AN INTEGRATED PEST MANAGEMENT SYSTEM FOR *ELDANA SACCHARINA* IN THE MIDLANDS NORTH REGION OF KWAZULU-NATAL

WEBSTER T M[1], MAHER G W[2] and CONLONG D E[3,4]

[1]Midlands North LPD&VCC, PO Box 581, Wartburg, 3233, South Africa. mnpd@sai.co.za
[2]South African Sugarcane Research Institute, PO Box 581, Wartburg, 3233, South Africa. geoff.maher@sugar.org.za
[3]South African Sugar Research Institute, P/Bag X02, Mount Edgecombe, 4300, South Africa. des.conlong@sugar.org.za
[4]School of Biological and Conservation Sciences, University of KwaZulu-Natal, P/Bag X01, Scottsville, Pietermaritzburg, 3209, South Africa

Abstract

Eldana saccharina Walker (Lepidoptera: Pyralidae) infestation in sugarcane in the Midlands North region of KwaZulu-Natal in South Africa was first found in 1988 on six farms in the Table Mountain/Bishopstowe area, when a maximum of 19 *E. saccharina*/100 stalks (e/100) was recorded. Since then, *E. saccharina* has been found in this area every year. In 1993/94 infestation peaked, with populations being found on 32 farms; and a maximum of 114 e/100 being recorded. During 2003/04 *E. saccharina* was found on 14 farms, with a maximum of 129 e/100 being recorded in the worst infected field.

Surveys in wetland areas and along river lines in the Midlands North region in 2001/02 showed *E. saccharina* to be present in the sedges *Cyperus dives* C.B.CL. and occasionally in *Cyperus latifolius* Poir. Encouragingly, while doing these surveys, parasitoids were found on *E. saccharina* larvae. Using this knowledge, the already well known management practices to control *E. saccharina* and resistant varieties, an environmentally friendly integrated pest management system (IPMS) was developed to reduce populations of *E. saccharina* to below economic threshold levels.

This paper describes the principles used in the development of the IPMS, so that it aligns with the environmental management system currently in place and complies with the best management practice (BMP) for sugarcane farming adopted by growers in the area. The IPMS will use a local farm with a long history of *E. saccharina* infestations as a case study, to show how preventative management practices can influence pest numbers and subsequent spread.

Keywords: sugarcane, eldana, environment, integrated pest management

Introduction

The Midlands North region of KwaZulu-Natal has for many years been considered free of the stalk borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae). However, recent surveys indicate that this pest is steadily on the increase in the region. With the danger of global warming, the lack of silicon in the soils and the fact that 30% of the district is planted to the susceptible variety N16, there are concerns that a serious increase in *E. saccharina* in the region is a real possibility.

Surveys in the natural wetlands and riverine areas have shown that *E. saccharina* is present in natural host plants in many parts of the region. Due to the fact that the spread of *E. saccharina* in sugarcane is linked to poor crop management, and that the use of best management practices (BMPs) by growers is being encouraged throughout the region, it makes sense to develop an integrated pest management system (IPMS) for the region. It is important that this proposed IPMS aligns with the environmental management system (EMS) currently being implemented by the Noodsberg cane growers.

Background

The Midlands North region has been divided into Eco-Zones, which form part of the Noodsberg Cane Growers' EMS. Eco-Zones are areas of similar climate and similar potential for sugarcane production, and are derived from the Department of Agriculture's Bio-Resource Units (BRU). Table 1 gives a breakdown of the major climatic features for each Eco-Zone.

Table 1. Breakdown of the major climatic features for each Eco-Zone.

Eco-Zone	Rainfall range (mm)	Altitude range (m)	Maximum temperature (ºC)	Minimum temperature (ºC)
1	801-850	451-900	26.7	6.1
2	701-750	451-900	27.5	5.9
3	751-750	451-900	26.8	5.8
4	901-1100	901-1400	25.3	7.0
5	801-850	901-1400	25.7	6.0
6	751-800	451-1400	26.6	6.8
7	851-900	901-1400	25.7	5.3 (frost)
8	901-1100	451-1400	27.1	5.3 (frost)
9	751-850	901-1400	26.1	4.6 (frost)
10	901-1100	901-1400	25.4	6.5
11	651-700	451-900	28.6	4.3 (frost)

Only Eco-Zones 7, 9, 10 and 11 have had no record of *E. saccharina* incidences, possibly due to the more frequent frost occurrences in these zones.

History

Figure 1 shows the number of farms affected by *E. saccharina* and the maximum e/100 for each year from the inception of the surveys in 1988 to the end of 2004.

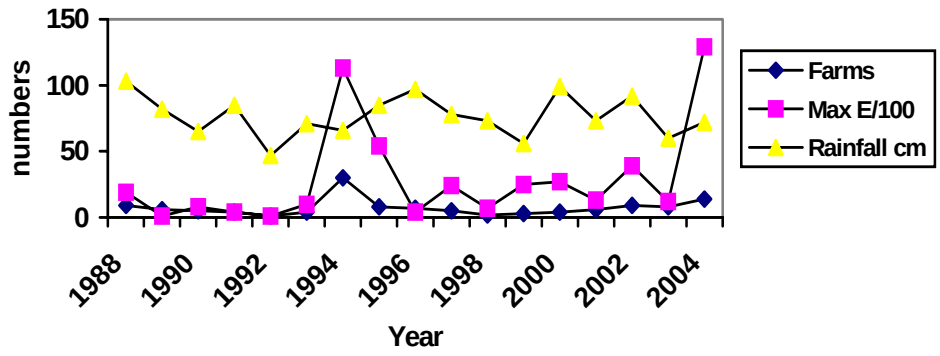

Figure 1. Number of farms affected, the maximum e/100 and the annual rainfall in centimetres for the period 1988 to 2004.

Figure 2 gives a breakdown of the total recorded incidences of *E. saccharina* by Eco-Zone for the entire period 1988 to 2004. The highest number of recorded incidences occur in Eco-Zones 1, 2 and 3, situated in the Umgeni river catchment.

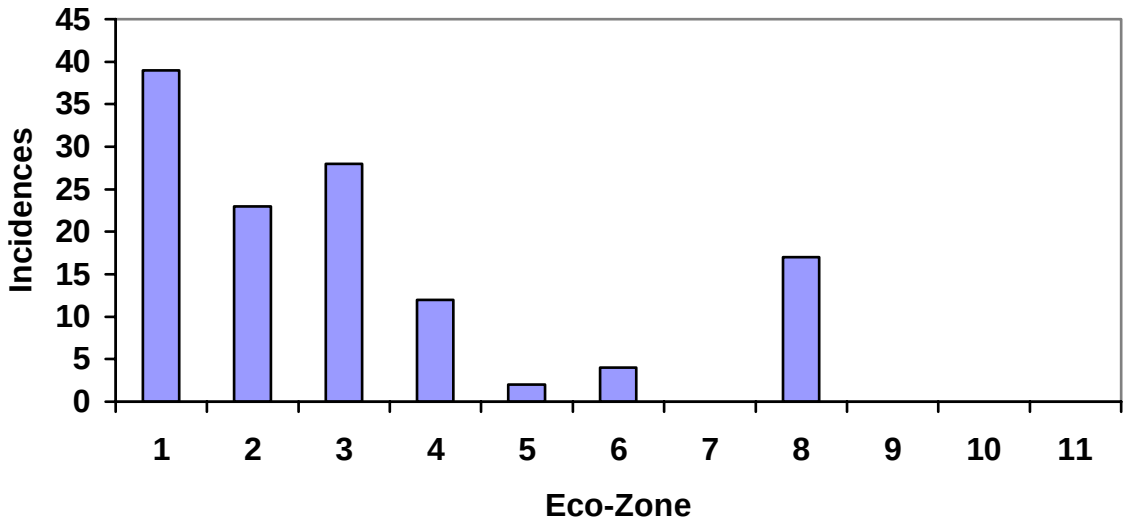

Figure 2. Total recorded incidences of *E. saccharina* by Eco-Zone, 1988 to 2004.

Although *E. saccharina* levels are relatively low in the Midlands North region, the major concern is the trend over the past five years. Records show that there is a steady increase in the numbers of farms where the pest has been recorded and in the average e/100. Figure 3 gives a summary of this trend.

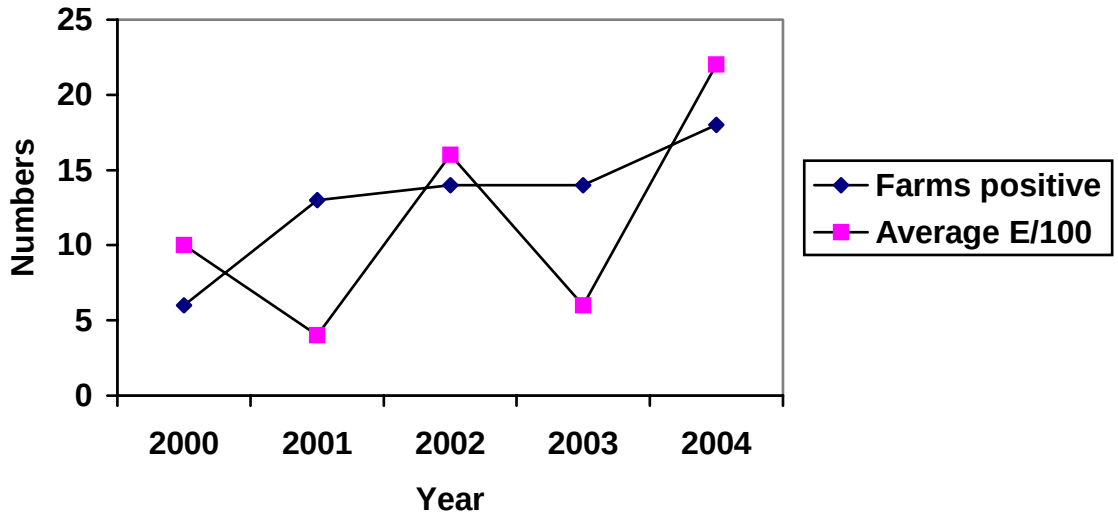

Figure 3. Summary of *E. saccharina* trends over the past five years.

Natural host plant surveys

Sedges (*Cyperus* spp), of which there are several species, can be reservoir hosts for stem borers. If there were only indigenous plants, these insects would be of no special consequence. After the introduction and cultivation of maize and extensive planting of

sorghum in vast areas of Africa where they did not occur originally, the insects followed the cultivated forms of their host plants and became more widely distributed (Polaszek, 1998).

Indigenous hosts adjacent to cultivated crops can provide extremely important refugia for natural enemies, as well as supplying the latter with sources of nectar, pollen and host/alternative prey (Schulthess *et al*, 1997). There are also several examples of adjacent indigenous habitats being used to suppress insect outbreaks by keeping the pest on the so-called indigenous trap plants. Furthermore, non-host plants intercropped with cereals have also been shown to have a significant effect on stem borer damage. Trials have shown that the grass *Melinis minutiflora* Beauv. intercropped with maize or sorghum significantly decreased levels of infestation by stem borers, and also increased larval parasitism of stem borers by the braconid wasp, *Cotesia sesamiae* (Cameron) (Polaszek, 1998).

The information on the roles of indigenous habitats in providing refugia for natural enemies and the possible use of indigenous hosts in strip cropping and as trap crops, will be helpful in the management of stem borers in the sugarcane cropping system (Conlong, 2001).

As a result of the above, surveys were carried out in surrounding natural vegetation in wetlands and riverine areas throughout much of the region from December 2001 onwards. These surveys confirmed that *E. saccharina* was present in the natural host plants (*C. dives* and *C. latifolius*) in many of the wetlands, dams and riverine areas in the Midlands North region. Table 2 gives the results of these surveys.

Table 2. Results of natural host plant surveys in the wetlands, dams and riverine areas.

Date	Eco-Zone	No. of sites	Type of site			Pest numbers recorded in each host plant	
			Dam	Wetland	River	*C. dives*	*C. latifolius*
Dec 01	1	5	x	x	x	86	10
Nov 02	2	3	x			111	0
Mar 02	2	3			x	24	0
Dec 02	3	1	x			0	0
	8	4	x			0	0
	2	1			x	1	0
Jan 05	2	5	x	x	x	128	0
Mar 05	3	1		x		0	2

Sampling took place in the wetland margins, edges of farm dams and along riparian zones. A five-man team, spread out in a ‘site area’ each cut 20 random umbel-bearing culms (total of 100) with supporting stems. The 20 random samples were examined at an extraction point, where the umbels were sorted into plant species (*C. dives* or *C. latifolius*).

All *E. saccharina*, other borers and any parasitoid stages found were placed individually in numbered vials containing laboratory-prepared diet medium. These were taken to the SASRI laboratory for further observation and development. The sampling method was conducted according to SASRI specifications (Conlong, 1990).

Annual surveys into the surrounding natural vegetation are being carried out by the Midlands North Pest and Disease team to monitor *E. saccharina* in these wild host plants.

In addition, there are two farms in the Midlands North region where *E. saccharina* has established itself in sugarcane along a riverine area where the natural host plants also support *E. saccharina* populations. Trials have been implemented on these farms using *M. minutiflora*. The results of these trials will be used to test the use of the 'push-pull' theory (Miller and Cowles, 1990) in the IPMS.

Integrated pest management

The development of sustainable agricultural systems is dependent on finding ways of managing pests in an environmentally friendly manner, while at the same time conserving natural resources, protecting biodiversity and human and animal health. There has been a move globally to reduce reliance on chemical pesticides and to implement a more balanced approach to pest management.

Integrated pest management (IPM), which combines biological control, host plant resistance and appropriate farming practices, and minimises the use of pesticides, is the best option for the future, as it guarantees yields, reduces costs, is environmentally friendly and contributes to the sustainability of agriculture (Agenda 21 UNCED – Maredia *et al*, 2003).

The different strategies used for IPM and the major salient features of IPM (Maredia *et al*, 2003) are shown in Table 3.

Table 3. Different strategies and salient features of IPM.

Strategies	Salient features
• Behavioural control • Biological control • Chemical pesticides • Cultural control • Host plant resistance • Mechanical control • Quarantine and regulations	• Multi-disciplinary approach • Integration of multiple strategies • Knowledge of information • Systems approach • Risk minimisation • Links agriculture with environment, biodiversity, human health and sustainability

IPM in sugarcane in South Africa

The South African Sugarcane Research Institute (SASRI) has developed control measures for *E. saccharina*. These control measures have been implemented on many farms in the coastal regions of the South African Sugar Industry for quite some time and include the following:

- Cutting the cane at an early age – 12 months.
- Applying reduced nitrogen levels – reducing nitrogen by 10-30 kg N/ha depending on soil category.
- Good field hygiene – remove all stalks and leave no stubble.
- Pre-trashing – remove trash from the stalk during August to October.
- Planting low risk varieties – N12, N21, N39 and N41.
- Controlled pesticide application – only in carry-over cane using alpha-cypermethrin once every two weeks for sixteen weeks.

Adopting the IPMS

Unfortunately, due to a lack of information, training and legislation governing IPMS in South Africa, the implementation and adoption of such a system by farmers in general has been

hampered. This often results in a pest management crisis developing before a high level of IPM is achieved. The system therefore needs to be adopted as a preventative measure in areas where pest levels are still low, such as in the case of the Midlands North region.

The case study farm

A farm with a long-standing history of *E. saccharina* infestation in the Midlands North region has been chosen as a case study. The objective of the case study is to show that with the implementation of an IPMS, the spread and impact of the insect can be controlled. This case study will be used as a 'blueprint' model for all other sugarcane farms in the region.

Location
The farm is situated in Eco-Zone 3, on the western side of the Greytown road approximately 5 km east of Albert Falls dam, latitude 29° 24', longitude 30° 28'.

Topography
The topography is gentle undulating with slopes ranging from 2 to 12%. Altitude is about 800 metres above sea level.

Soils
A soil survey to determine soil form, soil depth and total available moisture (TAM) has been carried out on the farm. Results are presented in Table 4.

Table 4. Soil Data showing soil forms, effective rooting depth, clay %, TAM and irrigation classes.

Soil form	% of farm	Rooting depth (mm)	Clay % group	TAM (mm)	Irrigation class
Hutton	83	500-800	20-35	70-120	1 and 2
Swartland	11	600	20-35	70	3
Shortlands	6	600	35-55	80	2

*Irrigation class: 1 = irrigable, no limitations.
2 = moderately irrigable with TAM of 70-100 mm.
3 = marginally irrigable with TAM of 50-70 mm.

Recent soil sample results from the SASRI Fertiliser Advisory Service (FAS) indicate high levels of potassium, calcium and magnesium, while leaf sample results indicate low silicon levels and excess iron and manganese levels.

Climate
Occasional frosts in winter and summer droughts cause conditions of stress in sugarcane. Table 5 shows the climatic data for Eco-Zone 3.

Table 5. Climatic Data of the farm showing rainfall in mm and maximum and minimum temperatures in ºC.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Rain	137	104	96	54	34	12	12	34	55	66	95	89	788
Max	26.8	26.8	26.2	24.5	22.6	20.4	20.6	21.9	23.3	23.9	24.6	26.5	
Min	16.3	16.3	15.2	12.3	9	5.9	5.8	7.9	10.4	12.1	13.6	15.3	

Irrigation
The sugarcane has been irrigated using pig slurry from the piggery situated on the farm. The pig slurry has been tested for suitability for irrigation by SASRI FAS and found to be unsuitable for irrigation due to excessive salinity and sodicity. Application rates have been excessive.

E. saccharina *history*
The first incidence of *E. saccharina* on the farm was recorded in 1988 in variety NCo293. To date a total of 14 different fields on the farm have had infestations of *E. saccharina*, with many of these showing repeat infestations. Variety N16 has recorded the highest number of incidences. Of concern is the fact that the pest has been found more often in sugarcane aged between 11 and 16 months and 20 to 22 months. The heaviest infestation of 39 e/100 was found in 20 month old N16. Figure 4 shows the history of *E. saccharina* levels from 1988 to 2004 on the farm.

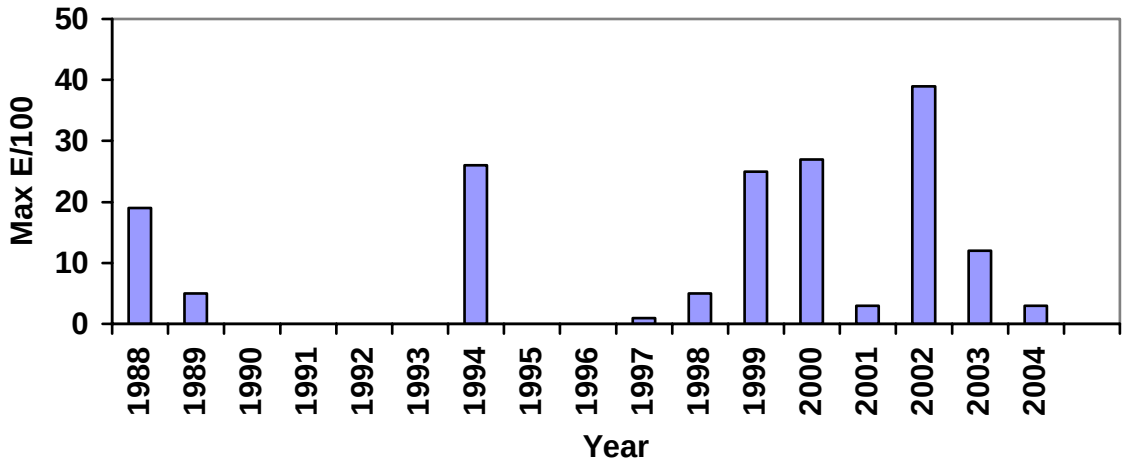

Figure 4. History of maximum e/100 levels from 1988 to 2004.

Initial surveys in the natural host plants in the wetland areas of the farm showed no evidence of the pest; however, more recent surveys have yielded positive results.

Management levels on the farm have not been in line with the recommended control measures for *E. saccharina*.

Proposed IPMS for case study farm

The philosophy behind the decision to implement an IPMS in the region comes from the belief that 'prevention is better than cure'. An integration of multiple strategies focussing mainly on cultural, agronomic and biological control measures, the use of insecticides with restraint and under specific conditions only will be encouraged to help control *E. saccharina*. The objective is to encourage all growers in the district to implement the IPMS whether they have been affected by *E. saccharina* or not.

Proposed management measures
- Land use plan:
  A land use plan (LUP) is a combination of a soil conservation network, a cane extraction network and a production management programme. To obtain optimum economic crop

production, it is necessary to integrate the agronomic and mechanisation practices with the climate, soils, water and topography of the farm unit. The grower has to recognise that different parts of the farm require different types of management and these must be integrated into a balanced working plan. It is vital to ensure that, while striving for optimum yields, protection of the environment is maintained.

Soil conservation works provide the basis of all LUPs. Together with the crop, the construction of field works ensures the protection of the most important resource on the farm - the soil.

The LUP should contain details and specifications with regard to:

- non-arable/natural bush areas
- wetlands and watercourses
- dams
- sensitive areas regarding burning, e.g. built-up areas and roads
- soils, including form, depth, erodibility and compaction
- waterways
- conservation terraces
- roads and extraction system
- strip planting
- minimum tillage
- areas suitable for trashing
- areas suitable for mechanisation.

Implementation of the LUP enables the conservation of soil and water, and also increases yield potential and long term sustainability of the natural resources on the farm.

- Clean Seedcane:
  E. saccharina free seedcane must be selected, preferably off the farm initially. The seedcane must be 'hot water' treated for 30 minutes at 50°C and dipped as setts in a phoxim solution of 2 ml/L water for 15 minutes prior to planting. A seedcane nursery should be developed on the farm to ensure a good supply of clean seed. No seedcane should be taken from fields within a 500 m radius of fields found with *E. saccharina.*

- Nutrition:
  The SASRI FAS recommendations should be used regarding rates of nitrogen. Where *E. saccharina* is a problem, the applied nitrogen should be reduced by between 20-30 kg N/ha. Leaf samples should be collected and sent to the SASRI FAS for analysis to determine silicon levels. Use should be made of the N:Si ratio on the leaf analysis sheet to determine the likely risk of *E. saccharina* infestation. If silicon levels are low apply the required amount of silicon as determined by FAS. The application of organics should be very carefully monitored and application rates should not exceed FAS recommendations.

- Variety selection:
  Varieties resistant to *E. saccharina* should be planted especially in problem areas and near natural host plants. Susceptible varieties should not be planted on farms with *E. saccharina* and intermediate varieties should be carefully selected and placed away from trouble spots. The following table gives a breakdown of the gazetted varieties for the Midlands North region and their susceptibility rating.

Table 6. Gazetted varieties and their rating for *Eldana saccharina* resistance in the Midlands North region.

Resistance category	Gazetted variety
Resistant	N21, N39, N41
Moderately resistant	N29 (rust)
Intermediate to resistant	N12, N17, N25, N37
Intermediate	N23, N24, N31, N40
Intermediate to susceptible	N22, N35, N36
Susceptible	N16, N27
Highly susceptible	N26, N30

- Field hygiene:
  Stalk residues and stubble in the field should be removed after harvest if the previous crop was heavily infested with *E. saccharina.* Leave and scatter the burnt tops in the field, as *E. saccharina* in South Africa is a borer infesting the lower portion of sugarcane stalks, and does not infest tops.

- Replanting:
  Fields that have been repeatedly infested with *E. saccharina* three times and more should be replanted, especially in the case of fields with high infestation levels. Fields with infestation levels of 5 e/100 and more should be ploughed out.

- Green manure:
  A relevant green manure crop should be planted after plough out. The field should be out of cane production for at least six months.

- Carry-over cane:
  Mature cane should not be carried over at all in an *E. saccharina* affected area. All cane that will be 22 months or more in November should be milled in *E. saccharina* affected areas. In non-affected areas it is important to ensure all mature cane is harvested before the close of the season.

- Age at harvest:
  All *E. saccharina* prone fields should be harvested at a younger age. The more susceptible the variety the younger it should be cut. Susceptible varieties should be cut at 12 months of age, intermediate 16-18 months and resistant 18-22 months.

- Loading zones:
  Loading zones should be kept clean and free of cane stalks. Avoid dumping cane from *E. saccharina* infested fields onto loading zones in *E. saccharina* free areas.

- Biological control:
  Napier fodder and wild sorghum attract the *E. saccharina* moth away from cane, while *M. minutiflora* discourages *E. saccharina* infestation. This type of vegetation should be encouraged in and around sugarcane fields, especially on contour banks and breaks. Where possible encourage predators such as earwigs, spiders and ants by trashing cane instead of burning.

- Natural hosts:
  Natural hosts such as sedges should not be removed from rivers, streams and wetlands. Sugarcane should not be planted too close to the natural hosts; leave a break of at least 10 m between the cane and the natural hosts.

- Pre-trashing:
  Where possible pre-trashing should be carried out especially during August to October, and in the older fields.

- Scouting:
  The frequency of the LPD&VC surveys may not be sufficient, so it is important that growers carry out frequent small surveys. Existing fields should be rated for *E. saccharina* hazard using the example table below. Fields with high scores have a higher *E. saccharina* hazard rating and should be monitored closely. This information should be passed onto the Pest and Disease officer.

Table 7. Example of the Scouting Sheet to be used by individual growers.

Environmental factor	Category	Score	Field number			
Varietal susceptibility	resistant	5				
	intermediate	10				
	susceptible	20				
Soil type	good deep soils	5				
	poor shallow/sandy soils	10				
Proximity to wetland/stream	>20m	10				
	10-20m	20				
Crop age	<12 months (<5 months irrigation)	5				
	12-18 months (6-10 months irrigation)	10				
	>18 months (>11 months irrigation)	20				
N application	low	2				
	standard	4				
	high	8				
		Total score				

- Marginal areas:
  Sugarcane should not be planted in marginal areas where soils are less than 450 mm deep, slopes exceed 20%, and/or rainfall is less than 750 mm per annum.

- Irrigation:
  A soil survey to determine TAM is essential, as this will ensure the implementation of a proper irrigation scheduling system. Irrigation water should be tested for quality and suitability by SASRI.

- Records:
  Records of *E. saccharina* infestation including field number, age of cane, variety, *E. saccharina* numbers and damage should be kept.

- Insecticides:
  The use of the insecticide alpha-cypermethrin would be considered as a last resort and requires very careful consideration. Only the registered method of application should be used. Selected carry-over fields with susceptible varieties on poor soils should be targeted with a maximum of 5 e/100 stalks or a maximum of 2.5% stalk length red.

All operations listed in the management strategy above, apart from the application of insecticides, should be carried out; there are no options or exceptions.

Discussion

The proposed preventative measures listed in the paper are designed to link with the SASRI control measures, the Noodsberg Cane Growers' environmental management system and the concept of integrated pest management. The objective is to use a multi-disciplinary approach, which incorporates conservation biological control measures, conserves the natural resources, is sustainable and environmentally friendly, and reduces reliance on chemical pesticides. Chemical pesticides are not discounted, although their use as a first line of defence is questioned in favour of trying other measures in combination first.

The owner of the case study farm has shown a willingness to implement the proposed IPMS. Progress is to be monitored over the next few years and the results presented in a future SASTA paper. All growers who have been affected by *E. saccharina* in the region are being encouraged to implement an IPMS as soon as possible. Agricultural enterprises are often criticised by environmentalists for opting for the 'quick fix' solution. Fortunately, the IPMS concept is expected to integrate well with sugarcane production, as chemical pesticide use is very limited and the nature of the crop allows for the development of an IPMS solution. It is important to ensure that all the 'tools' in the box are utilised and become a normal part of sugarcane production. Using the management measures in isolation could result in a worsening of the situation, for example encouraging the pest to move into young cane where there is no alternate host. It is possible that some of the management measures may require adjustment and fine tuning through time, therefore it is important that the IPMS is continually improved and subject to occasional reviewing.

Conclusion

The perception amongst many growers in the Midlands North region is that *E. saccharina* is not a significant threat in many parts of the region due to the prevailing climatic conditions. Many people are sceptical about the concept of global warming and believe that it is not a threat. Why or how *E. saccharina* first appeared on the case study farm is not easily explained; however, the important point is that it is present and has survived the most devastating frosts. The data show that the *E. saccharina* population is increasing in terms of the number of farms affected and the average e/100. Furthermore, pest may be adapting to the climatic conditions. This should be taken as a warning as the potential for the pest to spread is real. Management measures must be put in place on all farms as a matter of urgency. Prevention is better than cure!

Acknowledgements

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REFERENCES

Conlong DE (1990). A study of pest-parasitoid relationships in natural habitats: An aid towards the biological control of *Eldana saccharina* (Lepidoptera: Pyralidae) in sugarcane. *Proc S Afr Sug Technol Ass* 64: 111-115.

Conlong DE (2001). Biological control of indigenous African stemborers: What do we know? *Insect Sci Appl* 21: 267-274.

Maher GW and Schulz L (2003). An environmental management system for sugarcane in the Noodsberg area of South Africa. *Proc S Afr Sug Technol Ass* 77: 189-195.

Maredia KM, Dakouo D and Mota-Sanchez D (Eds) (2003). *Integrated Pest Mangement in the Global Arena*. CABI Publishing, Wallingford, Oxon, UK. ISBN 0 85199 652 3.

Miller JR and Cowles RS (1990). Stimulo-deterrent diversion: A concept and its possible application to onion maggot control. J Chem Ecol 16(11): 3197-3212.

Polaszek A (Ed) (1998). *African Cereal Stem Borers. Economic Importance, Taxonomy, Natural Enemies and Control*. CAB International in association with ACP-EU Technical Centre for Agricultural and Rural Co-operation (CTA). Wallingford, Oxon, UK. ISBN 0 85199 175 0.

Schulthess F, Bosque-Perez NA, Chabi-Olaye A, Gonou S, Ndemah R and Goergen G (1997). Exchange of natural enemies of lepidopteran cereal stemborers between African regions. *Insect Sci Appl* 17: 97-108.