CROP LOSSES DUE TO TWO SUGARCANE STEM BORERS IN REUNION AND SOUTH AFRICA

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Abstract

THE IMPACT on sugarcane yield of two key stem borer species, *Chilo sacchariphagus* and *Eldana saccharina,* were investigated over a period of 10 years in Réunion Island and South Africa. Replicated and randomised field plot trials were conducted. Treatments consisted of pest exclusion using concentrated and repeated chemical applications, of natural infestations, and of artificial inoculations to enhance these infestations. The relationship between borer injury (measured as percent bored internodes) and the corresponding stalk length and diameter, biomass, fibre and sugar content were determined. Borer injury impaired the growth and reduced quality of sugarcane stalks. *C. sacchariphagus* decreased stalk biomass to a greater extent than sucrose content. *E. saccharina* injury reduced sucrose content and increased fibre level, and affected to a lesser extent stalk biomass. Since *E. saccharina* typically attacks sugarcane early during the main period of biomass accumulation and *C. sacchariphagus* attacks later during the maturation phase, the timing of borer infestations might explain these results. Numerous components of stalk quality were negatively correlated to injury from both species. *Chilo sacchariphagus* impacted mostly sugarcane biomass while *E. saccharina* decreased sucrose content. Crop loss models, as well as the formulation of any IPM recommendation, would need to be specific to the borer species.

Introduction

The Asian spotted stem borer and the African stem borer, *Chilo sacchariphagus* (Lepidoptera: Crambidae) and *Eldana saccharina* (Lepidoptera: Pyralidae), are key pests of sugarcane; the first one occurring mainly in Mauritius, Réunion and Madagascar and Mozambique, the second in the west, east and southern Africa. Larvae feed on internal tissues, causing injury and yield decline. *Chilo sacchariphagus* typically attacks 3 to 7 month old plants whereas *E. saccharina* attacks older plants. In South Africa, *E. saccharina* has been the subject of intensive research into plant resistance, biological control, insecticide and cultural control (Conlong, 1994); however, the pest persists as a major constraint to sugarcane production. Definitive control strategies remain to be developed. Similarly, *C. sacchariphagus* continues to cause economic losses in Réunion (Goebel *et al*., 1999). The CIRAD and its partners have released *Trichogramma chilonis* to control this borer since 2000. Between 2003 and 2005, the efficacy of field releases of 100 000 to 200 000 *T. chilonis* per hectare was demonstrated in experimental plots. Therefore, this biocontrol program will be implemented in most of the sugarcane areas on the islands in the future (Goebel and Tabone, 2005).

Different approaches are traditionally adopted to assess crop losses due to insect injury. Manipulations of pest pressure in the field through insecticide applications and/or artificial infestations are often adopted (Walker, 1987). A successful protocol has been developed on Réunion Island to compare naturally infested plots, artificially infested plots, and plots treated with insecticides (Goebel *et al*., 1999).

This protocol was later implemented to study crop losses caused by *E. saccharina* in Kwazulu-Natal province, South Africa (Goebel and Way, 2003). The methodology of applying insecticides and artificial techniques to enhance pest pressure has been employed in cotton, sorghum, and maize trials (Walker, 1987). These newly developed techniques have addressed the problems encountered in past crop loss trials, where only single stalks with or without injury were compared. Major inaccuracies were produced because of the inherent variability in the characteristics of sugarcane stalks (Ellis *et al.*, 1959; Gonzales *et al*., 1977; Rajabalee *et al.*, 1990; Way, 2001). The field trials reported hereafter were conducted primarily to investigate how sugarcane yield components and juice quality are affected by borer injury. Because *C. sacchariphagus* attacks the crop at different periods of the growth cycle than *E. saccharina*, differences in responses were expected. These trials were also conducted in order to estimate injury-loss relationships for these borers, which are required to develop economic injury levels (EIL). Economic injury levels determine whether control options are warranted and, if so, the optimal time to initiate control measures (Pedigo *et al*., 1986). This work contributes towards our understanding of the relationship between borer infestation and yield losses. Here we provide an overview of the information obtained over several seasons from various trials conducted in Réunion and in South Africa.

Material and methods

From 1995 to 1998, field trials were conducted in sugarcane-growing areas of Sainte-Marie on the north coast and Saint-Paul on the west coast of Réunion Island. Similar crop loss trials were conducted on the SASRI experimental farms situated at Gingindlovu and Empangeni, in KwaZulu-Natal, South Africa during 2001 to 2005. In all trials, some plots were artificially infested with borers to increase infestation levels, and compared with plots treated with insecticides. For experiments conducted in Réunion, the widespread variety R579 (rated susceptible to *C. sacchariphagus*) was studied. In South Africa, NCo 376 (rated intermediately susceptible to *E. saccharina*) was studied. Plots were arranged in randomised complete block designs with 4 and 5 replicates in Réunion and South Africa, respectively. Plots were 60 m^2 in Réunion and 120 m^2 in South Africa. All plots were separated by 2 rows to minimise cross contamination.

The treatments consisted of naturally infested plots (T1), artificially infested plots (T2), and intensively protected plots (T3), which were treated with deltamethrin (12.5 g a.i. /ha) using a knapsack every 14 days and throughout the sugarcane growth. In Réunion, seventeen applications were applied from 2 to 10 months after harvest while, in South Africa, twelve applications from 4 to 9 months were applied. Inoculations involved either borer eggs placed between the stalk and leaf sheath (technique employed only in South Africa), or 3^{rd} instar larvae were forced to penetrate through the stem using a centrifugation tube inserted in an artificial hole made by drilling. Only the centre row was inoculated.

Inoculations were carried out either early or later during the crop cycle to investigate when borers are the most damaging to the crop. For *C. sacchariphagus* in Réunion, the trials conducted in 1995/96 and 1996/97 compared early insecticide applications (T2-30: five applications starting at 30 days after harvest) and late infestation (T2-90: five applications starting at 90 days after harvest). For *E. saccharina* in South Africa, the trials conducted in 2004/05 compared the effect on yield of early and late infestations, with artificial inoculation at 5 months in the crop cycle and a later one at 10 months.

Borer damage levels were assessed only in the centre row of each plot in 120 millable stalks. Stalks were harvested at ground level and removed to measure stalk length, stalk diameter, and stalk weight. Each stalk was then split longitudinally to count the number of internodes bored and the number of larvae infesting the stalk. Bundles of stalks were analysed in the laboratory to determine the different stalk parameters. The following were recorded: dry matter, sucrose, purity, fibre, Pol % cane, Brix % cane. Yields in tonnes per hectare (t/ha) were estimated from the stalk sample.

The effects of treatments on yield were compared using analysis of variance (ANOVA) with SAS software (SAS institute, 1999). Percent borer internodes were performed using the arcsine transformation before all statistical analysis, but are presented as untransformed means. The relationship between the percentage of bored internodes (independent variable) and yield characteristics (dependent variable) were determined by pooling partial or complete sets of data from each trial and, when no significant effect between blocks was observed, for each year. Regressions were fitted using general linear model (GLM). Another approach employed was to create injury-level classes by grouping stalk samples into 5% internodes bored increments (i.e., 0–5%, 6–10% ... 41–50%) according to Fuller et *al.* (1988). Data were subjected to GLM model analyses and regressions performed. Differences between harmonic means were identified using Duncan's multiple range test.

Results

Table 1 summarises the results of the injury and losses recorded in various trials conducted in Réunion and South Africa.

Table 1—Damage level and loss caused by *Chilo sacchariphagus* and *Eldana saccharina.*

Season	Locality	% Internodes bored*	Loss in cane mass in t/ha (%)**	Loss in sucrose in t/ha (%)**
C. sacchariphagus: Réunion				
1995/96	Sainte-Marie	13.3	28.6 (25.9%)	4.3 (27.9%)
	Saint-Paul	27.2	40.0 (26%)	4.7 (24.2%)
1996/97	Sainte-Marie	10.6	31.0 (22.9%)	4.8 (26.8%)
	Saint-Paul	5.0	8.8 (5.8%)	0.0
1997/98	La Bretagne	20.7	28.3 (21.2%)	4.2 (24.3%)
E. saccharina: South Africa				
2001/02	Gingindlovu	18.4	12.2 (15%)	3.4 (28%)
	Empangeni	17.4	8.6 (9.9%)	2.6 (22%)
2002/03	Gingindlovu	31.3	8.4 (31 %)	1.7 (50%)
	Empangeni	8.6	7.9 (9.8%)	1.2 (17%)
2004/05	Gingindlovu	14.0	7.6 (17%)	1.2 (21.4%)

* Level obtained from the most injured plots

** % Yield loss: Yield from protected plots (T3) – Yield from infested plots/ Yield from protected plots x 100

The impact on sugarcane yield was generally high at all sites where high infestation levels were observed. *C. Sacchariphagus* had a clear impact on cane weight, with a greatest reduction of 40 t/ha (26%) observed at Saint-Paul compared to a maximum yield of 160 t/ha in the treated plots. In that particular trial, losses in tonnes of sucrose are also expected as a consequence of losses in stalk weight. In South Africa, *E. saccharina* had a greater impact on sucrose yield compared to cane weight, with a decrease of 21.4 to 50% in highly infested plots. In all trials, insecticide applications maintained very low levels of injury with corresponding high yields.

Impact on cane yield components

Table 2 shows the effect of different treatments on a range of yield parameters (stalk length, diameter and weight.

In South Africa, artificially infested plots had high injury levels compared to naturally infested plots, demonstrating the success of the inoculation technique employed. In Réunion, insecticide treatments applied from 3 to 5 months yielded the best results compared to early applications from 1 to 3 months.

These results are consistent with the oviposition period of *C. Sacchariphagus* that generally begins at 3 months. Differences in stalk weight, length, and diameter were significant between treated and infested plots.

This was particularly evident in the case of *C. sacchariphagus*. In South Africa, experimental trials pointed out that the most affected parameter was the sucrose yield.

Similar results were obtained with both borer species in all trials when relatively high infestations were recorded (Table 1). They have already been reported by Goebel *et al.*, (1999); Goebel and Way (2003 and 2006).

Table 2—Effect of different treatments on borer injury, stalk characteristics and yield.

Plot/ treatment	Internodes bored (%)	Stalk length (cm)	Stalk diameter (cm)	Stalk weight (g/stalk)	Yield (t cane/ha)	Sucrose (t/ha)
Chilo sacchariphagus: Réunion, Sainte-Marie, 1995/96 trial						
T1	13.3 a	213.5 d	3.05 b	1400 c	81.1 b	11.1 c
T2-30	8.9 b	223.5 c	3.22 a	1558 b	89.7 b	12.7 bc
T2-90	2.5 c	233.6 b	3.26 a	1780 a	104.8 a	14.6 ab
T3	2.1 c	244.5 a	3.36 a	1910 a	110.4 a	15.4 a
F	47.5	21.4	7.3	20.7	12.03	10.00
P	0.0001	0.0001	0.0001	0.0001	0.0001	0.0032
Eldana saccharina: South Africa, Gingindlovu, 2001/02 trial						
T1	6.2 b	135.5 a	2.14 a	513.8 b	73.2 b	10.8 b
T2	18.4 a	129.4 b	2.05 b	459.2 b	67.7 c	8.9 c
T3	2.1 b	140.7 a	2.19 a	566.9 a	79.9 a	12.3 a
F	39.1	5.78	4.94	7.80	25.50	46.53
P	0.0001	0.0280	0.0040	0.0132	0.0003	<0.0001

T1 = natural infestation; T2 = artificial infestation (South Africa); T2-30 = 5 insecticide applications from 30 days after harvest (Reunion); T2-90 = 5 insecticide applications from 90 days after harvest (Reunion); T3 = intensive protection (both countries). Means followed by the same letter are not statistically different (P>0.05, Student-Newmans-Keuls).

Sucrose and fibre

In plots with relatively high *E. saccharina* infestations, the quality of sugar and sugar contents were significantly reduced compared to protected plots (Table 3).

Fibre content was found to be always higher in infested plots. Conversely, *C. sacchariphagus* injury had a marginal impact on juice quality, and only a slight effect on fibre content. Again, these results were expected given the timing of attack.

Table 3—Effect of different treatments on fibre and sucrose contents

Plot/ treatment	Internodes bored (%)	Fibre%cane	Brix%cane	Pol%cane	Purity	Sucrose %cane
Chilo sacchariphagus: Réunion, Sainte-Marie, 1995/96 trial						
T1	13.3 a	15.4 a	19.7 a	18.3 a	92.5 a	13.4 a
T2-30	8.9 b	14.0 b	20.3 a	18.4 a	93.0 a	14.0 a
T2-90	2.5 c	14.6 ab	20.2 a	18.7 a	92.6 a	14.2 a
T3	2.1 c	13.7 b	20.0 a	18.4 a	92.2 a	14.0 a
F	47.5	5.41	1.29	1.36	3.16	2.36
P	0.0001	0.0211	0.3300	0.3152	0.0786	0.1392
Eldana saccharina: South Africa, Gingindlovu, 2001/02 trial						
T1	6.2 b	13.0 b	16.3 a	14.7 a	90.3 a	13.4 a
T2	18.4 a	13.8 a	15.1 b	13.2 b	86.9 b	11.6 b
T3	2.1 b	12.6 b	16.4 a	14.8 a	90.5 a	13.5 a
F	39.1	6.56	8.34	17.71	20.23	22.68
P	0.0001	0.0206	0.0111	0.0012	0.0007	0.0005

T1 = natural infestation; T2-30 = 5 insecticide applications from 30 days after harvest (Reunion); T2-90 = 5 insecticide applications from 90 days after harvest (Reunion); T3 = intensive protection (both countries). Means followed by the same letter are not statistically different (P>0.05, Student-Newmans-Keuls).

Injury and yield relationships

Table 4 summarises correlations obtained in the trials during 1995/96 in Reunion and during 2001/02 in South Africa.

Table 4—Comparison of stalk components and juice quality as functions of borer injury using the general linear model analysis.

	C. sacchariphagus (1995/96 trial)			*E. saccharina* (2001/02 trial)		
Dependent variable	R^2	*F*	*P*	R^2	*F*	*P*
Stalk mass	0.33	238.85	0.0001	0.17	94.70	0.0001
Stalk length	0.28	186.53	0.0001	0.10	60.36	0.0001
Stalk diameter	0.12	66.59	0.0001	0.04	28.77	0.0001
Sucrose weight	0.03	21.67	0.0001	0.39	291.34	0.0001
ERC % cane	0.014	14.30	0.0002	0.50	451.58	0.0001
Purity	0.011	11,71	0.0007	0.36	261.16	0.0001
Fibre	0.082	42.00	0.0001	0.31	204.90	0.0001

Regressions for *C. sacchariphagus* and *E. saccharina* were performed on 480 observations

In all the trials conducted in Réunion, a highly significant relationship was obtained between *C. sacchariphagus* injury and stalk mass and height and, to a lesser degree, with stalk diameter (Table 3). As expected, juice quality, i.e. brix, pol, purity, and sucrose content were poorly correlated with *C. sacchariphagus* injury, except for fibre content where the correlation was found to be a bit stronger. In the instance of *E. saccharina*, estimable recoverable crystal (ERC % cane), juice purity, sucrose and stalk weight were negatively correlated with the percentage of bored internodes. As predicted, fibre content was positively correlated with injury. As opposed to *C. sacchariphagus*, the correlation with stalk parameters was weaker. Results were similar in other trials.

Loss estimation

Table 5 shows the extent that *C. sacchariphagus* injury affected yield for the 1995/96 trial in Réunion. Uninfested stalks obtained from the protected plots were considered as the optimal yield achievable in the absence of the pest. Accordingly, the variable 'yield loss' was calculated as the difference between the yield in each successive injury level classes and the control.

Table 5—Effects of *C. sacchariphagus* on cane yield at Saint-Marie, Réunion, in 1995–96.

% Internodes bored increment	N	% Internodes bored	Stalk mass (kg)	Yield (t/ha)
0	256	0.0	1.90 a	127.1
1–5	47	4.6	1.89 a	126.7
6–10	49	8.3	1.62 ab	108.8
11–15	49	13.1	1.37 bc	91.7
16–20	30	18.5	1.12 cd	75.5
21–25	25	23.1	1.10 cd	73.4
26–30	11	27.3	0.87 de	58.5
+31	13	39.1	0.76 e	50.8

For each variable, the means (stalk mass) followed by the same letter are not statistically different ($P>0.05$, Duncan's multiple range test). Anova: df = 472; F = 35.72; P= 0.0001

Linear regressions showed that yield losses due to *C. sacchariphagus* can be calculated using the following equations at Sainte-Marie for 1996 ($Y= -6.7 + 2.8x$; $r^2 = 0.96$); Saint-Paul for 1996 ($Y= -25 + 2.1x$; $r^2 = 0.99$) and La Bretagne for 1998 ($Y = -17.3 + 2.2x$; $r^2 = 0.97$). For example at Sainte-Marie, 16% losses are expected with 10% bored internodes, 38.8% with 20% and 60.8% with 30%. In this particular trial, an estimated decrease of 2.8 t/ha in cane weight could be expected for each additional percent internodes bored. The other loss equations provide lower yield reduction at Saint-Paul and La Bretagne.

Eldana saccharina loss regressions using injury classes in the 2001/02 trial show: ERC% ($Y = 0.10x - 0.24$; $r^2 = 0.98$); cane yield (Y t/ha = $0.48x + 3.76$; $r^2 = 0.90$) and sugar yield (Y t/ha = $0.11x + 0.07$; $r^2 = 0.99$). Accordingly, at 10% internodes bored, a decline of 0.76 units (5.5%) of sucrose recovery (or ERC as measured in South Africa) can be expected in the NCo 376 crop. This is equivalent to 8.5 t/ha of cane yield (11.2%) and 1.2 t/ha of sugar yield (11.1%). At 20% bored internodes, the ERC loss increases to 1.8 units, which equates to 13.4 t/ha for cane yield and 2.3 t/ha sugar. Regarding both of these sugarcane borers, the GLM analysis did not illustrate a significant yield loss below 5% of internodes bored. This concurs with previously published data.

Discussion

The overall results clearly show the importance of considering all aspects of loss, including quality (sucrose) and sugarcane biomass. Feeding by borer larvae reduced the size and mass of sugarcane stalks in addition to the quantity of juice. Infested stalks contained higher levels of gums and non-sugar juice components. The presence of borers retarded stalk maturation. Goebel *et al.* (1999) observed that the presence of *C. sacchariphagus* influences sugarcane plant physiology in a similar manner as water stress, particularly when internodes become severely dry during the growth phase. Similar symptoms were reportedly caused by *Diatraea saccharalis* (Charpentier *et al.*, 1965).

Regression analysis confirmed that plant biomass is significantly reduced by *E. saccharina*. Such an 'essential loss' has often been omitted from the majority of the previous crop loss studies. Sucrose content, which is affected to a greater extent, was in the past the valuable component of the crop. However, the recent interest in producing ethanol from sugarcane may result in a change in emphasis.

The impact caused by *C. sacchariphagus* on cane weight, and to a lesser extent by *E. saccharina*, suggested that these borers might have caused adverse effects on normal plant growth and physiology, as reflected by a significant reduction in stalk length and diameter (Goebel *et al.*, 1999, Goebel and Way, 2003; Goebel and Way, 2006). Any reduction in plant biomass seems to depend on the time that the borer attacks during the crop cycle. Early infestations generally appear to have a greater impact on cane weight at harvest compared to later infestations (Goebel and Way, 2006). For this reason, control strategies developed against *C. sacchariphagus* in Réunion have been focused on early infestations, for example, releasing egg parasitoids in the early phase of the crop cycle. The objective is to prevent borer populations from increasing, thereby avoiding high infestations and related yield losses (Goebel and Tabone, 2005).

The impacts on quality of sugar and related stalk components are more relevant in the case of *E. saccharina* injury (Goebel and Way, 2003) due to late infestations and subsequent adverse effects on sucrose. No significant impact of *C. sacchariphagus* on sucrose parameters was shown from all the trials conducted in Réunion. Infestation by either borer species caused an increase in percent fibre. This is partially due to a reduced water uptake. *Diatraea saccharalis* (Hensley, 1971) and *Eoreuma loftini* (Legaspi *et al.*, 1999) have similar detrimental effects on stalk parameters in sugarcane.

Previous crop loss studies in sugarcane were based on assessing single stalks obtained from fields with varying degrees of injury (Martorell and Bangdiwala, 1954; Ellis *et al.*, 1959; Gonzales *et al.*, 1977; Rajabalee *et al.*, 1990; Way, 2001). While this technique can be used to demonstrate a reduction in sucrose, it fails to illustrate the reduction in stalk weight because of the large variability inherent in the stalks in each sample (Goebel and Way, 2003). Experience has shown that it is difficult to detect losses in stalk weight in field crops with precision. Dedicated and intense trials are therefore required where stalks within the same population are sampled. The trials completed in Reunion and in South Africa have addressed this major shortcoming.

A further important aspect to consider from this work is the success of the insecticide application technique. Such treatments suppressed the pest in a manner that cannot be guaranteed in plots subject to natural infestations. Moyal (1998) used the same technique to exclude maize stem borers in Côte d'Ivoire.

In South Africa, the loss attributed to *E. saccharina* from these particular studies was estimated at approximately 143 000 tonnes Recoverable Value (RV) for the 2003/2004 milling season. This figure equates to an estimated R153 million or approximately 15 million Euros (Goebel *et al.*, 2005), which is more than the R50-60 million previously estimated (Way, 2001).

In Réunion, *C. sacchariphagus* annual losses have been estimated at 8 to 10 million Euros. This figure varies depending on the area cultivated to the more susceptible R579 variety (Goebel and Tabone, 2005). Crop loss equations derived from this research have been used to estimate theoretical economic injury levels (Goebel *et al.*, 1999; Goebel *et al.*, 2005). These thresholds can be used as a guide when decisions are made in the respective sugar industries.

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BAISSES DE RENDEMENTS CAUSÉES PAR DEUX FOREURS DE TIGE DE CANNE À SUCRE À LA REUNION ET EN AFRIQUE DU SUD

Par

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MOTS CLÉS: Canne à Sucre, Foreur de Tige, Infestation Artificielle, Dégât, Perte de Rendement.

Résumé

L'IMPACT sur le rendement de la canne à sucre de deux espèces importantes de foreur de tige, *Chilo sacchariphagus* et *Eldana saccharina*, a été examiné sur une période de 10 ans à l'Ile de la Réunion et en Afrique du sud. Des essais sur parcelles distribuées de manière aléatoire et avec répétitions furent menés au champ. Les traitements consistaient en l'exclusion des ravageurs au moyen d'applications chimiques concentrées et répétées, d'infestations naturelles, et d'inoculations artificielles pour améliorer les infestations. L'effet des dégâts causés par le foreur (mesuré en termes de pourcentage d'entrenœuds perforés) sur la longueur et le diamètre de la tige, la biomasse, et la teneur en fibre et sucre, fut déterminé. Les dégâts causés par les foreurs résultèrent en une diminution de croissance et de qualité des tiges de canne. L'effet néfaste de *C. sacchariphagus* sur la biomasse des tiges était supérieur à celui sur la teneur en saccharose. Les dégâts causés par *E. saccharina* ont réduit le taux de saccharose et augmenté la teneur en fibre mais ont affecté dans une moindre mesure la biomasse des tiges. Ces résultats pourraient être expliqués par la période à laquelle les attaques de foreurs se font dans le cycle de la canne. *E. saccharina* attaque la canne à sucre tôt pendant la période principale d'accumulation de biomasse, tandis que, l'infestation causée par *C. sacchariphagus*, se fait plus tard, pendant la phase de maturation. Une corrélation négative a été démontrée entre les nombreux paramètres liés à la qualité des tiges et les dégâts causés par les deux espèces. *Chilo sacchariphagus* affectait principalement la biomasse de la canne à sucre alors que l'attaque de *E. saccharina* diminuait la teneur en saccharose. Tout modèle de pertes de rendements, ainsi que la formulation des recommandations de lutte intégrée, devraient être spécifiques à l'espèce de foreur.

PÉRDIDAS DEBIDAS A DOS BARRENADORES DEL TALLO EN REUNIÓN Y SUD ÁFRICA

Por

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PALABRAS CLAVE: Caña de Azúcar, Barrenadores del Tallo, Infestación Artificial, Daño, Pérdidas de Cosecha.

Resumen

SE INVESTIGÓ durante un periodo de 10 años, el impacto que tienen dos especies importantes de barrenadores, *Chilo sacchariphagus* y *Eldana saccharina*, sobre la producción de caña de azúcar, en la isla de Reunión y Sudáfrica. Se realizaron ensayos en parcelas de campo, al azar y con repeticiones. Los tratamientos consistieron en la exclusión de la plaga a través de la aplicación concentrada y repetida de insecticidas sobre las infestaciones naturales, y de inoculaciones artificiales para aumentar estas infestaciones. Se determinó la relación entre el daño del barrenador (expresado en términos del porcentaje de entrenudos barrenados) y el correspondiente valor del diámetro y del largo de los tallos, biomasa, fibra y contenido de azúcar. El daño que causa el barrenador afectó el crecimiento y redujo la calidad de los tallos de la caña de azúcar. *C. sacchariphagus* redujo la biomasa de los tallos en un mayor grado que el contenido de azúcar. El daño causado por *E. saccharina* redujo el contenido de sacarosa y aumentó el contenido de fibra, y afectó en un menor grado la biomasa de los tallos. Puesto que *E. saccharina* ataca típicamente a la caña de azúcar en las etapas iniciales del principal período de acumulación de biomasa, y que *C. sacchariphagus* ataca tardíamente durante la fase de maduración, el momento en que ocurren las infestaciones del barrenador podrían explicar estos resultados. Varios componentes de la calidad de los tallos estuvieron correlacionados negativamente con el daño causado por ambas especies. *Chilo sacchariphagus* tuvo efecto más que todo sobre la biomasa de la caña de azúcar, en tanto que *E. saccharina* redujo el contenido de azúcar. La modelación de las pérdidas de cosecha, al igual que la formulación de cualquier práctica de MIP, debe ser específica a la especie del barrenador considerada.