INTEGRATION OF INSECTICIDES IN THE MANAGEMENT OF *SESAMIA GRISESCENS* WARREN (LEPIDOPTERA : NOCTUIDAE) IN SUGARCANE AT RAMU, PAPUA NEW GUINEA

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ABSTRACT

The larva of the noctuid moth borer, Sesamia grisescens *Warren is a serious pest of sugarcane and has become one of the major constraints to sugar production at Ramu Sugar plantation, Papua New Guinea. Recent developments in the management of* S. grisescens *using insecticides are discussed in this paper particularly, the use of a pheromone trapping/monitoring system to schedule insecticide spraying. It has been found that spraying carried out during the moth flight period is effective in controlling young larvae before they bore into the stems, thus minimizing damage to sugarcane. Strategies to minimize the use of insecticides and the management of potential insecticides resistance are also discussed.*

***Keywords**: sugarcane,* Sesamia grisescens, *integrated pest management, permethrin.*

INTRODUCTION

There are several species of sugarcane stem borers native to New Guinea. Those that are pests of sugarcane at Ramu Sugar plantation are a weevil borer *Rhabdoscelus obscurus* Biosduval and the moth borers *Sesamia grisescens* Warren, (Lepidoptera : Noctuidae), *Chilo terenellus* Pag. (Lep. : Pyralidae) and *Scirpophaga exceptalis* Walker (Lep. : Pyralidae) (Kuniata *et al* 2001). Among these stem borers, *S. grisescens* is the most serious with potential for causing crop losses of up to 31 tonnes cane per ha, valued at more than K11 mill per annum (Kuniata 1998). In addition to these crop losses, Ramu Sugar Limited now spends up to US$350,000 annually for the control of *S. grisescens* on its 9,200ha sugar plantation. The weevil borer is a secondary pest and has a strong association with damage from the moth borers especially that from *S. grisescens* (Kuniata & Sweet 1994). The control of *S. grisescens* larvae reduces the number of bored cane and thus weevil borer damage. Both *C. terenellus* and *S. exceptalis* may be serious pests at times but crop losses are usually significantly lower than those observed for *S. grisescens*.

Details of an integrated pest management (IPM) strategy for *S. grisescens* was discussed by Kuniata (1999) and this has been implemented on the Ramu Sugar plantation with significant success. This IPM strategy involves aspects of cultural control, use of natural enemies and insecticides against *S. grisescens*. In this paper, recent developments in the use of insecticides and their integration in this IPM strategy for the management of this stem borer are discussed. Strategies implemented to delay possible development of insecticide resistance are also discussed.

Biology and Ecology

The noctuid moth, *Sesamia grisescens* Warren, is native to New Guinea (Holloway 1989) and has become a serious pest of sugarcane at Ramu Sugar plantation in Papua New Guinea causing sugar losses as high as 18%. Studies of the biology of *S. grisescens* showed that the moth is largely confined to sugarcane and other *Saccharum* spp. with large diameter stalks (Young & Kuniata 1992). Female moths oviposit behind the green leaf sheaths of sugarcane. The young larvae feed gregariously on the leaf sheaths for 2-3 days before boring into the stalk, 8-15cm below the meristem (growing point) region [Young & Kuniata 1992]. Bored stalks are usually killed within 2 weeks and extensive rotting of damaged stalks occurs as a result of larval feeding and the invasion of saprophytic fungi. In the fourth to fifth instar stage, the larvae disperse to infest nearby un-bored stalks, boring large entry holes. In some cultivars, these stalks produce dead-hearts (dead spindles) with extensive production of side shoots.

The pest completes its whole life cycle on sugarcane. Populations have been highly synchronized with a generation time of 60-70 days and 5 ½ generations annually [Young & Kuniata

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1992]. The population is at its highest in April-May, inflicting the greatest damage to the crop.

Pest Monitoring

Successful implementation of IPM strategies often requires an effective and efficient monitoring system of the pest population. This can be simple as; counting of pests/damaged cane, to sophisticated techniques, such as the use of pest modelling. The usefulness of these systems are that, they provide a predictive role based on historical records of population trends and can give an early warning that pest populations/damage could become economically important if they reach certain population thresholds.

From 1986 up until 2000, a destructive sampling method was used to monitor the pest and the damage caused. The method involves taking 200 stalks, sampled at random in a block; the stalks are split open and various life stages of *S. grisescens* and damage recorded. These are then used to direct releases of parasites and insecticide spraying. The cost of this sampling technique was estimated at about US$2 per tonne of sugar or US$90,000 per annum which is about 3% of potential crop loss (US$2.75 million) [Kuniata 1999] .

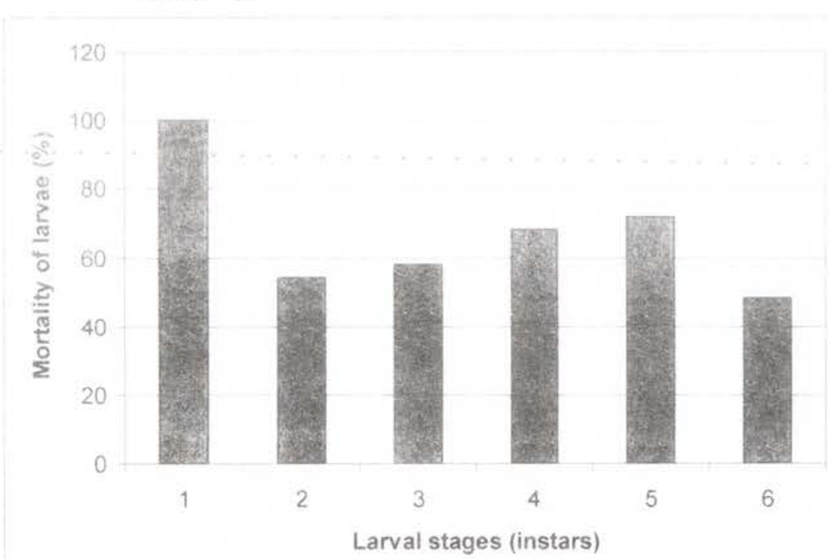
A pheromone has been identified for *S. grisescens* (Whittle *et al.* 1995) and this has been artificially synthesized and used to monitor moth numbers in the field. Recently, an economic threshold of 2 moths per trap per night was designated as the basis for scheduling insecticide spraying. The estimated cost of this monitoring technique was about US$25,000 per annum which is <1% of the value of potential crop losses. However, the increased effectiveness (reliability) and efficiency compared with destructive sampling have resulted in lower pest numbers and damage observed in the 2001 crop and the 2002 crop[(K. Korowi, unpublished data)]. Insecticides were sprayed when the moths were in flight, in an attempt to have residues already on the plants when the eggs hatch. Up to 100% mortality in hatching eggs/young larvae was observed in the field (K. Korowi, unpublished data) thus preventing subsequent damage to the stems of sugarcane. Using this approach, and by alternating between insecticide groups, excellent control has been obtained in the 2001/2002 season.

Insecticide Screening

A number of products have been evaluated both in bioassays (in the laboratory) and in small plot trials in the field. Those that performed well in field trials were further evaluated in semi-commercial trials using a spray plane and custom-built spray rig. A product is used commercially after at least 18 months following the evaluation process.

It was generally observed that mortality of *S. grisescens* larvae was highest when the larvae are still feeding on the leaf sheaths, with mortalities increasing with dose rates (Figure 1). Once the larvae have bored into the stalks, insecticides have a limited effect on the borers, especially in the

Figure 1. **Mortality of *S. grisescens* larvae due to insecticide spraying.**



These data were averaged from weekly samples (40-80 blocks) taken over February –May 1997.

second and third instar stages which are normally found inside the stalks. The larvae start migrating from primary infested stalks to damage other (secondary) stalks at the 4[th] instar stage. This process causes the larvae to come into contact with insecticide contaminated surfaces, giving slightly higher mortalities but still lower than those obtained with 1[st] instar larvae.

Other field observations have shown that larvae found in the upper sections of a bored stalk, and above the exit/entry hole, are less affected by insecticides (Figure 2). However, all the larvae found at the entry/exit hole and those lower down are readily killed, indicating the re-distribution of the insecticide on the plant with rainfall. As such spraying done before rains are received, especially critical with spray plane, appear to cause high mortalities in larvae of *S. grisescens*.

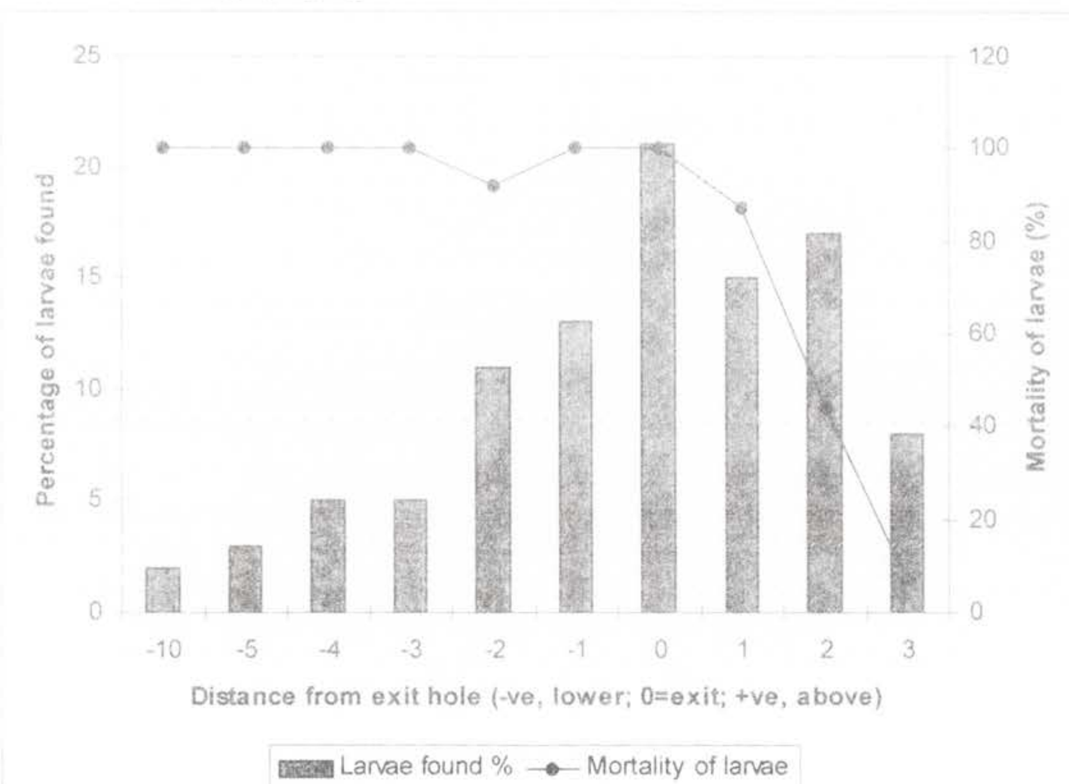
Commercial Spraying

The total area under sugarcane at Ramu is about 8,500 ha, with up to 16,000 ha sprayed for the control of *S. grisescens* annually. Data from initial whole field size trials (n=20) indicated highly significant increases in cane yields were achieved due to reduced infestations and damage in sprayed compared to unsprayed cane (Table 1). In other field trials, an increase of up to 200% in cane yield and up to 150% in sugar yields has been observed (Kuniata 1999).

Where no insecticide spraying was carried out, 5 ½ generations of *S. grisescens* were observed annually (Figure 3(a)), with larvae numbers highest during March-April. Although the peaks in larvae numbers were still seen in years where insecticides were used, these were generally lower and flatter. Similar trends were observed for damage associated with *S. grisescens* (Figure 3(b)) where damage levels were much flatter compared to unsprayed cane.

From 1997 to 2000, a threshold of 16 larvae per 200 stalks was used to select fields for insecticide spraying, while parasites are released at lower levels of attack. As a result, some damage would have already occurred before spraying was carried out. In 2001/2002, the system was changed slightly, using a threshold based on moth numbers from pheromone traps. Starting in July 2001, a threshold of 2 moths/ pheromone trap per night was used and insecticide spraying took place when the moths

Figure 2. **Distribution of *Sesamia* larvae in relation to entry/exit holes on the sugar cane stalks. As an indication of re-distribution of insecticides on the plant following spraying.**



The distance from exit hole is in centimetres.

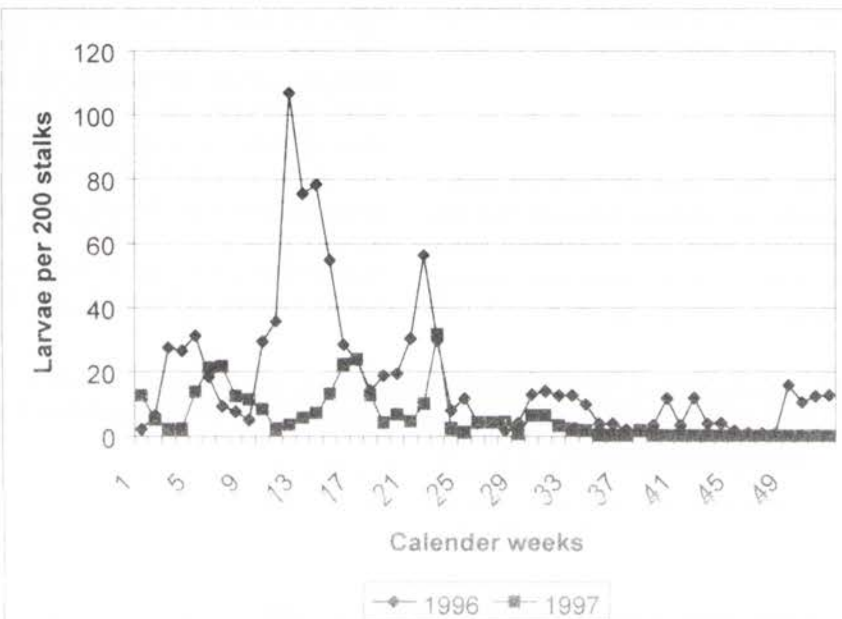
Table 1. **Summary of *S. grisescens* conrol in semi-commercial trials sprayed with lambda-cyhalothrin (Karate 2.5EC) in the 1996 season**

	Sesamia per 100 stalks			Cane Yield(t ha^{-1})
	Larvae	Pupae	Bored stalks	
Sprayed	11.3	0.3	10.7	75.0
Unsprayed	62.4	12.2	66.0	47.7
t-test	2.97 $p<0.01$	2.18 $p<0.05$	4.98 $p<0.001$	7.20 $P<0.001$

Number of fields used = 20.

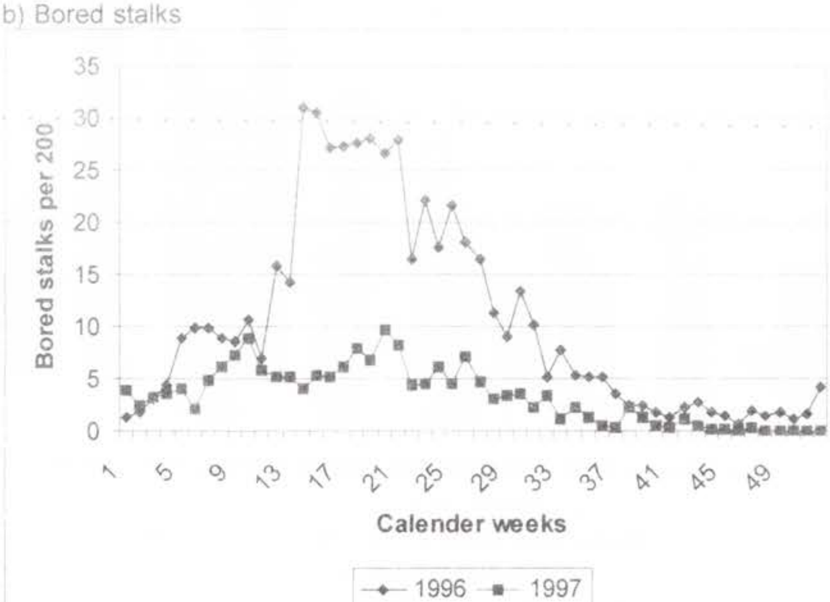
Figure 3. **Summary of *S. grisescens* larvae numbers and bored stalks observed in 1996 unsprayed compared to those**

a) Larvae



Counts were made on a weekly basis and covered 200-300ha per week.

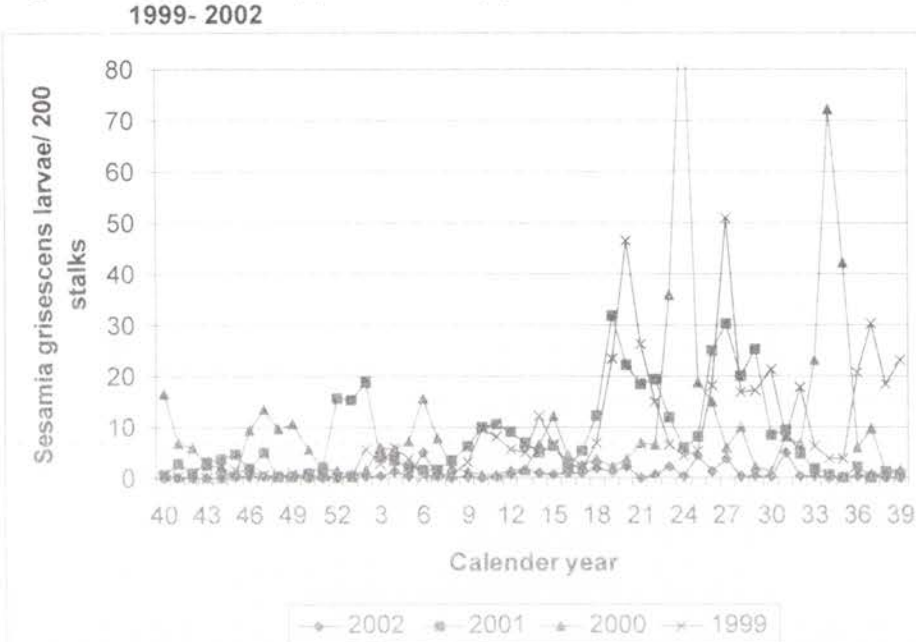
b) Bored stalks



were active. It is possible that some moths would have been killed during flights but the main objective is to ensure the insecticide is already on the plants, especially in the leaf sheaths, before the eggs hatch and before young larvae bore into the stems. Up to 100% mortality in eggs/ young larvae was observed in the field. As a result of this, *S. grisescens* populations and borer damage declined towards the latter part of 2001 and this continued to remain low during the 2002 season (Figure 4).

The other issues that need to be considered (Figure 5) are; insecticide resistance management (IRM), application techniques to be used, and cost of the product. Insecticide resistance has been observed in many tropical insect pests and it is important that management of this potential problem is taken into consideration when implementing a spraying program. A similar approach to that developed for cotton in Australia for *Helicoverpa armigera* Hubner (Lep. : Noctuidae) (Forester *et al.* 1993) is used for *S. grisescens* on Ramu Sugar plantation. This strategy involves alternating between groups of

Figure 4. **Summary of (a) larvae and (b) bored stalks observed in 1999- 2002**



In 2002 moth counts were used to schedule insecticide spraying where previously this was done based on counts made from split cane.

b) Bored stalks

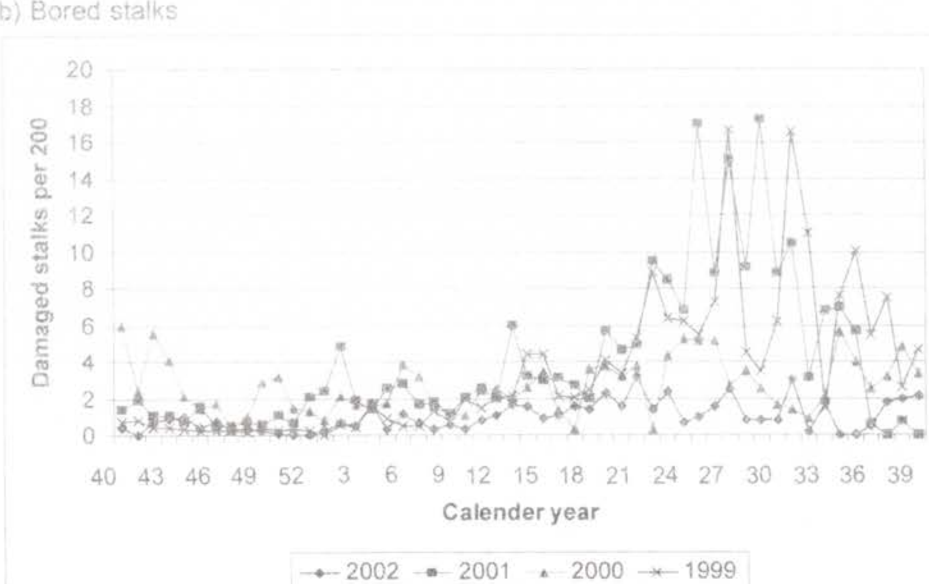
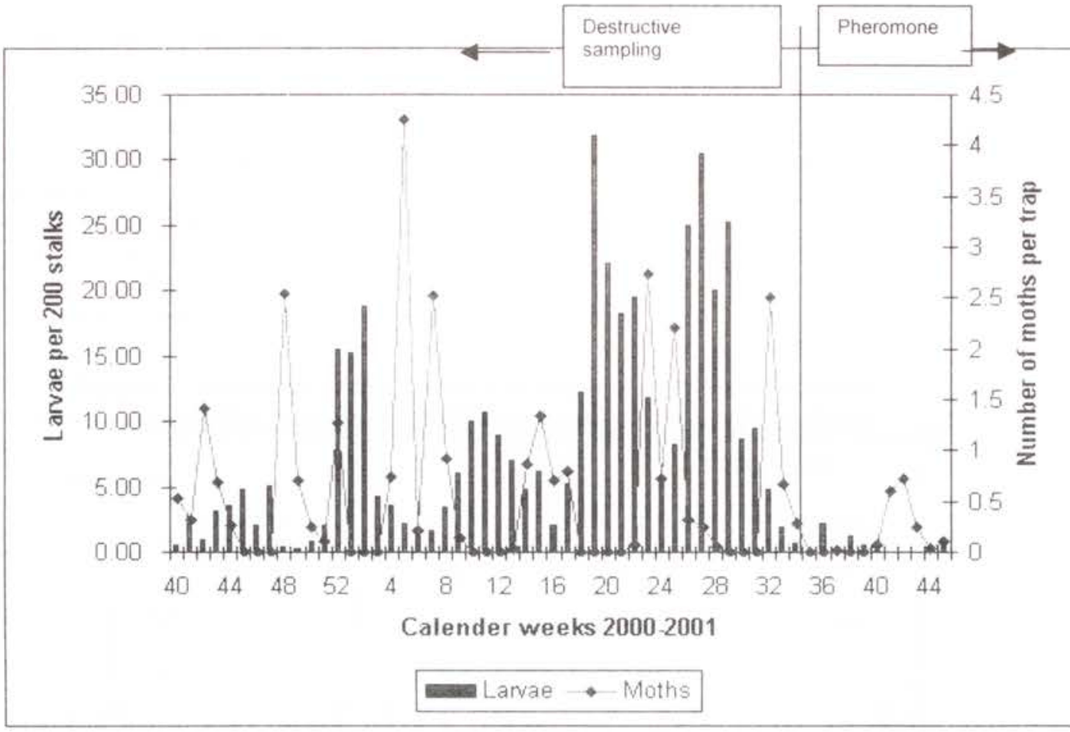


Figure 5. **Monitoring of moths using pheromone and larvae counts from split cane.**



Insecticides used for Sesamia spraying in 2000/2001 season

Mimic	Permethrin/ Karate	Acephate	Mimic	Mospilan

insecticides in an attempt to delay the development of insecticide resistance (Figure 5). Terbufenozide (Mimic [R]) is an insect growth regulator (IGR) specific for moths and it is used during July to October. It is an expensive product but is used on a small area of young cane (<2000 ha). The synthetic pyrethroids (permethrin/ lambdacyhalothrin) have a knock-down effect on the pest, a limited residue life in the field and are relatively cheaper than the IGR. These are used between December and April, effectively using the spray plane when large areas need to be covered in a limited time. Acephate, an organo-phosphate (OP) insecticide, did not work well in 2001 and therefore was withdrawn from commercial use. A new product, Mospilan [R] (acetamiprid) has been introduced towards the end of 2001 and has performed quite well. This product affects the Ach receptor of the insects' central nervous system as an antagonist of Ach, the opposite action to OPs. Again, this is another expensive product but with a smaller area treated, it may fit in to the November – December period. So far no incidence of insecticide resistance has been reported in this system for *S. grisescens*.

Another aspect that has been incorporated in the spraying strategy is the consideration of insecticide residues. The pyrethroids have a with-holding period of up to 7 days and are therefore used in the January-March period. Harvesting starts in April. After this period selective spraying using permethrin/ lambda-cyhalothrin especially in younger cane is carried out. The other products (usually with extended with-holding periods) are not used in the crop to be harvested that year but only in younger crops that are usually planted/harvested in February-May.

To spray the large treatment area in December – April, a spray plane is used. Since in some blocks, the crop would be too tall and the use of ground rigs would cause more damage to the crop. Liquid formulations of permethrin/ lambda-cyhalothrin are used as opposed to mixing of wet-able powders/ granular formulations, which may result in long down-times during mixing and loading of the plane. The custom-built ground spray rigs are used between May and November in applying terbufenozide and acetamiprid both granular formulations.

Monitoring of *S. grisescens* moths using a synthetic pheromone (Whittle *et al* 1995) in conjunction with larvae numbers determined from splitting cane began in 1999. During this time, it was observed that peaks of moths were immediately followed by larvae peaks (Figure 5), suggesting the possibilities for using the moth counts to schedule insecticide spraying. At the same time a threshold of 2 moths per trap per block was determined and this was used to trigger any insecticide spraying. Therefore, in October 2001, insecticide spraying was carried out in all the blocks showing >2 moths. In recovery surveys, it was found that up to 100% of larvae mainly 1st –2nd instars were killing while still in the leaf sheaths (before boring in to the stalks). This approach continued in to 2002 season and proved successful in reducing *S. grisescens* damage in the 2002 crop.

'Road to Reduced Insecticide Reliance'

Integrated pest management (IPM) utilizes all suitable techniques and methods in as compatible a manner as possible to maintain pest populations below a threshold causing economic injury. This represents a change from the philosophy of pest control by eradication to the management of entire pest populations, not just localized ones (Dent 1991). Emphasis is placed on the use of a combination of methods aimed at providing suitable, long-term, control with the minimum of harmful side effects. Development of IPM depends partly on a good understanding of the biology and life history of the target pest. All such information is then integrated in a range of cultural, insecticidal and bio-ecological controls so that potential pests remain at sub-economic levels.

The Crop Production system used at Ramu Sugar plantation has already been described (Kuniata 1999 & 2000). An interaction matrix was used to identify production factors that have a significant effect on S. grisescens populations. The most significant includes; varietal resistance, time of planting/ratooning, and the use of natural enemies. High risk sites have been identified on the plantation and resistant varieties are used in these areas. These sites are usually along river-banks and it is important that spray drift is reduced as a result of less spraying frequency (less drift to non-target sites).

More than 60% of the 1800 ha of cane to be planted each year is planted during March-June thus presenting a semi-mature crop (less attractive to S. grisescens) when populations start to increase in February to March the following year (Kuniata & Sweet 1994). Cane planted/ratooned from September to November will be highly susceptible to borer damage but this area is smaller and can be easily sprayed for borer control, thus reducing insecticide usage further.

A small parasite rearing facility has been established and is routinely producing Pediobius furvus Gahan (Hymemoptera : Eulopidae) and Cotesia flavipes Cameron (Hym. : Braconidae) parasites for field release. All the fields showing a threshold lower than 14 larvae per 200 stalks are used for parasite releases. It has been shown that parasite releases made 10-14 days following insecticide spraying appear not to be severely affected especially following the use of pyrethroid insecticides.

The implementation of the strategies described above has resulted in a reduction of the area sprayed from more than 19,400 ha in 1997 to about 2,560 ha in 2002 (Table 2). A useful assessment for effective use of insecticides is the calculation of ratios between sugar production and total active ingredients used. Total active ingredients used since 1997 have shown a declining trend from >4,000 kg a.i. to about 700 kg a.i. in 2002 (Figure 6). As efficient pest monitoring methods are used, combined with appropriate insecticides and application methods, the ratio between sugar production and active ingredients used should continue to increase.

CONCLUSION

Insecticides will continue to be used in IPM systems especially in mono-cropping situations. They provide important pest management tools, which need to be used sensibly because of the potential problems they can cause to the agro-ecosystem, to plantation workers and to the environment. Understanding the ecology and biology of *S. grisescens* and careful selection and phasing of insecticides for the control of this pest has had a significant impact on sugar production at Ramu Sugar plantation. The strategies implemented in late 2001 have resulted in the lowest *S. grisescens* levels ever seen. This made a significant contribution towards sugar yields in the 2002 season.

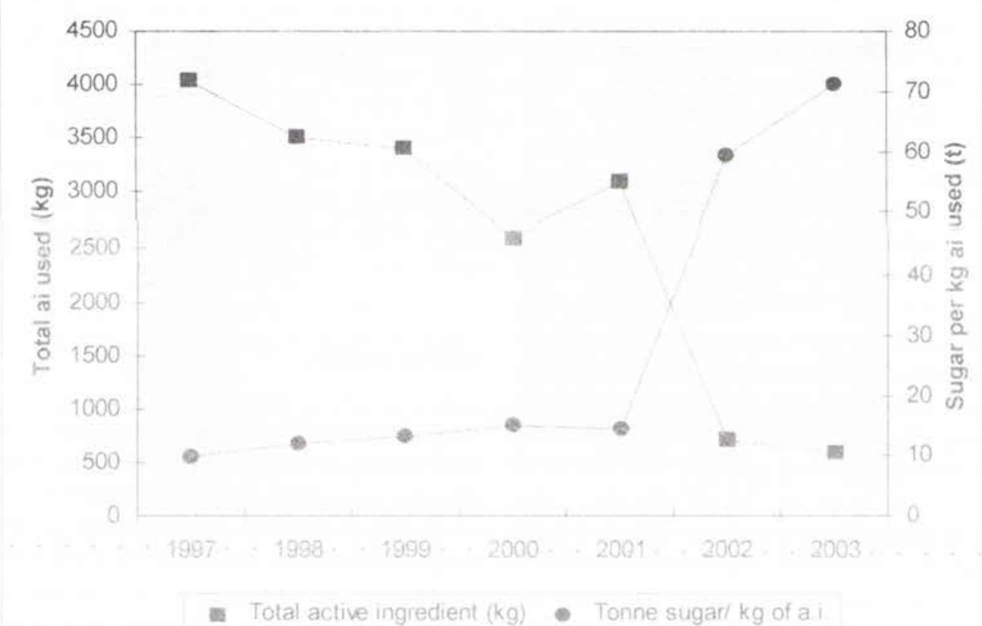
A reduction in active ingredients used in the last five years has indicated that positive trends in effective use of insecticides are being achieved. At

Table 2. **Summary of total area sprayed and active ingredients used for the control of *S. grisescens* at Ramu Sugar plantation. 1997 - 2002.**

Parameters	1997	1998	1999	2000	2001	2002
Total area sprayed (ha)	19,409	17,432	17,407	12,834	14,191	2556
Insecticides used (kg ai)						
- Permethrin	3,853	3,282	3,046	1,601	2,045	534
- - lambdacyhalothrin	78	79	72	4	1	0
- monocrotophos	29	0	0	0	0	0
- acephate	50	117	210	346	77	0
- terbufenozide	4	9	55	635	837	105
- aetamiprid	0	0	0	7	124	70
- others*	14	12	22	0	0	0
Total active ingredients (kg)	4,028	3,498	3,405	2,592	3,084	709

* others – malathion/chlorphyrifos / carbaryl.

Figure 6. **Summary of total active ingredients of all insecticides used for the control of *S. grisescens* in sugarcane at Ramu Sugar plantation.**



the same time, there has not been a case of resurgence of secondary pests since the implementation of this strategy in 1997.

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