCIÓN Y CALIDAD DEL JUGO DE LA CAÑA AZÚCAR

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Resumen

En 1996, plantas de caña infectadas por el virus de la hoja amarilla (ScYLV), registrado como causal del síndrome de la hoja amarilla (YLS), se encontraron en Louisiana. Se establecieron experimentos en el campo para evaluar el impacto potencial de la enfermedad en la industria azucarera de Louisiana. En el primer experimento, la producción y calidad del jugo de las plantas infectadas y no infectadas del cultivar LCP82-89 fueron comparadas. Las producciones de azúcar por unidad de área se redujeron en 11% y 14% en la primera y segunda soca, respectivamente. El número de tallos y tonelaje se redujo en las parcelas con tallos infectados por el ScYLV. La calidad de los componentes de la caña, % brix, % sacarosa, % fibra y % pureza, no variaron entre las plantas infectadas y las sanas. Sin embargo, % brix, % sacarosa, y % pureza fueron mayores en el jugo obtenido del tejido de hojas de tallos infectados en comparación con el mismo tejido de plantas sanas. En un segundo experimento, jugo de hojas y tallos de plantas infectadas y sanas en plantilla, primera soca y segunda soca de los cultivares LCP82-89 y LHo83-153 fue analizado. Los componentes de la calidad de la caña no difirieron en ninguno de los cultivares. En el jugo proveniente de hojas infectadas por ScYLV, el % sacarosa fue mayor en LCP82-89 y el % pureza y las concentraciones de almidón fueron mayores en ambos cultivares mientras que las diferencias en polisacáridos y oligosacáridos totales no se detectaron. El contenido de dextrana fue inconsistente. Las hojas superiores son removidas de los tallos durante la cosecha mecánica, sin embargo, éstas no se pueden eliminar cuando los tallos se encuentran volcados. Al no poderse cortar éstas hojas van a la fábrica elevando los niveles de almidón que puede disminuir la eficiencia fabril.

Palabras claves: caña de azúcar, sindrome de la hoja amarilla, YLS.