AN ASSESSMENT OF THE LOSS IN SUCROSE YIELD CAUSED BY THE STALK BORER, *ELDANA SACCHARINA*, IN SWAZILAND

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Abstract

A series of assessments were initiated to determine the crop losses caused by the stalk borer *Eldana saccharina* Walker (Lep: Pyralidae) in Swaziland. Results indicate that losses in yield of recoverable sucrose amount to about 1% for every 1% internodes damaged. Losses resulted largely from adverse effects on cane quality (reduced brix, pol and purity and increased fibre % cane). Reductions in cane mass were also apparent, but were only significant in cane harvested towards the end of the season. Two varieties were examined and both appeared to be affected to a similar extent. Problems associated with the method used to estimate these losses are discussed.

Introduction

Since the presence of eldana borer (*Eldana saccharina* Walker) was first recorded in Swaziland in 1972 (Carnegie[1]) it has become widely distributed throughout the industry. Millyard surveys (Fig 1, 2 and Table 1) have shown that levels of infestation are generally low, although there is considerable variation between areas and within each season.

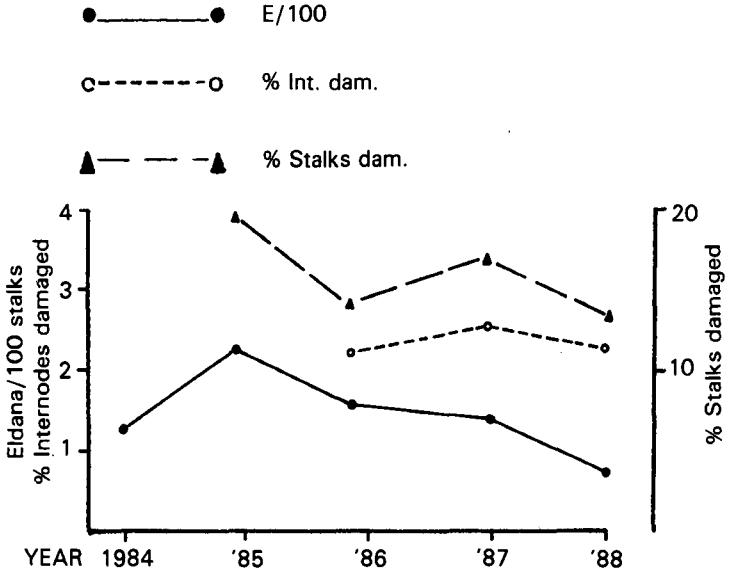

FIGURE 1 Annual trends in eldana levels and associated damage in Swaziland (1984–1988).

Table 1

Comparison of Eldana levels between mills (1985/1988)

Region	Mill	Eldana/100 stalks	% Stalks damaged	% Internodes damaged
North	Mhlume	2,20	19,48	2,77
North	Simunye*	—	—	2,91
South	Ubomo	0,75	11,82	1,34

* Approximately 80% of the cane delivered to the Simunye Mill is billeted and % Internodes damaged is the only measure than can be used for comparative purposes.

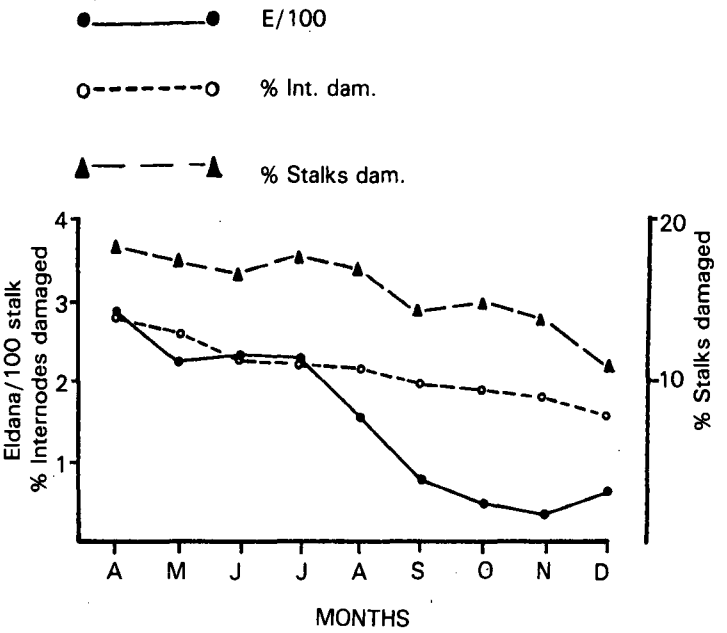

FIGURE 2 Seasonal trends in eldana levels and associated levels of damage in Swaziland (1985–1988).

Eldana is nevertheless considered to be the major pest of sugarcane, especially in the north of the country where large areas of cane are grown on stress-prone duplex soils, and where instances of very heavy infestation occur periodically.

The economic losses attributable to the pest are a continuing cause for concern and became the subject of numerous studies following a widespread increase in eldana levels during the 1985 season. Initial work carried out at Mhlume Sugar Company confirmed findings of Waiyaki,[4] Smaill and Carnegie[3] and demonstrated that losses could be considerable and resulted largely from an adverse effect on cane quality (Workman, Myeni, unpublished results). A relationship between level of damage and cane yield has been proposed by Nuss *et al*[2] and more recently by Nixon (unpublished) together with indications that the combined effects on yield and quality may vary for different varieties.

The purpose of the work described here was to confirm these findings and to provide a standard by which the relative importance of the pest can be established in Swaziland.

Method

Estimates of crop loss were obtained by comparing samples having varying levels of internode damage with samples of undamaged stalks. The procedure outlined below was repeated on three occasions during the harvesting season viz. early (May), mid (August) and late (November) and on each occasion on two sugarcane varieties (NCo376 and N14).

The procedure comprised 4 stages:

1. Selection of sample, examination of stalks and sorting according to number of internodes damaged per stalk
2. Preliminary sampling to determine the yield and quality characteristics of each category of damage
3. Determination of the relationship between % internode damage and frequency of occurrence of stalks with increasing numbers of internodes damaged
4. Assessment of the effect of % internode damage on yield of recoverable sucrose which was carried out as follows:
   - by making up samples with predetermined levels of % internodes damaged using the relationship shown in Appendixes 1 and 2
   - by calculation

Selection, examination and sorting of stalks.

- Cane was selected from a commercial field which was known to have a level of internode damage of between 5 and 10%. The field was examined prior to harvest and 5 - 10 tons of cane was loaded mechanically from the windrow at a site previously selected for uniformity of growth
- The lower portion of each stalk was split longitudinally from the base upwards and examined for signs of eldana damage (borings and associated red discoloration)
- Each stalk was then placed in a category based on the number of internodes damaged.

Preliminary sampling:

Samples of 40 stalks were taken at random from each category of damage. In practice stalks with more than 4 internodes damaged were relatively scarce and samples were taken only from categories of 0, 1, 2, 3, and 4 internodes damaged. The samples were subdivided into 4 replicates of 10 stalks. Measurements of stalk diameter and length were taken before the samples were weighed and sent to the laboratory for analysis of cane quality.

Determination of the distribution of damage within samples of differing % internodes damaged:

Two sets of survey data were examined to determine the relationship between % internodes damaged and the frequency of occurrence of stalks with differing amounts of damage. The data were obtained from:

- Pre-harvest field surveys at Mhlume Sugar Company in 1987
- Millyard surveys at the Mhlume Mill during the 1987 season

The data indicate consistent relationships which are summarised in Appendices 1 and 2. A comparison of the relationship at two levels of % internode damage is shown in Figure 3.

Assessment of the effect of % internode damage on yield of recoverable sucrose.

- Samples of predetermined levels of % internode damage from 0 to 20% were made up by mixing different amounts of stalks from each category of damage in accordance with the relationships in Appendices 1 and 2. Each sample, representing a specific level of % internode damage comprised 20 stalks and was replicated 5 or 6 times. Samples were measured and weighed before being analysed for cane quality

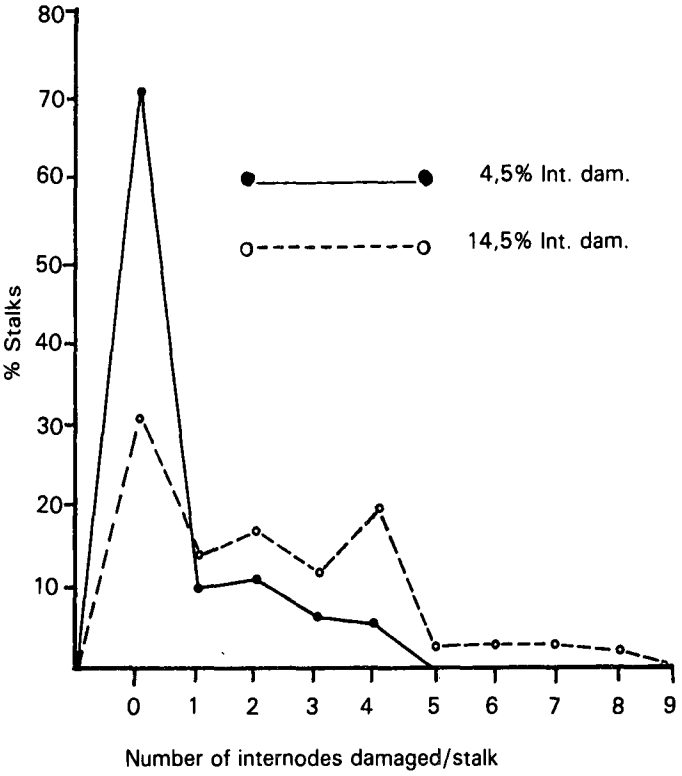

FIGURE 3 An example of the different frequencies of occurrence of stalks with increasing numbers of internodes damaged at two levels of % internodes damaged (from Appendix 2).

- Estimates of the effects of varying levels of % internode damage were calculated. In this exercise the yield and quality information from the preliminary samples was used together with the relationships in Appendices 1 and 2. Weighted means were derived for cane weight, ers % cane and g ers/stalk for specified levels of % internodes damaged.

Results

Analysis of stalks with increasing numbers of internodes damaged. (Preliminary samples).

Stalks with increasing levels of damage yielded progressively less recoverable sucrose compared with the undamaged controls (Fig 4). Both cane mass and quality were lower,

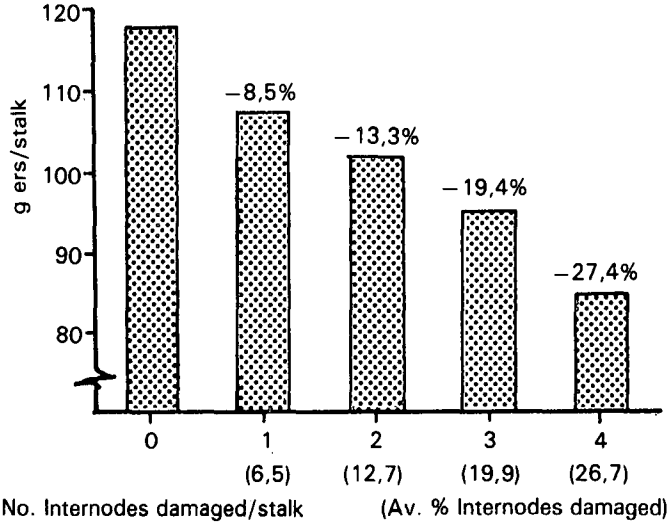

FIGURE 4 The effect of increasing numbers of internodes damaged by eldana on yield of recoverable sucrose per stalk.

although it was apparent that the effect on cane quality was more important and on average accounted for approximately 60% of the difference.

Cane quality

Stalks with increasing amounts of damage had lower brix % cane while fibre % cane was apparently unaffected except at the highest level of damage where it increased marginally. Moisture content was unaffected and if anything showed a tendency to increase with increasing damage. Poorer cane quality was further characterised by lower sucrose % cane and a lower juice purity.

The major effects on cane quality were generally well correlated with amount of damage (Table 2). It was also apparent that dry matter % was reduced with increasing damage.

Cane mass

Cane mass was affected to a lesser degree than cane quality, and measurements indicated that the tendency for the more severely damaged stalks to weigh less was more a function of reduced stalk height than reduced diameter.

Results indicated that the two varieties were affected similarly and that the adverse effects, on cane mass in particular, were more pronounced in the samples taken late in the season.

Effects on yield and quality of % internodes damaged

The results from samples (Table 3) showed that yield of recoverable sucrose was negatively correlated with increasing levels of % internodes damaged (r = −0,84 average). The magnitude of the reduction averaged 1,03% for every 1% internodes damaged and in the most severely damaged samples losses of up to 25% were recorded (Figure 5). Both cane mass and quality were adversely affected, although reductions in cane quality were more consistent (r = 0,96) and appeared to account for the greater proportion of the total loss.

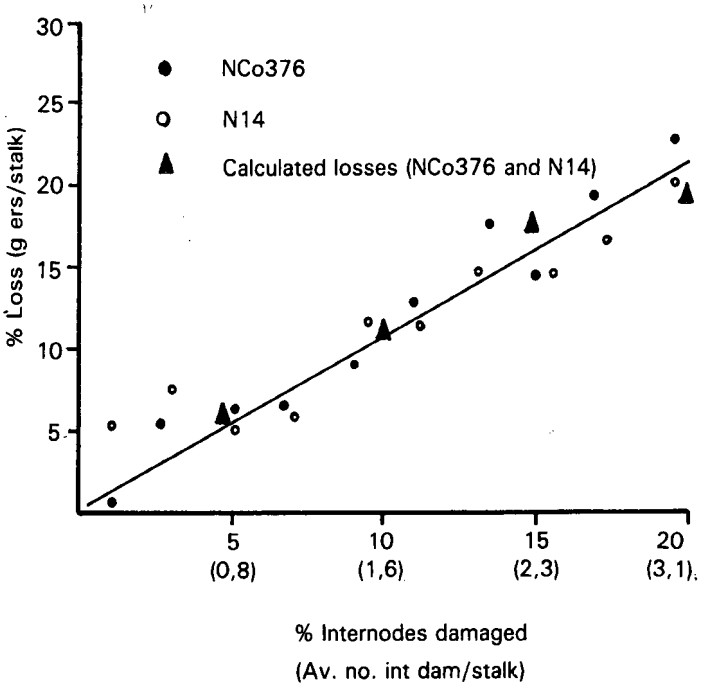

FIGURE 5 The relationship between % internodes damaged by eldana and % loss in recoverable sucrose.

Table 2

Yield characteristics of stalks with increasing numbers of internodes damaged by eldana (Correlation and regression co-efficients r & b).

No. of internodes damaged per stalk	Stalk measurements				Cane quality						
	Number of internodes	Stalk length (m)	Stalk width (cm)	Stalk mass	Moisture % cane	Dm % cane	Fibre % cane	Brix % cane	Purity % cane	Pol % cane	Ers % cane
0	15,7	1,94	2,10	846	66,45	33,55	16,01	17,54	88,38	15,50	13,82
1	15,5	1,88	2,09	804	66,88	33,11	15,93	17,18	87,52	15,03	13,31
2	15,8	1,87	2,04	794	67,27	32,72	16,03	16,69	87,19	14,55	12,84
3	15,2	1,82	2,07	771	67,59	32,41	15,98	16,43	85,68	14,06	12,24
4	15,2	1,84	2,09	737	67,70	32,30	16,46	15,84	84,51	13,36	11,49
			r	0,98	–	–	–	−0,99	−0,98	−0,99	−0,99
			b	−0,04	–	–	–	−0,06	−0,14	−0,08	−0,09
			s(b)	0,004	–	–	–	0,004	0,015	0,003	0,004

Table 3

Correlation and regression co-efficients (r & b, intercept a) showing the relationship between % internodes damaged by eldana and cane mass, ers % cane and g ers/stalk.

Variety/ Season	Stalk mass (g)				Ers % cane				Ers per stalk (g)			
	r	a	b	s(b)	r	a	b	s(b)	r	a	b	s(b)
NCo376	−0,63	683	−3,0	0,9	−0,96	12,95	−0,11	0,012	−0,92	89	−1,06	0,14
N14	−0,42	828	−2,0	1,8	−0,96	13,63	−0,09	0,010	−0,75	114	−1,04	0,26
Early	−0,01	661	0,1	1,5	−0,97	11,27	−0,08	0,007	−0,69	75	−0,51	0,17
Mid	−0,48	858	−2,0	1,6	−0,96	15,00	−0,12	0,012	−0,86	129	−1,28	0,26
Late	−0,92	748	−5,5	0,9	−0,94	13,60	−0,10	0,014	−0,94	102	−1,37	0,17
Mean	−0,52	756	−2,5	1,4	−0,96	13,29	−0,10	0,011	−0,84	102	−1,05	0,20

The effects of season (Figure 6) were significant and results showed that yield losses were greater in cane harvested late in the season. This was largely due to an effect on cane mass, although in some instances cane quality also was affected.

There were indications that yield losses were greater in NCo376 than in N14.

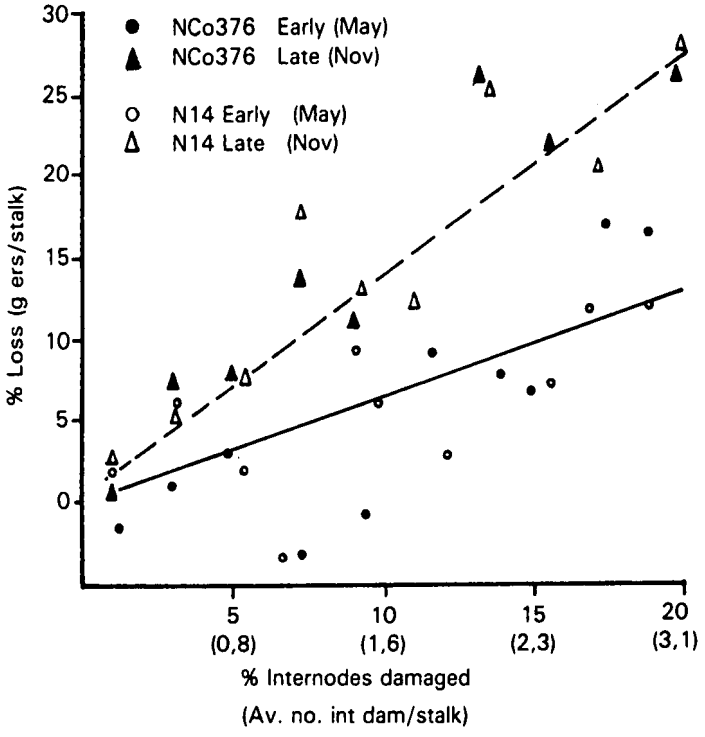

FIGURE 6 Seasonal differences in the relationship between % internodes damaged by eldana and % loss in recoverable sucrose.

Cane mass

The mass of cane sampled early in the season was not significantly affected by the level of damage. Cane mass was increasingly reduced in the later samplings, however, and the losses were well correlated with level of damage (r = 0,92). The magnitude of the loss averaged 0,33% for every 1% internodes damaged. This increased to as much as 0,73% late in the season where losses in cane mass amounted to between 10 and 15% in the most severely damaged samples. There were some indications that the effects on cane mass were more pronounced in NCo376 than in N14, although the differences were not significant.

Cane quality

Reductions in cane quality were consistently well correlated with the level of damage. The magnitude of the loss averaged 0,1 units of ers % cane (0,75%) for every 1% increase in level of internode damage.

Reductions in cane quality (Appendix 3) resulted from lower brix % cane, pol % cane and juice purity, and these effects tended to be more severe in the mid season samples. The losses averaged 0,3%, 0,5% and 0,3% respectively (brix, pol, purity) for every 1% increase in the level of internodes damaged. The effects on moisture content were more variable. The effects on fibre content were clearly dependent upon season and significant increases were only recorded in the early season samples.

The effects on cane quality were apparently greater in NCo376 than in N14 for every parameter measured, although the differences were not large.

Calculated effects

Estimates of the losses in recoverable sucrose by calculation were very similar to those determined from sample analysis. The results are summarised in Figure 5, where calculated losses when 5, 10, 15 and 20% internodes were damaged, have been plotted.

It should be noted that yield information for stalks with more than 4 damaged internodes were extrapolated from the results of the preliminary samples.

Discussion

The fact that stalks infested with eldana weigh less and have poorer quality than undamaged stalks is not surprising and has been reasonably easy to establish. Difficulties arise, however, when the relationships are taken to represent actual losses since it cannot be reliably ascertained whether the reduced yield is actually caused by eldana, or whether it reflects the preference of the eldana for a particular type of stalk. If the information is used directly, it must be assumed either that the pest attacks every stalk at random, or that all stalks are similar prior to attack. This is clearly not the case with eldana where a complex host/pest interaction exists and is known to be strongly influenced by the physiological state of the crop. An interpretation of the results presented in this paper must take cognisance of this fact, although it should also be noted that the sampling procedure was drawn up to minimize any confounding effects. A frequency distribution of stalk heights comparing undamaged stalks with those with 4 internodes damaged (Fig 7) was inconclusive, but showed no clear indication of a preference by eldana for smaller and presumably more stressed stalks.

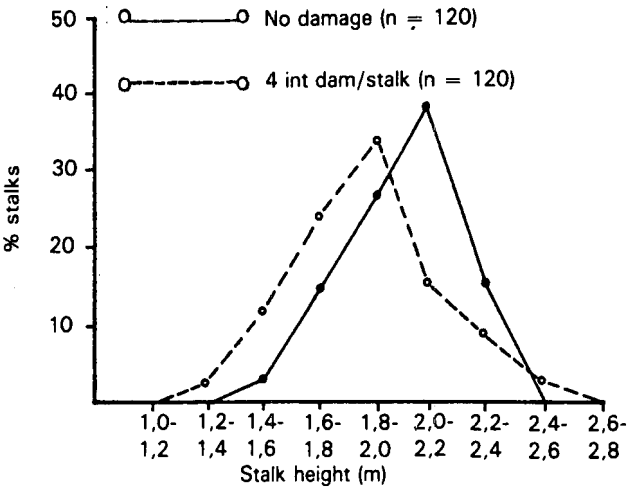

FIGURE 7 Frequency distribution of stalk heights from preliminary samples of NCo376.

Results from this study have indicated that losses in yield of recoverable sucrose are more a function of cane quality than of cane yield. Decline in cane quality was consistently well correlated with the level of % internode damage, and can result in losses in sucrose yield as well as in reduced recovery at the mill.

The magnitude of the losses compared well with those reported by Waiyaki,[4] Workman, Myeni and Nixon (unpublished), while they were apparently more severe than suggested by Smaill and Carnegie.[3] The tendency for the reduction in cane quality to be greater in NCo376 than in N14 may be due to it having thinner stalks, allowing each eldana larva to do proportionately more damage. The losses in cane quality were surprisingly large and presumably result from the fact that eldana generally attacks the more mature internodes in the lower half of the cane stalk.

The effects on cane yield were very much more variable, but on average were similar to those proposed by Nixon (unpublished) and somewhat less than those suggested by Nuss *et al.*[2] Losses in cane yield were more pronounced later in the season and apparently resulted from reduced stalk height.

The fact that losses in yield increased as the season progressed may have reflected the fact that the major proportion of the damage observed in late harvested cane seems to occur considerably earlier in the season. This is supported by the visual observation that there was a greater prevalence of older, more dessicated borings in the late season samples. If this is so, and survey data (Fig 2) tend to support the observations, then it might be expected that losses in cane yield may increase with increasing cane age. This would apply particularly to cane that was young at the time of the first major infestation, which occurs during the autumn months.

Conclusions

While it must be accepted that there are shortcomings in the methods used in these assessments, it is proposed that the data presented probably represents a reasonable approximation of the losses caused by eldana.

It appears that, on average, in 11–12 month old cane a 1% loss in yield of recoverable sucrose can be associated with every 1% of internodes damaged. The effects of season were significant, however, and losses varied from about 0,7% early in the season to 1,3% in cane harvested towards the end of the season. Losses in yield of recoverable sucrose were caused largely by reductions in cane quality. The effects on cane yield were more variable and were apparently negligible in early harvested cane, but became progressively more severe in cane harvested later in the season. There were indications that varieties could be affected to different degrees, although more definitive work would be necessary to demonstrate this trend conclusively.

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APPENDIX 1

The relationship between % internode damage and the frequency of occurence of stalks with differing amounts of damage. (Pre-harvest trial survey: Mhlume 1987)

Av. % internodes damaged	No. obs.	Frequency of occurence (%) of stalks with increasing damage									% Stalks damaged
		Internodes damaged per stalk									
		0	1	2	3	4	5	6	7	8	
1,2	26	91	3,0	4,0	1,5	0,5					9
3,0	26	80	7,0	7,5	3,0	1,5	1,0				20
5,0	26	68	10,5	12,0	4,5	2,5	1,5	1,0			32
7,1	26	60	10,5	12,5	8,0	5,5	2,0	1,5			40
9,2	26	53	9,5	15,5	9,0	5,5	3,5	2,5	1,5		47

APPENDIX 2

The relationship between % internode damage and the frequency of occurence of stalks with differing amounts of damage. (Millyard surveys — Mhlume Mill 1987)

Av. % internodes damaged	No. obs.	Frequency of occurence (%) of stalks with increasing damage										% Stalks damaged
		Internodes damaged per stalk										
		0	1	2	3	4	5	6	7	8	9	
0,6	204	93	5	2								7
2,5	165	79	8	7	3	3						21
4,5	87	70	9	10	6	5						30
6,5	46	56	13	15	8	7	1					44
8,5	33	49	13	15	9	11	1	1	1			51
10,6	16	45	11	15	11	13	2	1	1	1		55
12,6	8	42	9	13	10	16	4	4	1	1		58
14,6	5	30	13	16	11	19	2	3	3	2	1	70
16,6	4	26	11	19	10	20	5	4	3	1	1	74

APPENDIX 3

Correlation and regression co-efficients (r & b) showing the relationship between % internodes damaged by eldana and components of cane quality

Variety/ Season	Moisture % cane			Brix % cane			Fibre % cane			Purity % cane			Pol % cane		
	r	b	s(b)	r	b	s(b)	r	b	s(b)	r	b	s(b)	r	b	s(b)
NCo376	0,38	0,4	0,21	−0,93	−0,06	0,008	0,37	0,03	0,019	−0,94	−0,26	0,035	−0,95	−0,09	0,010
N14	—	—	—	−0,93	−0,05	0,006	0,61	0,04	0,018	−0,94	−0,21	0,028	−0,96	−0,08	0,008
Early	−0,54	−0,02	0,013	−0,94	−0,04	0,004	0,88	0,07	0,012	−0,96	−0,22	0,024	−0,97	−0,06	0,006
Mid	0,62	0,04	0,017	−0,96	−0,07	0,008	0,50	0,03	0,017	−0,92	−0,24	0,039	−0,96	−0,11	0,010
Late	0,47	0,04	0,026	−0,88	−0,05	0,009	0,09	0,01	0,026	−0,94	−0,24	0,032	−0,93	−0,08	0,012
Mean	0,20	0,02	0,019	−0,93	−0,05	0,007	0,49	0,04	0,018	−0,94	−0,24	0,031	−0,96	−0,08	0,009