IMPACT OF REPEATED APPLICATIONS OF ALPHA-CYPERMETHRIN ON *ELDANA SACCHARINA* (LEPIDOPTERA:PYRALIDAE) AND ON ARTHROPODS ASSOCIATED WITH SUGARCANE

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Abstract

In five field–scale insecticide trials, the repeated application of the synthetic pyrethroid alpha-cypermethrin to carry-over cane, reduced damage caused by the sugarcane borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) to the crop. The insecticide was applied with mistblowers at a rate of 200 ml formulation/ha in 350 L water/ha, once every two weeks for 16 weeks, commencing when the crop was 6-9 months old. At harvest, average damage and larval numbers were reduced by 72% and 73% respectively. ERC % cane increased by an average of 28%.

Arthropods were monitored in two of the trials by means of pitfall trapping. Results showed that there was some impact of the treatment on abundance and diversity, primarily over the period of treatment application. However, at crop harvest, five months after treatment application ended, there was no significant effect. The impact on ants, considered important predators of eldana, was similar. It is concluded that this approach to suppressing borer infestations may have commercial value.

Keywords: sugarcane, insecticide, alpha-cypermethrin, *Eldana saccharina*, borer

Introduction

The African sugarcane borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (eldana) is the most serious pest of sugarcane in southern Africa. While there is limited effect on tonnage, the most serious effect of this pest is on cane quality, and high infestations can result in deliveries being rejected at the mill (Atkinson and Carnegie, 1989).

Research programmes that have been developed to investigate control options for eldana include host plant resistance, biological control, and the use of insecticides. Recent results from the insecticide programme are the subject of this paper.

Investigations into the use of insecticides for the control of eldana have been conducted with varying intensity at the South African Sugar Association Experiment Station (SASEX) since the late 1970s. Approaches to control have included both aerial and ground application, the latter including the use of mistblowers, knapsack sprayers and ultra low volume application equipment. Using these methods insecticides have been applied to stubble, mature crops and carry-over crops (Heathcote, 1984), with the latter being the focus of the most recent trials.

In the South African sugar industry, sugarcane is not milled between December and April. In this period, crops that are 10 months old in December will only be harvested when they are about 15 months old. Such ‘carry-over’ crops are particularly vulnerable to eldana. The current strategy is to suppress eldana infestations through the use of insecticides to allow such crops to be carried over without severe eldana damage. In early trials single applications were examined. More recently double applications over the period of eldana moth peaks (typically around October to November) were investigated (Leslie, 1997). Currently, multiple applications prior to the moth peak have been tried, with promising results.

Initially, a number of insecticides were tested (Heathcote, 1984), but for some time trials have focused on the synthetic pyrethroids, particularly cypermethrin and most recently alpha-cypermethrin.

Numerous studies have shown adverse effects on arthropods associated with crops treated with insecticides (see, for example, Dent, 1991). Thus, in addition to examining the impact of insecticide use on eldana and the damage it causes, its effect on arthropods associated with sugarcane was also investigated.

Materials and methods

Insecticide choice and rates

The insecticide used was the synthetic pyrethroid alpha-cypermethrin (Fastac SC^{R}). This choice was based on earlier studies, which showed that cypermethrin was the most effective of the insecticides tested (Heathcote, 1984). The rate applied was based on what would normally be considered effective (about 100 ml formulation/ha.). This was doubled on the assumption that, should a trial fail to show an effect, such failure could not be attributed to too low a rate of insecticide used. The insecticide was therefore applied at a rate of 200 ml formulation/ha in 350 L/ha water.

Application method and frequency

Trials comprised replicated randomised plots (three treated and three untreated), each approximately 0,4 ha in area. The insecticide was applied using Sthil Sr 320 mistblowers with nozzles set at number 4, and baffles directing the airstreams into rows of standing sugarcane. Insecticide was applied once every two weeks over a 16-week period (eight applications).

Trial sites

Five trials were conducted, each at a different location on the north coast of KwaZulu- Natal. Treatment application commenced in August 2001, when the crops were between six and nine months old. All but one trial received eight applications (trial 3 received six applications). Crop ages, treatment dates and surveys dates are given in Table 1.

Data collection and analysis

For each trial, a pre-treatment and four post-treatment surveys were conducted over the period of the trial from July to April (see Table 1). A sample of 50 stalks was collected randomly from each of the six plots in each trial. At each sampling the following data were recorded: number of internodes, number bored, and the number of larvae (or pupae) recovered. From the data collected, the percentage of internodes bored and larvae per 50 stalks were calculated for each sampling period.

Table 1. Crop age, time of treatment application and survey date for five eldana insecticide trials.

Trial No.	Crop age at spray (months)	Treatment dates								Survey dates				
		1	2	3	4	5	6	7	8	Pre	1st	2nd	3rd	4th
1	9	14.08.01	28.08.01	11.09.01	25.09.01	10.10.01	22.10.01	06.11.01	19.11.01	19.07.01	17.10.01	06.12.01	07.02.02	03.04.02
2	8	06.08.01	20.08.01	03.09.01	17.09.01	01.10.01	15.10.01	30.10.01	13.11.01	17.07.01	03.10.01	03.12.01	04.02.02	05.04.02
3	8	07.08.01	27.08.01	18.09.01	08.09.01	31.10.01	20.11.01	-	-	17.07.01	03.10.01	03.12.01	04.02.02	03.04.02
4	6	13.08.01	29.08.01	10.09.01	26.09.01	09.10.01	23.10.01	05.11.01	21.11.01	18.07.01	18.10.01	12.12.01	06.02.02	02.04.02
5	8	08.08.01	21.08.01	04.09.01	19.09.01	02.10.01	16.10.01	01.11.01	14.11.01	16.07.01	19.10.01	03.12.01	05.02.02	04.04.02

At the time of the final survey, estimates of yield were made for each plot in each trial. This required the collection of six samples comprising 16 stalks from randomly selected positions within each plot.

Arthropod monitoring

In two of the five trials, the impact of the insecticide treatment on epigeal arthropods was monitored. Pitfall traps (14 mm diameter glass tubes containing a glycerol alcohol preserving solution) were placed along selected interrows of one treated and one untreated plot of the two trials, at a density of between 60 and 70 traps/ha. Following the procedures used by Draper and Conlong (2000), traps were placed out for three days and then retrieved. This sampling procedure was repeated every three weeks for the duration of the trial.

The arthropods collected were categorised as ants, mites, predacious beetles, crickets, collembolans and hemipterans (hoppers). The remaining types collected were all grouped together in one category made up of woodlice, cockroaches, earwigs, beetles and hemipterans not included in the main grouping.

Results

Eldana damage

The average eldana damage in the five trials is shown in Figure 1. In the pre-treatment assessments (conducted in July) there was no difference in damage between treated and untreated plots. However, damage in the untreated plots increased progressively over the following nine months, whereas damage in the treated plots remained low (generally below 5% internodes bored). In the final (April) surveys, damage in the untreated plots was close to four times greater than that of the untreated plots. The average reduction in damage was 72%.

Results from each trial were analysed separately using paired t-tests. A pair consisted of the treated and untreated estimates of damage for each sampling date. Where such tests failed the normality or equal variance tests, the Mann-Whitney rank sum test was used. Significance was set at the 5% level for all comparisons. For this analysis the data from the three replicates were combined, and results are summarised in Table 2.

The significance of the differences varied, but the trends shown in Figure 1 are clear: insecticide treatment reduced damage significantly.

Table 2. Results from significance tests comparing estimates of damage and larval numbers in treated and untreated plots of five insecticide trials for each sampling date, using the Mann-Whitney rank sum test.

Trial	Date	Percentage internodes bored		Eldana/50 stalks	
		Signif.	*P* value	Signif.	*P* value
Trial 1	July	NS	0.8	NS	0.63
	Oct	NS	0.09	NS	0.62
	Dec	S	0.001	S	0.01
	Feb	S	0.11	S	0.001
	Apr	S	0.001	S	0.001
Trial 2	July	NS	0.98	NS	0.54
	Oct	S	0.007	S	0.32
	Dec	S	0.001	S	0.005
	Feb	S	0.001	S	0.001
	Apr	S	0.001	S	0.001
Trial 3	July	NS	0.67	NS	0.84
	Oct	S	0.005	NS	0.36
	Dec	S	0.001	S	0.001
	Feb	S	0.001	S	0.001
	Apr	S	0.001	S	0.001
Trial 4	July	NS	0.25	NS	0.79
	Oct	NS	0.05	NS	0.27
	Dec	S	0.001	S	0.001
	Feb	S	0.001	S	0.001
	Apr	S	0.001	S	0.001
Trial 5	July	NS	0.87	S	0.004
	Oct	S	0.001	NS	0.19
	Dec	S	0.001	S	0.001
	Feb	S	0.001	S	0.03
	Apr	S	0.001	S	0.005

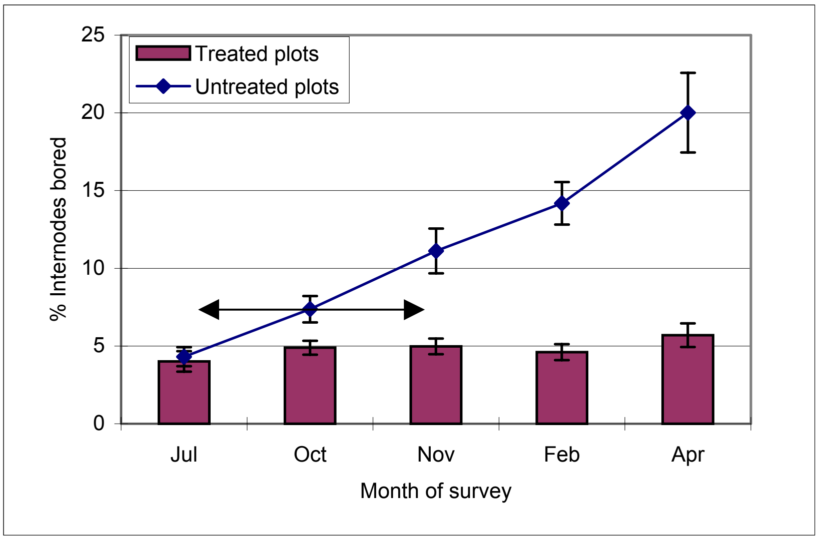
Larval numbers

Trends in larval numbers are also shown in Figure 1, and were similar to those shown for damage estimates, *viz.* little or no difference between treated and untreated plots initially, but an ever-increasing and significant difference as the crops aged. Data were analysed following the same procedures adopted for examining eldana damage, and these results are also summarised in Table 2.

In the final survey, the average reduction in larval numbers in treated plots was 73%.

Yield estimates

Estimates of yield were taken just before the final surveys and harvest of the cane at an age of about 16 months. Results are given in Table 3. In all trials, estimated recoverable crystal (ERC % cane) was higher in the treated plots, and in three of the five trials this difference was significant. The percentage difference ranged from 7,2 to 49,7%, with an average of 28%. The treatment had no significant effect on estimates of tons sucrose/ha, although in all trials yield estimates were greater in the treated plots, ranging from 4,2 to 48,7%, and averaging 20% (Table 3). Similarly, there was no effect of treatment on tons cane/ha.



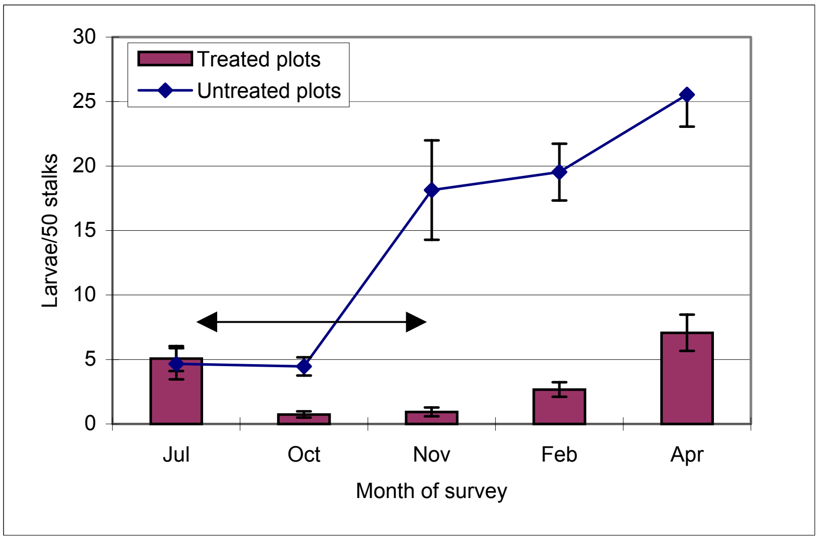


Figure 1. Effect of repeated applications of alpha-cypermethrin on eldana damage (top graph) and larval numbers (bottom graph) in carry-over cane. Horizontal line indicates the period over which insecticide was applied. Error bars represent one standard error.

Effect of treatment on epigeal arthropods
Although a number of arthropod groups were monitored, only data relating to arthropods generally, and ants specifically, are considered.

Results are shown in Figures 2 and 3. Overall abundance of arthropods in treated and untreated plots of Trial 1 are shown in Figure 2. Over the period of treatment application (denoted by horizontal arrow) abundance was significantly reduced at only one sampling date. In trial 2 numbers were significantly reduced at three sampling dates during the period of treatment application and at a few dates after this. However, by the time the trial ended, there were no significant differences in the abundance of arthropods between treated and untreated plots.

Table 3. Yield parameters for five insecticide trials.

Trial	ERC % cane		Difference	
	Treated	Untreated	(trt – untrt)	%
1	11.4	10.6	0.8	7.2
2	10.1	6.8	3.2*	46.7
3	10.8	7.2	3.6*	49.7
4	11.3	9.1	2.2	23.9
5	11.7	10.3	1.4*	13.1

Trial	Estimated t cane/ha		Difference	
	Treated	Untreated	(trt – untrt)	%
1	67.6	65.9	1.7	2.6
2	99.9	87.5	12.4	14.2
3	83.8	85.3	-1.5	-1.8
4	57.3	63.0	-5.7	-9.0
5	135.8	133.5	2.3	1.7

Trial	Estimated t sucrose/ha		Difference	
	Treated	Untreated	(trt – untrt)	%
1	8.9	8.1	0.8	9.9
2	11.6	7.8	3.8	48.7
3	10.2	8.0	2.2	27.5
4	7.4	7.1	0.3	4.2
5	17.8	15.9	1.9	11.9

* = values significantly different. *P*=0.05

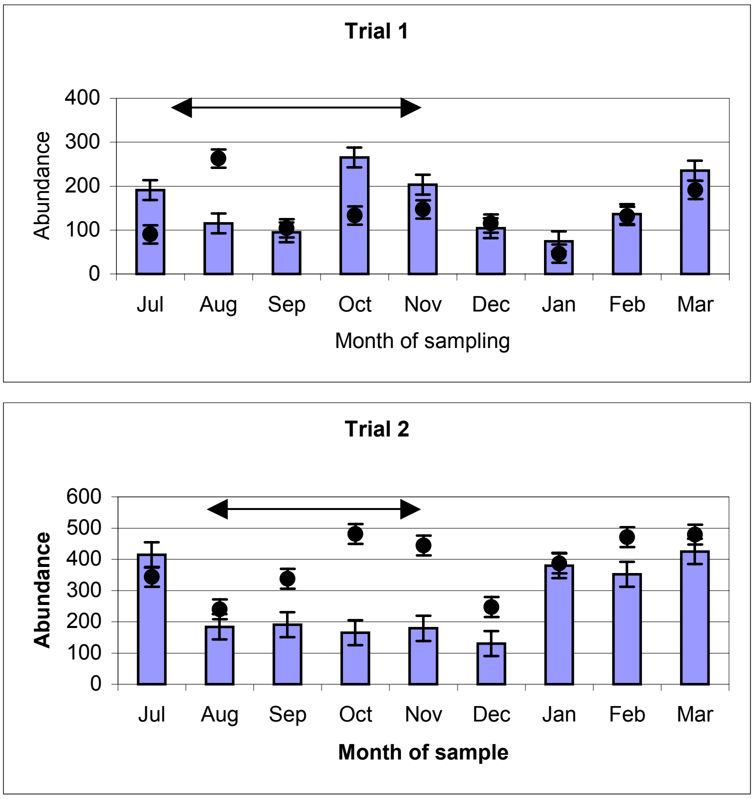


Figure 2. The abundance of arthropods trapped in treated (bars) and untreated sugarcane in two insecticide trials. The horizontal line indicates the period over which insecticide was applied. Error bars represent one standard error.

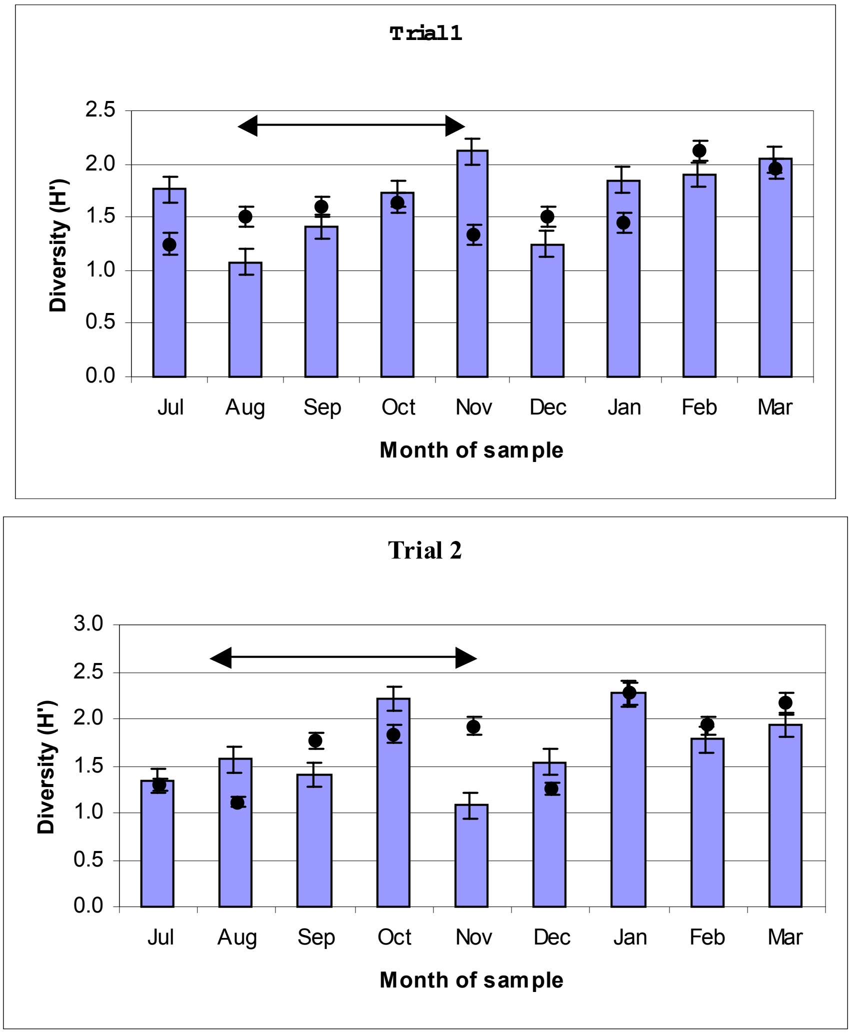


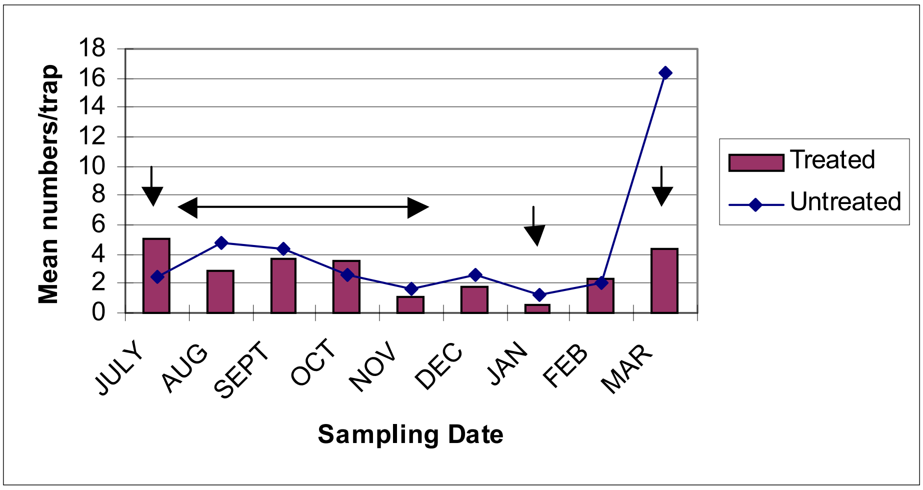
Figure 3. The diversity (H') of arthropods trapped in treated (bars) and untreated sugarcane in two insecticide trials. The horizontal line indicates the period over which insecticide was applied. Error bars represent one standard error.

Arthropod diversity was calculated using the Shannon's diversity index (H'). This index is one of the most frequently used diversity indices, and it is commonly employed in ecological studies (Ludwig and Reynolds, 1988; Magurran, 1988). Results are shown in Figure 3. At some sampling periods, in both trials, diversity was lower in treated cane than in untreated cane. This was most evident over the period of treatment application. However, by the time the crop was harvested, there was no difference in diversity estimates.

Of the arthropods monitored, ants were the most abundant group. Previous studies on the impact of predators on eldana (Leslie, 1986) have shown that this group probably includes the more important predators of eldana, and the impact of insecticides on this group is therefore of particular concern. For this reason, data for ants were analysed separately, and their abundance in the two trials is shown in Figure 4. Little difference in numbers between treated and untreated cane was evident for most of the period of trial 1. Only in the last assessment, four months after insecticide application ended, were numbers trapped significantly greater in the untreated cane. It is unlikely that this difference was associated with the treatment, and it should be considered an anomalous result.

In the second trial monitored, and numbers were lower in the treated cane over the period of treatment application, particularly towards the end of the period of treatment application.

However, after application stopped there were no significant differences between treatments up to the time of harvest.



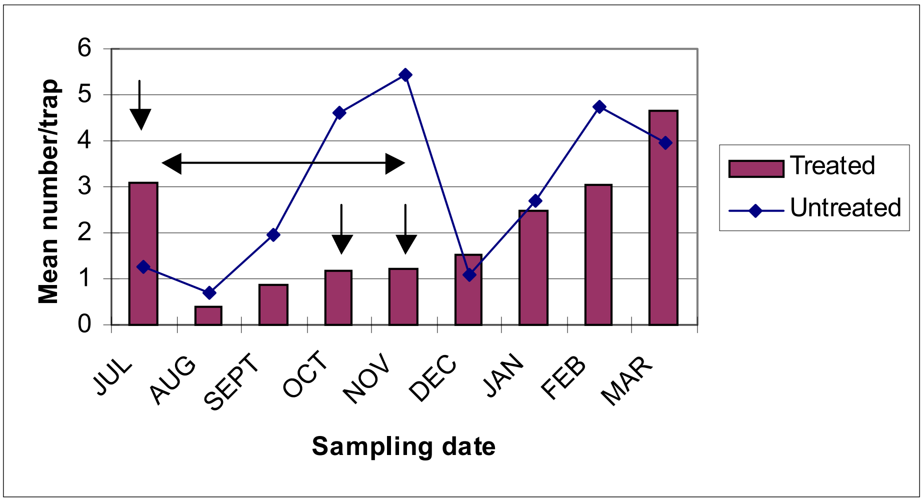


Figure 4. Trends in the abundance of ants in treated (bars) and untreated sugarcane in two insecticide trials (Trial 1 top, Trial 2 bottom). The horizontal arrow indicates the period over which insecticides were applied. Vertical arrows indicate the sampling times when there were significant differences between catches in treated and untreated sugarcane.

Discussion

The results from this revised approach to applying insecticides are very encouraging. All trials showed significantly reduced damage and population levels in the final surveys, and in several surveys before this. In previous trials, where two or three applications of insecticide were used, the results, while positive on occasions, were too inconsistent to be considered reliable. In trial 3 in the current study, only six applications were made, and there were nevertheless significant differences in damage, larval numbers and ERC % cane. Thus, while eight applications gave clear results, it is probable that with fewer than eight but more than three applications, damage could still be reduced significantly.

As in previous trials, yield estimates were made prior to the crop being harvested. From estimates of ERC % cane and tons cane/ha, tons sucrose/ha were obtained.

While in three of the five trials significant differences in ERC % cane were shown, none of the trials showed significant differences in tons cane or tons sucrose, both of which are estimated values. This is to be expected, as the principal effect of eldana damage is on cane quality and not tonnage. The latter is determined by several factors such as field topography, soil depth and aspect, the effects of which are independent of insecticide treatment. Comparisons should thus be confined to the measured value of ERC % cane.

Based on a labour cost of R20/day (2002 value), the cost of applying an insecticide eight times is estimated to be about R700/ha, excluding the cost of application equipment and water.

A recently completed study by the Plant Protection Research Institute's Unit for Pesticide Science (van der Walt, 2003), suggests that more efficient ways of applying insecticide may be possible, and will improve efficacy and reduce costs.

A factor not included in the current study is the effect of pre-trashing. Previously it was estimated that pre-trashing on its own could reduce eldana damage by up to 30% (Carnegie and Smaill, 1982). This, combined with the current use of insecticide, would have a greater effect on Eldana, although costs would be higher.

Another aspect that has to be considered is the effect on the economics of growing sugarcane of being able to carry-over a percentage of fields. Even if the cost of keeping eldana damage and populations low in a treated carry-over field is not recovered by the yield of that field, it is probable that the reduced input costs resulting from lower harvesting and transport costs, as well as ultimately longer ratoon cycles, may more than compensate for such cost.

The analysis of pitfall trap catches just prior to harvest, showed that the treatment effects on abundance and diversity were temporary, and this is encouraging. However, over the period of treatment application, differences between trials were shown in the effect of the treatment on general arthropod abundance. However, the lack of serious impact on ants, important predators of eldana, is particularly encouraging. Nevertheless some effect on the arthropod community was evident and, if the number of insecticide applications can be effectively reduced, this could further reduce the impact on arthropods.

Conclusions

Repeated applications of alpha-cypermethrin to sugarcane significantly reduced eldana damage and larval numbers in treated sugarcane. The treatment significantly increased ERC % cane in some trials. While such treatment at some sampling periods reduced arthropod abundance and diversity, the effect was variable and temporary.

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