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STRATEGIES TO CONTROL GREYBACK CANEGRUB IN EARLY HARVESTED RATOON CROPS

by

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SD02022

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EXECUTIVE SUMMARY

Greyback canegrubs consistently cause losses of $5-10 million per year to sugarcane producers, with periodic disastrous outbreaks where losses are about $20-40 million. This indicates that the current strategy is inadequate to manage this pest in the modern production environment. This project targets one important constraint to developing a better management package - the inability to treat ratoon crops, the crop category contributing most to outbreaks. The specific aim was to largely overcome this constraint through, simultaneously, demonstrating to and encouraging growers to adopt more advanced and efficient control systems, whilst exploring the potential of a new insecticide within the system framework. This project saw a joint involvement between SRDC, BSES, the industry-funded Inkerman Cane Protection and Productivity Board (CPPB), and Bayer CropScience, to facilitate more rapid and relevant registration of a compound for use in sugarcane production.

Long-term BSES and SRDC program goals are to develop combinations of new and existing cultural, biological and chemical tactics into newer, flexible, integrated pest management (IPM) strategies to modulate the severity and frequency of losses and to provide more affordable and sustainable controls. In evaluating a new insecticide for use in ratoon crops, grower participants and supporting staff were introduced to the concept of developing more modern IPM practice for managing greyback canegrub. The new system may also be applicable to other control agents. The aim is for integrated strategy with flexibility - new risk-assessment-based systems for selecting fields suitable for this treatment, or for alternative tactics, and 'trap-cropping' concepts for attaining maximum benefit from a specific treatment through cross-protection of neighbouring fields.

A number of insecticides were investigated for their potential to fulfil this role. The relatively new product Confidor, a liquid formulation of the chloronicotinyl insecticide imidacloprid, with different activity and properties to the current organophosphate insecticide chlorpyrifos, offered the best prospects for its potential to protect ratoon crops.

The project demonstrated the efficacy of the insecticide Confidor® 200 SC (200 g imidacloprid /L) for greyback canegrub control in sugarcane and develops a new system to protect a ratoon crop with insecticide. Between 300-360 g ai/ha (1.5-1.8 L/ha) of this product applied 100-150 mm deep in the soil alongside rows of ratoon shoots behind coulters, between September and December, provides the most consistent and economically beneficial control where infestation occurs.

Planning rules have been identified to guide growers in cost-effective use of Confidor. Selected fields should have good prospects for a healthy crop, ie good growing conditions to take maximum advantage of any benefit that treatment provides, and the potential to be ratooned at least one more time. Where conditions were suitable, benefit:cost ratios of 3.5-8 were attained.

Criteria applied in this and SRDC project BSS205 resulted in at least 70% probability of identifying ratoon fields likely to be infested sufficiently to benefit from pre-emptive planning of the harvest and subsequent treatment with Confidor. These criteria include predisposing variables such as proximity to known infestation, infestation of the previous crop in that field, proximity to feeding trees, crop harvest date, and growing conditions, in addition to fixed conditions such as soil type.

However, BSES strongly recommends that Bayer CropScience and BSES continue to co-operate to identify factors that may allow further increases in the efficiency and consistency with which Confidor is used; the variability of responses seen in this project indicates such improvement is probable. Sugarcane producers also need definitive information to determine the ideal proportions of ratoon fields that should be harvested early and treated, in order to attain maximum benefit from this strategy and the trap-cropping tactic in particular, and for reducing pesticide costs.

BSES and companies other than Bayer CropScience are collaborating to evaluate other products with potential in this role, but several constraints need to be overcome before further development can proceed. In view of the proposed registration of a CR-formulated imidacloprid against greyback grub, we recommended that the industry continues the search for effective alternative control agents, to reduce almost total reliance on one compound and a relationship with one supplier.

Effective application methods and equipment, indicative product rates, and timing for treatments with Confidor have been proven. Many farmers have demonstrated, through their participation in the program and purchase and use of product under a large-scale experimental permit and an emergency use permit, their willingness to adopt the new tactic, strategy, and product. Using the efficacy data and management plan from this project, Bayer CropScience is seeking registration for the product for use within an IPM program for Australian sugarcane. Agronomic, pest management, and economic considerations have been combined to propose what the evidence suggests are reasonably reliable planning rules, to identify the most appropriate fields for treatment and to identify fields where Confidor treatment is inappropriate and alternative tactics more appropriate. The practicality of developing a modern IPM program for greyback canegrub has been boosted immeasurably through the research and implementation processes in this project. The challenge is now to keep this development process active for the full range of cultural and biological tactics, rather than for insecticides alone.

1.0 BACKGROUND

Greyback canegrubs consistently damage the northern sugarcane industry, regularly causing losses of \$5-10 million each year, and periodic disastrous outbreaks with direct losses of \$20-40 million. In 2001, total crop loss plus protection costs plus costs of replanting damaged crops was about \$59 million. This indicates that the existing, inflexible, archaic system is inadequate to manage this pest in the modern production environment. BSES and SRDC programs aim to develop and implement newer integrated pest management (IPM) systems that combine new and existing cultural, biological, and chemical tactics, to reduce the severity and modulate the frequency of damage and to provide affordable and sustainable controls.

This project aimed to provide canegrowers with insecticidal capacity to control the pest in ratoons, the most vulnerable crop category with the greatest proportion of damage. Simultaneously, it sought to introduce growers to newer IPM concepts for managing greyback canegrub.

With the present controlled-release (CR) chlorpyrifos products (suSCon® Blue, suSCon® Plus), the concepts of confining insecticide treatment to specific plant cane fields identified as being at high risk of greyback grub damage is of no benefit for second ratoon or older crops, and effective treatment of old and unprotected ratoons is impractical. CR chlorpyrifos, the only insecticide registered as at 1999, is only effective if applied into the open furrow stage of plant crops and it subsequently protects first ratoons to a lesser extent. It is not readily applied to ratoon crops in a way that it can function effectively. Soil pH above 6.2 quickly renders CR chlorpyrifos ineffective; such levels occur in the Burdekin region, a major production region suffering severe damage, or elsewhere if elevated through lime-based soil amelioration practice. Routine prophylactic application of this CR-product to plant crops is very expensive, and the tactic is not sufficiently flexible to rapidly reduce populations at critical times, particularly if a high proportion of older ratoons is being grown.

This project specifically combines ‘new’ strategy with ‘new’ insecticide to protect ratoon crops, as ratoons generally incur the major proportion of damage, especially outside the Burdekin region, and cannot be protected with current systems. The strategy is to limit treatment to fields or portions of fields with the highest risk of infestation and greatest likelihood of economic benefit from investment. ‘New’ insecticides were ones not currently registered but which had controlled greyback canegrub in preliminary BSES field trials in ratoons, and which had good prospects for registration. At least two insecticides appeared very suited to the IPM approach to grub control, and relatively easy to apply without complex equipment: Confidor® 200 SC (200 g imidacloprid per L), and Regent® 200 SC (200 g fipronil per L). They are more tolerant of soil pH conditions than chlorpyrifos, are relatively safe, and have different modes of action to other pesticide groups thus lessening risks of insecticide resistance, and do not require complex and expensive CR-formulation to maintain activity for the 3-5 month period required.

2.0 OBJECTIVES

This project aimed to identify and refine (promising) insecticide treatments for application to early harvested ratoons for management of greyback canegrubs, and to integrate these into canegrub pest management best practice.

Objectives in this process were to:

- compare combinations of insecticide rate, application method, and timing on control of greyback canegrub;
- identify the most effective and practical combinations of tactics, and refine the variables;
- integrate successful insecticide treatments with a range of cultural and biological tactics for greyback grub management.

In this project, researchers and other participants:

- extensively tested the insecticide product Confidor 200 SC (200 g a.i./L imidacloprid) and identified effective combinations of rate, application method, and timing for controlling greyback canegrub;
- conducted a preliminary field test and a bioassay with another insecticide (fipronil), and obtained a limited amount of data;
- obtained data on and/or practical experience of:
    - which categories of early-harvested ratoons function as 'trap-crops' in which ovipositing beetles preferentially aggregate;
    - the extent to which insecticide treatment could reliably be limited to those early-harvested trap areas;
    - the extent to which other categories of ratoon crop, not necessarily early-harvested, are likely to act as 'trap-crops' that may require either protection with insecticide or cultural tactics to prevent population build-up for the future;
    - integrating 'early-harvested trap-crops' into best practice grub management strategies, including treatments with Confidor or other insecticides, the biological insecticide BioCane™, and natural disease epidemics;
    - economic evaluation of treating particular classes of crop with Confidor.

3.0 METHODOLOGY

3.1 Insecticide products, rates, application method and timing

We initially identified the liquid insecticide Confidor 200 SC (200 g imidacloprid per L) as the most suitable for detailed experimentation, based on preliminary BSES data and willingness of the owners (Bayer (Australia)) to register the product through NRA and to contribute to and co-operate with the project.

The liquid insecticide Regent 200 SC (200 g fipronil per L), registered in sugarcane for wireworm control, was also considered, but preliminary field and screening trials were not encouraging and the company was less keen to contribute to a joint project. However, we conducted a preliminary field trial of application methods suited to ratoon treatment with Regent. We also conducted a bioassay with fipronil by a different treatment method.

The granular insecticide product Rugby® (100 g cadusafos per kg) is very toxic to greyback grubs and is registered for use against other grub species in sugarcane and was considered for this project. However, we felt that, because the registered application method is into the stools when ratoons are relatively small, the product would need to remain active for 4-5 months if it were to be used as a ratoon treatment for greyback grub control. The product does not normally persist this long, especially at pH >6.5. Further development is proceeding with Crop Care on acidulation of granules to extend activity of cadusafos, with the aim of making the product useful for ratoon treatment especially in neutral to alkaline Burdekin soils.

3.2 Testing most suitable rate, application methods and timing for Confidor

In 1999 we established 11 field trials in the irrigated Burdekin region. Six were randomised complete-block small-plot experiments, three with factorial treatments of product rates and treatment dates (Table 1a) and three with treatment combinations of product rates and treatment methods and treatment dates (Table 1b). Five large demonstration-plots were established with Confidor treatments at a range of dates and of crop situations (Table 1c). To refine treatment variables in 2000, we established 25 field trials in the irrigated Burdekin region and at (mostly) non-irrigated sites in the Herbert, Gordonvale and Tableland regions. Eight were replicated-block small-plot experiments; four (Table 2a) tested product rates, and four (Table 2b) compared treatment dates at two rates, with one comparison of stool splitting and side dressing also included. Eight (Table 2c) replicated large-plot experiments were established to test one or two product rates. Seven (Table 2d) replicated large-plot experiments were established to compare two application methods (stool-splitting and side-dressing).

Table 1a - 1999-established replicated-block field trials: Details of treatment rates, application dates and equipment.

#	Poli			Rossiter			Milburn		
	ai/ha (g)	**Date**	**Eqp***	**ai/ha (g)**	**Date**	**Eqp***	**ai/ha (g)**	**Date**	**Eqp***
1	1000	25/08/99	over	283	14/09/99	over	235	26/8/99	over
2	624	25/08/99	over	484	14/09/99	over	388	26/8/99	over
3	343	25/08/99	over	928	14/09/99	over	663	26/8/99	over
4	234	1/11/99	over	273	1/11/99	over	255	1/11/99	over
5	492	1/11/99	over	541	1/11/99	over	540	1/11/99	over
6	748	1/11/99	over	757	1/11/99	over	856	1/11/99	over
7	278	23/11/99	inter	265	23/11/99	inter	270	24/11/99	inter
8	591	23/11/99	inter	488	23/11/99	inter	499	24/11/99	inter
9	841	23/11/99	inter	763	23/11/99	inter	766	24/11/99	inter
10	325	6/01/00	inter	292	15/12/99	inter	252	8/12/99	inter
11	505	6/01/00	inter	584	15/12/99	inter	560	8/12/99	inter
12	830	6/01/00	inter	865	15/12/99	inter	805	8/12/99	inter
0	0	-	-	0	-	-	0	-0	-

*All treatments applied as side-dressings; using over-row or inter-row equipment

Table 1b - 1999-established replicated-block field trials: Details of treatment methods and rates at two application dates.

#	Treatment method	Kelly 'a'		Mau		Roberts 'a'	
		Rate	Date	Rate	Date	Rate	Date
1	in single slit in stool centre	312	16/9	200	10/9	330	16/9
2	in single slit in stool centre	570	16/9	325	10/9	670	16/9
3	in single slit in stool centre	937	16/9	536	10/9	1000	16/9
4	in two slits in stool @ 300mm	312	16/9	257	10/9	333	16/9
5	in two slits in stool @ 300mm	500	16/9	412	10/9	489	16/9
6	in two slits in stool @ 300mm	937	16/9	697	10/9	916	16/9
7	in side-dressing slits @ 500 mm	312	16/9	259	10/9	327	16/9
8	in side-dressing slits @ 500 mm	625	16/9	492	10/9	511	16/9
9	in side-dressing slits @ 500 mm	930	16/9	751	10/9	875	16/9
13	in side-dressing slits @ 500 mm	290	9/12*	283	6/12	270	18/11
14	in side-dressing slits @ 500 mm	670	9/12*	544	6/12	570	18/11
15	in side-dressing slits @ 500 mm	996	9/12*	886	6/12	865	18/11
10	nil	0	-	0		0	
11	nil (=10)**	0	-	0		0	
12	nil (=10)**	0	-	0		0	
0	nil (=10)**	0					

*Applied by inter-row tractor; all others applied with over-row equipment
**Called "10" in SAS analysis of yield

Table 1c - 1999-established large-plot field trials: Details of product rates and application methods

Grower	Methods and equipment	Date	ai / ha (g)
P. Sgarbossa, Kirknie Rd, via Home Hill	twin coulters 280 mm apart through stool; over-the-row tractor; 2 reps	24/8/99	540
Alan Blaik, Hodel Rd, Haughton R	twin coulters; slots 550 mm apart beside stool; Inter-row tractor 2 reps	15/12/99	450
Bob Gibson, Kirknie Rd, via Home Hill	twin coulters; slots 550 mm apart beside stool; Inter-row tractor; 1 rep	10/12/99	592
M. Kelly 'b', Brown Rd, Mona Park	single coulter through middle of stool; over-the-row tractor; 2 reps	15/12/99	550
S Roberts 'b', Northern Rd, Rita Is.	single coulter through middle of stool; over-the-row tractor; 1 rep	14/9/99	350-500

Table 2a - 2000-established replicated-block small-plot field trials: Details of Confidor applications by side dressing at different rates.

Treatment #	Rates of imidacloprid (g ai/ha)			
	Ponzo & Galetto (Boatfield) Home Hill	Russell Young, Rita Is	Graham Lyons, Poletti Rd, Giru	Paul Romeo, Bruce Hwy, Ayr
0	0	0	0	0
1	228	110	135	171
2	257	175	190	250
3	320	210	237	295
4	460	330	339	415
5	680	395	489	643
Date applied	6/9/2000	7/9/2000	8/9/2000	4/10/2000

Table 2b - 2000-established replicated-block small-plot field trials: Details of Confidor side-dressed at two rates on three dates, or by stool splitting.

Treatment # (method)	Rate (g ai /ha) and application date			
	R. Stockdale, McDowell Rd, Home Hill	P & N Pitiris, McDowell Rd, Home Hill	W Scougall, Green Hill, Cairns	S. Nucifora, Highleigh, Gordonvale
0	0	0	0	0
1 (side-dress)	588 (27/7/2000)	588 (27/7/00)	460 (3/8/00)	514 (3/8/00)
2 (side-dress)	264 (27/7/2000	264 (27/7/00)	323 (3/8/00)	370 (3/8/00
3 (side-dress)	603 (1/10/2000)	684 (3/10/00)	519 (11/10/00)	432 (11/10/00)
4 (side-dress)	402 (1/10/2000)	376 (3/10/00)	382 (11/10/00)	343 (11/10/00)
5 (inter-row)	443* (12/12/00)	426 (6/12/00)	388 (15/02/01)	Not applied**
6 (inter-row)	295* (12/12/20)	327 (6/12/00)	283 (15/02/01)	Not applied**
7 (split-stool)	435 (3/10/00)	362 (3/10/00)	321 (11/10/00)	370 (11/10/00)

*Treatment error – applied to wrong plots ** December 2001 site too wet, and not infested

Table 2c - 2000-established large plot field trials: Details of rates and dates for ratoon side-dressing with Confidor.

Farm	Rates (g ai / ha)	Replicates	Date
Saunders & Baldotto, Home Hill	0, 260, 360	1	6/9/00
Ponzo & Galetto, Home Hill	0, 375	1	6/9/00
DiBella, Rita Is	0, 408	2	7/9/00
G. Lyons, Giru-Clare	0, 414, 264	1	8/9/00
G. Lyons, Giru-Clare	0, 264	3	8/9/00
P. Romeo & Sons Ayr	0, 323	2	4/10/00
A & C Spano, Ingham Line	0, 256	1	5/10/00
D. Rankine, Tinaroo Ck, Mareeba	0, 380	2	14/10/00
G. Despot, Kurrimine	0, 386, 450	2	19/10/00
G. Despot, Kurrimine	0, 250	4	19/10/00
G Despot, Kurrimine	0, 400	2	19/10/00
H. Binder, Kurrimine	0, 413	3	20/10/00

Table 2d - 2000-established large-plot field trials: Details of rates of Confidor applied by stool splitting and by side dressing, and dates.

Farm	Rate (g ai / ha)	Replicates	Date
S. & C. Lamari, Ingham Line	0, 380	2	10/9/00
R. Blanco, Blackrock, Ingham	0, 450	2	11/9/00
D & B & R Celotto, Abergowrie	0, 440	2	12/9/00
Eda Vella, Abergowrie	0, 427	1	12/9/00
S & J & J Arcidiacono, Gordonvale	0, 344	3	12/10/00
J. Markotich Green Hill, Cairns	0, 314	1	12/10/00
D. Rankine, Mareeba	0, 355	2	13/10/00
G Adil, Arriga (Mareeba)	0, 275, 518	2	17/10/00
J. Mc Avoy, Innisfail	0, 350	2	18/10/00

Table 2e - BioCane and Confidor combination trials, established 1999-2001: Details of treatment, establishment date and trial design.

Farm	Design	Year, crop class and treatments	
Sgarbossa (a)	Randomised complete block	**1999 (ratoon)** FI1045WP @ = 33kg/ha FI1045WP @ = 17kg/ha Confidor @ 500 g/ha FI1045WP 33 + Confidor FI1045WP 17 + Confidor untreated	**2000** (out)
McDonald and Sgarbossa (b)	Randomised complete block	**2001 (plant)** BioCane 33 kg/ha BioCane 66 kg/ha Confidor 200g/ha Confidor 400 g/ha Confidor 200+ BioCane 33 Confidor 200 + BioCane 66 Confidor 400 + BioCane 33 Confidor 400 + BioCane 66 untreated	**2002 (1 ratoon)** - - - - Confidor 200 g/ha Confidor 200 g/ha - - -
Raitelli (a)	Replicated block	**1999 (plant)** BioCane 33 kg/ha BioCane 33 kg/ha BioCane 33 kg/ha	**2000 (1 ratoon)** Confidor 264 g/ha Confidor 604 g/ha untreated
Langdon and Raitelli(b)	Randomised complete block	**1999 (plant)** BioCane 33 kg/ha BioCane 33 kg/ha BioCane 33 kg/ha BioCane 33 kg/ha BioCane 33 kg/ha	**2000 (1 ratoon)** Confidor 125 g/ha Confidor 250 g/ha Confidor 375 g/ha Confidor 500 g/ha untreated
M. Kelly	Replicated block	**1999 (plant)** BioCane (plant crop) BioCane (plant crop) BioCane (plant crop) BioCane (plant crop) BioCane (plant crop)	**2000 (1 ratoon)** suSCon Plus 1.3L Confidor 2.0L Confidor 2.2L Confidor untreated
J Veronese and W. Saro	Randomised complete block	**2001 (plant)** Confidor 400g/ha Confidor 200g/ha Confidor 400g/ha BioCane 33 kg/ha BioCane 33 kg/ha BioCane 33 + Confidor 400 suSCon Blue Untreated	**2002 (1 ratoon)**
V. Cervellin	Replicated blocks	**2000 (plant)** BioCane BioCane BioCane untreated	**2001 (1 ratoon)** Confidor 400g/ha Confidor 200g/ha nil nil
G. Morley	Replicated blocks	**2000 (plant)** BioCane nil BioCane nil	**2001 (1 ratoon)** Confidor 200g/ha Confidor 200g/ha nil nil

3.3 Combinations of tactics – economics, criteria identifying suitable fields

To address this objective, all 36 of the 1999 and 2000-series field trials (Tables 1a-c; 2a-d) were established in sites identified by us or by co-operating farmers as being where Confidor treatment could be integrated with broader-consideration pest management plans. All were established in relatively early-harvested ratoons considered, for a variety of reasons, as being 'trap-crops' at high risk of greyback canegrub infestation, and our predictive capacity can be calculated from the degree of infestation each site experienced. Observation on variations at or surrounding each site, particularly in-crop height and also the degree and extent of infestation already present, were used to attempting to identify the role of these criteria in successfully establishing trap-crop areas. Estimates of the minimum necessary extent of 'trap-cropping' treatment with Confidor are deduced from our observations. We used economic benefit:cost assessment of treatment responses as the primary indicator of effective treatment and as a criterion to identify fields suitable for treatment.

3.4 Integrating insecticide treatment with other tactics and management plans

Participative development of farm management plans. To address the third objective, farmers planed and implemented their own strategy in 2001, with advice on application methods and rates for chemical and integration with other tactics from project staff or other BSES and CPPB staff. BSES ran a large series of workshops for growers and support staff to develop integrated greyback grub management plans for Burdekin and northern and central region farms (Hunt *et al* (2002)- the 2001 *GrubPlan* program). BSES conducted similar workshops in 2002.

Integrating Confidor with the BioCane biological agent. Randomised complete block and replicated block design field experiments were established (Table 2e) to test possible synergy between Confidor and the biological control agent BioCane™, (Bio-Care Technology), an artificial culture of strain FI-1045 of the entomogenous fungus *Metarhizium anisopliae* particularly virulent to greyback canegrub. In 1999, one trial (Sgarbossa (a)) was set out in ratoons at Ayr with a liquid suspension of BioCane spores (formulation FI-1045 WP) at spore populations equivalent to 33 kg (the 'full' rate) and 17 kg (half-rate) BioCane per hectare in various combinations with Confidor. BioCane was also applied by farmers to plant cane at three sites at Ayr in 1999 (Langdon, Raitelli (a),(b)), and at two sites in 2000 at Ingham (Morely, Cervellin), with the intention of over-treating these areas with various Confidor combinations in the following ratoon. BSES officers established four complete-block small-plot sites with BioCane in 2001 (MacDonald, Sgarbossa (b), Saro, Veronese) with the intention of over-treating some plots with Confidor in 2002.

3.5 General methods

Monitoring. At all 36 sites, grub-infestation pattern, treatment effects on grubs and grub numbers, and cane and sugar yields were assessed if the site became infested. Assessment of subsequent ratooning ability was also noted or assessed as needed.

Field site selection. All BSES trial sites in 1999, 2000 and 2001 were in fields generally harvested before August, with light infestation or nearby to heavy infestation, and with previous history of damage, to increase the probability (risk) of new infestation. Farmer-initiated trials in 2001 were in fields mostly selected during GrubPlan workshops as being 'at-risk' by the above criteria, and so functioned as strategically placed 'trap-crops'.

Trial design. All BSES field trials were in replicated-block layouts. Randomised complete-block small-plot (four rows by 20 m long) designs with four or five replicates were used to assess factorial combinations of treatment rates and dates and methods, and BioCane combinations. Randomised block designs with plots four rows wide and full field-length and generally with two replicates were used to practically evaluate treatment efficacy of rates and application dates and methods. Several additional plots established without replication were used as observation and demonstration sites.

Application equipment for Confidor. A three-point linkage mounted applicator to suit conventional over-row operations was constructed to our requirement using Inkerman CPPB funds and some BSES equipment. It had twin 650 mm diameter coulters mounted in Bonel pivoting frame hangers, each fitted with an adjustable toolbar clamp, and a narrow-shank (18 mm) follower tine. Liquid was delivered to the soil from the follower tine by either a backwards-directed, brass, flat-fan sprayer nozzle spraying in a vertically aligned band, or in a single-stream by a downward-directed plastic garden irrigation emitter. Depth wheels to control penetration, 300 kg of steel ballast weights to aid penetration where necessary, and two spring-coil tines with mini-mouldboards for covering the application slot were also fitted to the unit. The unit was supplied in a cradle to facilitate its stability, storage, adjustments, and movement onto and off trucks and utility vehicles.

A 200 L 'Hardi' spray-tank assembled with electrically-powered pump, recirculation, and pressure regulator was mounted on the toolbar, and connected by snap-fittings and 8 mm nylon tubing to the nozzle assembly on the tines. This liquid-delivery system unit was used to apply insecticide to replicated large strip trials and to some farmer-scale replicated trials.

Replicated block small-plot trials were treated mostly with over-row operated equipment. Delivery was by a gas-pressurised BSES-constructed unit capable of independently delivering six different liquid treatments, clamped to the toolbar and connected by snap-fittings and 8 mm nylon tubing to the nozzle assembly behind the coulters. Alternatively Bayer (Australia) provided a 25 kW tractor set for inter-row operation, where inter-row application was necessary because of the crop-size or conditions. It was equipped with a linkage-mounted unit fitted with twin 500 mm coulters on pivoting hangers similar to the above units, operated against the sides of the rows. Liquid was independently delivered from six gas-pressurised containers similar to that described above.

For farmer-initiated treatments in 2001, specifications tested and proven in this project were applied to design and construction of commercial equipment to apply Confidor to ratoons. In the Burdekin region, three contractors applied most treatments, and at least four farmer-constructed units were used. In the Mulgrave region, two contractors performed most applications, and at least five farmers also built or modified equipment to carry out the operation. In the Herbert, BSES and CPPB co-operated to modify and make available and supervise BSES equipment, used by at least 10 growers. Mourilyan and Tully CPPBs constructed units for use in their areas.

Equipment for applying immobile chemicals to ratoons. To apply immobile chemicals or BioCane to soil to control damage by greyback grub, the prime need is to physically disperse the chemicals in the soil widely enough in the critical zone to be likely to intercept the grubs before sufficient time elapses for damage to roots and stool. To this end, we used equipment designed to create horizontal slots through the soil approximately 150 mm deep, the level at which controlled-release insecticides and cyclodiene insecticides have been shown to work best. Pivoting coulter assemblies were fitted with narrow (18 mm wide) trailing tines. We compared two arrangements for applying Regent (fipronil), an immobile chemical, to ratoons. In the first arrangement, a single coulter-assembly with a tine-shoe 150 mm wide was used. The other arrangement was with twin coulter-assemblies 300 mm apart, each carrying a 75 mm-wide tine-shoe.

Assessing influence of crop heights on infestation. In 1999 and 2000, stalk-height measurements were collected for seven of the early-harvested 'trap' sectors and adjacent later-harvested sections in the Burdekin region. The height of the top visible dewlap on 10 randomly selected stalks in at least two sectors of each trap-crop and two sectors of adjacent later-ratooned crop was measured. At other sites in the Burdekin and in other regions, assessment of height observations was limited to calibrated stalk-height estimation with a measuring pole and observing mean canopy height difference in the two crop categories using line-of-sight comparisons.

Assessment of grub numbers. Between February and May in 2000, 2001 and 2002, holes 40 cm long by 60 cm wide to the subsoil layer were dug around randomly selected sugarcane stools to assess numbers of third-instar grubs. Four or five holes were dug per plot in randomised-block trials (20-25 stools per treatment, per trial), and eight stools were sampled at each of two locations in each plot in the large-plot trials (16-24 stools per treatment, per trial). Sampling in treated plots was carried out if numbers in untreated plots equalled or exceeded 1 per stool, and sometimes if slightly fewer, so long as preliminary sampling indicated populations were reasonably consistent. Depending on the distribution of numbers and to equalise variance across treatments, especially where numerous zeros were recorded, numbers from individual stools were transformed to power 0.44, or numbers for all holes in each plot were combined and transformed, before analysis.

Assessment of root damage. In cases where sampling for grub numbers was impossible owing to crop lodging, post-harvest non-parametric ratings of remaining root-mass were used to confirm decreased grub activity as the probable cause of yield change due to treatment. In several cases, post-harvest ratoon-shoot populations were also counted as indicators of additional crop growth potential, but not measured by current crop-benefit assessment.

Assessment crop & sugar yield. Crop yield in randomised complete-block design trials was sampled by weighing (± 1 kg) the commercial product from two rows in the centre of each plot, using the BSES truck-mounted weighing machine. Most replicated block strip-plots were estimated from commercial bin-weights for a measured area from each. Alternatively, the truck-mounted weigher was used to estimate yield from infested sectors of strip-plots if grub activity was unevenly distributed through the field. Estimated sugar content of cane was mostly measured on six-stalk samples from each plot processed through the BSES small-mill and measured by a standard BSES laboratory method. In some cases samples from each treatment were measured as part of the commercial milling process.

Assessment of insecticide effect on weight of surviving grub. Undamaged grubs were collected from untreated and treatment plots during the sampling operation at seven sites over 2 years and later weighed (± 0.1 g). Weights were recorded to test the hypothesis that if

Confidor has a greater effect as a behavioural modifier or an antifeedant than as a direct toxicant, then there may be a weight difference among grubs from the various treatments.

Reporting. Regular progress reports on findings were presented to SRDC, to Bayer, and to industry members and key people and groups throughout the project. Participating farmers and local extension staff were involved or kept informed of actions, activities, and progress, as appropriate.

4.0 RESULTS

4.1 Effects of Confidor application rates and methods and treatment dates

4.1.1 1999-established field trials

Influence on grub numbers- 2000. Three randomised-block small-plot trials comparing product rates and application methods and treatment dates (Kelly, Mau, Roberts sites) and two replicated large-plot trials were infested. Untreated plots at the other six sites were sampled but were not sufficiently infested for the remaining plots to be meaningfully evaluated. Analysis of variance was applied to transformed ($x^{0.44}$) grub numbers from individual randomised-block trials, and to combined data from all three trials. Individual ANOVA results, using Statistix (Analytical Software) are summarised in Table 3.

Table 3 - 1999-established trials: Analysis of variance statistics for (grub numbers $^{0.44}$) in 2000 from individual trials.

Parameter	Kelly (#1)	Mau (#2)	Roberts (#3)
F (treat)	1.53,	1.17	2.07
df	16, 204	16, 203	15, 191
P	0.1268	0.3258	0.0307*

There was a significant treatment effect on grub numbers at only one site, but similar relative trends in the responses to treatments occurred at each site. A combined analysis was performed (Table 4), although it should be recognised that product rates are not identical for each treatment combination in all three trials. The lack of any significant interaction between treatments and sites (i.e. similar responses to treatment at each site) indicates that it is valid to recognise the highly significant (P = 0.0002) treatment effect in the combined data. All four untreated plots had significantly more larvae than the most effective treatments, and there was no significant difference between treatments. Linear regression of insecticide application rate (independent variable) against proportional control for the combined data-set was significant for only the September application by side dressing (F = 3.72; df 1,143; P = 0.056); however, the coefficient was negative. We cannot explain why the regression of the rate against response for side dressing in November was non-significant (F = 0.0, df 1,143; P = 0.95). Grub numbers from the two large-plot trials are summarised in Table 5; again indicating similar responses from two application method and treatment date combinations.

Table 4 - 1999-established trials: data from Kelly, Mau and Roberts trials combined. Analysis of variance and means for grub numbers in 2000.

ANALYSIS OF VARIANCE TABLE FOR (GRUB NUMBERS)$^{0.44}$

SOURCE	DF	SS	MS	F	P
SITE (A)	2	19.0217	9.51085	18.13	0.0000
TREAT (C)	15	24.4921	1.63281	3.11	0.0002**
REP (B)					
A*B	9	2.66977	0.29664	0.57	0.8234
A*C	30	13.1556	0.43852	0.84	0.7097
A*B*C	135	70.8164	0.52457		
SAMPLE (D)					
A*B*C*D	576	220.448	0.38272		
TOTAL	767	350.604			

LSD (T) COMPARISON OF MEANS (GRUBS / STOOL)$^{0.44}$ BY TREATMENT

#	RATE*	METHOD&DATE		/STOOL	(MEAN)$^{0.44}$	GROUPS
10	0	0	0	1.8	1.0185	I
0	0	0	0	1.6	0.9997	I
12	0	0	0	1.7	0.9755	I I
11	0	0	0	1.4	0.9022	I I I
1	L	SPLIT, SINGLE, 9/99		1.4	0.8807	I I I I
14	M	SIDE, DUAL, 11/99		1.0	0.6861	. I I I I
3	H	SPLIT, SINGLE, 9/99		0.93	0.6644	... I I I
9	H	SIDE, DUAL, 9/99		1.02	0.6622	... I I I
2	M	SPLIT, SINGLE, 9/99		0.8	0.6251	... I I I
4	L	SPLIT, DUAL, 9/99		0.83	0.6065	..... I I
5	M	SPLIT, DUAL, 9/99		0.9	0.5987	..... I I
13	L	SIDE, DUAL, 11/99		0.8	0.5981	..... I I
6	H	SPLIT, DUAL, 9/99		0.75	0.5834	 I
15	H	SIDE, DUAL, 11/99		0.71	0.5561	 I
7	L	SIDE, DUAL, 9/99		0.60	0.4969	 I
8	M	SIDE, DUAL, 9/99		0.64	0.4614	 I

*** L = 200-350 g ai / ha; M = 350 – 600 g ai / ha; H = 600-1000 g ai / ha**

THERE ARE 5 GROUPS IN WHICH THE MEANS ARE NOT SIGNIFICANTLY DIFFERENT
CRITICAL T VALUE 1.978 REJECTION LEVEL 0.050
CRITICAL VALUE FOR COMPARISON 0.2924 STD ERROR FOR COMP 0.1478
ERROR TERM USED: SITE*REP*TREAT, 135 DF

Table 5 - 1999-established large-plot trials. Grub numbers in 2000.

Site	Treatment	Untreated (grubs / stool ± SE)	Treated (grubs / stool ± SE)
Kelly (b)	single coulter 9/99, 550 g/ha	2.1 ± 0.4 (n=42)	1.04 ± 0.4 (n=42)
Gibson	side dress, 12/99, 590 g/ha	2.6 ± 0.6 (n=7)	1.3 ± 0.3 (n=10)

Influence on crop yield – 2000. Cane, sugar-content, and sugar-yield estimates at harvest were analysed for each of the three trials, where data from four untreated plots in each replicate were combined. Analysis of variance statistics (Table 6) indicate significant treatment effects at only one site (Kelly).

Table 6 - 1999-established small-plot trials. Significance (*P*) of statistics for yield data from Kelly, Mau and Roberts.

Parameter	Effect	Kelly	Mau	Roberts
Cane yield	Model	< 0.0001	0.22	0.40
	Treatment	< 0.0001	0.89	0.46
Sugar content	Model	0.0001	0.36	0.85
	Treatment	< 0.0001	0.77	0.88
Sugar yield	Model	< 0.0001	0.29	0.20
	Treatment	< 0.0001	0.89	0.14

Comparisons of means for each yield parameter from Kelly (Table 7) indicate significant benefits due to treatment to cane yield and sugar content. However, responses do not appear to relate to rates of product applied. Thus, comparisons of the contribution of four application methods and timing variables (centre-slot in September, dual-slot in September, side-dressing in September, and side-dressing in December) and the rate variable (200-280 g, 500-670 g, 930-996 g) were made (Table 8a), indicating little consistent difference between methods or rates.

Table 7 - 1999-established small-plot trial (Kelly). Comparisons of individual means for cane, sugar content and sugar yield in 2000.

Cane yield (t / ha)		Sugar content (CCS)		Sugar yield (t / ha)	
Treat #	**Mean***	**Treat #**	**Mean***	**Treat #**	**Mean***
2	111.6 a	15	18.1 a	2	19.6 a
15	108.1 ab	5	18.0 a	15	19.5 ab
14	107.6 ab	4	17.7 ab	14	18.9 abc
13	106.2 ab	2	17.6 ab	13	18.4 abc
1	104.2 ab	14	17.5 ab	5	18.0 abc
8	102.0 ab	6	17.5 ab	1	17.9 abc
5	100.9 b	7	17.4 ab	8	17.7 abc
6	100.5 b	8	17.4 ab	6	17.5 bc
3	100.5 bc	13	17.4 ab	3	17.3 c
9	90.6 c	1	17.2 ab	4	16.0 c
4	89.9 cd	3	17.2 ab	7	15.5 c
7	88.8 cd	9	17.0 b	9	15.5 c
10	85.6 cd	10	15.3 c	10	13.1 d

* Means within columns followed by same letter do not differ significantly (P<0.05).

Table 8a - 1999-established small-plot trial (Kelly). Analysis of variance and comparison of combined treatments means for cane yield, sugar content and sugar yield from four application methods and three product rates.

Factor	Treatment	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
Application method and date	centre-slit in September	105.4 a	17.3 a	18.3 a
	twin-slits in September	97.1 ab	17.7 a	17.2 ab
	side-dressing in September	93.8 bc	17.2 a	16.2 b
	side-dressing in November	107.3 a	17.6 a	18.9 a
	untreated	85.6 c	15.3 b	13.1 c
	P	< 0.0001	< 0.0001	< 0.0001
Product rate	200-280 g ai /ha	-	-	16.9 a
	500-670 g ai / ha	-	-	18.6 a
	930-996 g ai / ha	-	-	17.4 a
	untreated	-	-	13.1 b
	P	0.060	0.82	0.043

*Within columns and cells, numbers followed by the same letter do not differ significantly

Table 8b - 1999-established large strip-plot trials. Cane yield, sugar content and sugar yield from three sites treated with Confidor 200 SC at 500 g ai / ha.

Site (and application)	Treated			Untreated		
	Cane yield (t/ha)	CCS	Sugar yield (t/ha)	Cane yield (t/ha)	CCS	Sugar yield (t/ha)
Gibson (Nov side-dressing)	106.6	16.3	17.4	78.39	14.97	11.73
Kelly (b) Rep 1	106.1	17.4	18.5	75.1	16.5	12.4
Rep 2 (Sept stool-split)	104.8	18.1	19.0	88.0	17.0	15.0
Sgarbossa Rep1	107.8	11.6	12.5	95.5	10.8	11.6
Rep 2 (Sept side-dress)	85.2	12.4	10.5	86.6	11.8	10.2

Five yield comparisons from three large-scale strip-plot sites (Kelly, Gibson and Sgarbossa) consistently indicate increased cane and sugar yields (Table 8b) due to treatment with 500 g ai /ha imidacloprid applied by the range of methods and dates (November side-dress, September side-dress, and September stool-split).

Brief conclusions from 2000 were that:

- treatment with Confidor could be reasonably consistently beneficial;
- further work should concentrate on rates of product between (250-500 g ai/ha) as higher rates did not provide significantly greater benefits;
- the most convenient and universally-applicable application method by side-dressing is probably as effective as any other;
- treatment in September seems almost as effective as treatment in November.

4.1.2 2000-established field trials

Influence of rate of Confidor on grub numbers in 2001. All four randomised-block trials (Table 9) were reasonably infested. After transformation ($x^{0.44}$) to normalise variance of data, there was statistically significant ($P < 0.05$) reduction in grub numbers in only one trial (Lyons); at this site numbers decreased with increasing dose, as expected. Most effective reduction at each site was 42-87%, although results were not always consistent with rate. Over all sites, the relative effect of different rates was variable, although generally numbers decreased with treatment.

Table 9 - 2000-established replicated block small-plot trials. Influence of rates (g ai / ha) of Confidor 200 SC applied by side dressing to young ratoons on greyback canegrub numbers in 2001.

Boatfield 6 September		**Young 7 September**		**Lyons 8 September**		**Romeo 4 October**	
g ai /ha	**Grubs (/stool)**	**g ai /ha**	**Grubs (/stool)**	**g ai /ha**	**Grubs (/stool)**	**g ai /ha**	**Grubs (/stool)**
0	1.6	0	0.85	0	0.75 a	0	5.3
225	1.3	110	0.85	135	0.7 a	170	5.1
260	1.2	175	0.55	190	0.45 a	250	5.2
320	1.3	210	1.0	240	0.3 ab	295	3.0
460	1.0	330	1.3	340	0.45ab	415	3.8
680	0.75	395	0.5	490	0.1 b	640	3.5
P	0.45		0.52		0.0011*		0.21

*Means followed by the same letter do not differ significantly

Six strip-plot trials were reasonably infested. Population reductions of 47-86% (Table 10) were similar to those in the small-plot trials. The effect was significant ($P < 0.05$) at only two sites (diBella and Lyons(a)); again, relative effect of different rates was variable.

Table 10 - 2000-established replicated large-plot trials, at Ayr. Influence of rates of Confidor 200 SC applied by side dressing on greyback canegrub numbers in 2001.

Site	Rate - g ai / ha (date)	Grubs / stool	*P*
Saunders & Baldotto	0 260 (6/9/00) 360 (6/9/00)	0.8 0.9 0.5	0.59
Ponzo & Galetto (Boatfield)	0 375 (6/09/00)	1.0 1.1	0.5
diBella	0 400 (7/09/00)	2.4 a 0.33 b	0.046*
Lyons (a)	0 260 (8/9/00) 410 (8/9/00)	4.6 a 2.5 b 1.6 b	0.01
Lyons (b)	0 260 (8/9/00)	0.9 0.25	0.10
Romeo & Sons	0 320 (4/10/00)	1.9 0.75	0.09

* Friedman non-parametric test
* Within cells, numbers followed by the same letter do not differ significantly

Influence of rate of Confidor on crop yield in 2001. There were no significant (P < 0.05) treatment effects on yield in three of the randomised-block trials (Table 11), although there were significant replicate effects at two sites (Romeo and Boatfield). Yield was not assessed at Young's site due to failure by the relief harvester operator to follow plans agreed with BSES staff. In Romeo's trial, one end of the trial site was not infested, whilst the other was inundated with vast numbers of grubs (> 14 per stool), virtually destroying the crop and the suitability of data for analysis of variance. Over the three sites, maximum yield increases were 1.0, 1.9, and 4.6 t sugar per ha. Generally, highest rates (490, 640, 680 g ai /ha) resulted in highest yields, but responses to other rates at each site were inconsistent.

Table 11 - 2000-established replicated block small-plot trials. Influence of rates of Confidor applied by side dressing on yields in 2001.

Boatfield 6 September				Lyons 8 September				Romeo 4 October			
g/ha	Cane yield (t/ha)	CCS	Sugar yield (t/ha)	g/ha	Cane yield (t/ha)	CCS	Sugar yield (t/ha)	g/ha	Cane yield (t/ha)	CCS	Sugar yield (t/ha)
680	113.7	17.4	19.8	489	104.5	15.6	16.3	640	92.6	11.1	10.0
460	117.4	16.9	19.8	135	94.4	16.2	15.3	250	82.7	8.9	8.2
320	111.1	16.9	18.9	237	93.7	16.0	14.9	415	75.9	8.9	7.3
225	108.2	16.9	18.4	190	93.2	15.4	14.5	295	70.9	9.9	6.9
0	106.2	17.3	18.8	0	96.1	14.8	14.4	170	69.6	8.2	6.1
260	101.0	17.0	17.1	339	81.2	15.8	12.9	0	70	6.8	5.4
P	0.49	0.51	0.56		0.26	0.20	0.51		0.089	0.23	0.14

Yield assessments were completed at four strip-plot trials (Table 12). There was sufficient replication for ANOVA of yield data at only one site (Lyons(a), NSD). However, large-sample (3-30 t) commercial yield comparisons with all untreated plots resulted in yield increases of 0, 3.3, 1.4, 3.1, 7.0, and 3.4 t sugar / ha from the six comparisons. None of these sites were ratooned, although at Lyons' there were indications of useful ratooning in the treated sections but not in the untreated.

Table 12 - 2000-established replicated large-plot trials, at Ayr. Influence of rates of Confidor applied by side dressing on crop yield in 2001.

Site	Rate (g ai / ha) (date)	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
Ponzo & Galetto (Boatfield)	0	122.1	17.8	21.7
	375 (6/09/00)	117.5	17.9	21.0
Saunders & Baldotto	0	51.4	12.8	6.6
	260 (6/9/00)	70.1	14.2	10.0
	360 (6/9/00)	53.8	14.9	8.0
diBella	0	86.9	12.9	11.2
	400 (7/09/00)	98.8	14.5	14.3
Lyons (a)	0	65.8	13.25	9.0
	260 (8/9/00)	97.6	16.47	16.2
	410 (8/9/00)	82.5	15.15	12.5
P		0.18	0.27	0.18

Table 13 - 2000-established replicated-block small-plot field trials. Influence of treatment date and rate and method of application on greyback grub numbers in 2001.

Stockdale (Home Hill)			Scougall (Cairns)		
Application date	Rate (g ai / ha)	Grubs (/stool)	Application date	Rate (g ai / ha)	Grubs (/stool)
-	0	1.7	-	0	2.0 a
27/07/00	# 588	1.3	3/08/00	# 460	0.4 cd
27/07/00	# 264	1.3	3/08/00	# 320	0.6 cd
1/10/00	# 600	1.3	11/10/00	# 520	0.3 cd
1/10/00	# 400	0.7	11/10/00	# 380	0.2 d
1/10/00	* 435	0.9	11/10/00	* 320	0.7 cd
12/12/00	## 440	0.25	15/02/01	## 390	1.7 ab
12/12/00	## 295	1.12	15/02/01	## 280	1.1 bc
		P = 0.22			P = 0.001

Side-dressing with over-row equipment
* In a single-slot by stool-splitting with over-row equipment
Side-dressing with inter-row equipment
Means followed by the same letter do not differ significantly

Influence of treatment date on grub numbers in 2001. Observation on the influence of date of treatment was confined to randomised block designs. Only two of these trials were infested. Best treatments (Table 13) resulted in 80-90% reduction. At Home Hill in the Burdekin region (Stockdale), October and December treatments tended (P = 0.22) to have greater effect than late July treatment. At Green Hill near Cairns (Scougall), early August and mid-October treatments were equally (P = 0.001) effective, both being more effective than inter-row applied treatment in February.

Influence of treatment date on crop yield in 2001. Crop yield assessments (Table 15) were carried out on the two trials that were infested. Whilst treatment effect was not significant at the Home Hill site, the treated plots were visibly far better grown and healthier than untreated plots. Crop yield benefit at the site had been restricted due to erratic irrigation and severe weed infestation, the farmer taking the view that the damaged field was mostly a sacrifice trap-crop and not worth further attention to detail: thus the crop was unable to reach its full potential. Also, data at this site were compromised due to an error on one date where treatments were applied to the wrong plots in several replicates, resulting in uneven numbers of plots for different treatments. The (rain-grown) Green Hill crop was well maintained, and delivered significant treatment yield effects. August treatments delivered 3.0-3.1 t sugar per ha benefit, and the October treatments 2.0-2.8 t sugar per ha benefit, although these were not significantly different. The February treatment delivered no benefit. Plots with August or October treatments would have ratooned, whereas other treatments and untreated controls lost numerous stools at harvest and would not have ratooned.

Table 14 - 2000-established replicated large-plot trials in non-irrigated northern regions. Influence of application methods (side dressing or stool splitting) of Confidor on greyback canegrub numbers in 2001.

Farm	Rate (g ai /ha)	Method	Grubs* (per stool)	*P*
Blanco (Ingham)	0		2.5	0.21
	450	centre-split (11/09)	1.0	
	450	side-dressed (11/09	0.8	
Celotto (Abergowrie)	0		1.2	0.063
	440	centre-split (12/09)	0.9	
	440	side-dressed (12/09)	0.4	
Vella (Abergowrie)	0		4.5 a	0.008
	420	centre-split (12/09)	1.4 b	
	420	side-dressed (12/09)	1.2 b	
Arcidiacono (Gordonvale)	0		1.2	0.55
	340	centre-split (12/10)	0.5	
	340	side-dressed (12/10)	0.9	
Rankine (NE Tableland)	0		3.5 a	0.027
	355	centre-split (13/10)	0.5 b	
	355	side-dressed (13/10)	0.9 b	

* within cells, numbers followed by the same letter do not differ significantly

Influence of application methods on grub numbers in 2001. Only two of the randomised-block sites were infested (Table 13). At Home Hill in the Burdekin region (Stockdale), stool-split and side-dressing applied treatment, both in October, were similarly (P = 0.22) effective at reducing numbers. At Green Hill near Cairns (Scougall), stool-splitting and side-dressing treatments applied in October were (P = 0.001) equally effective.

Five (Table 14) of the split-plot sites treated in mid-September or mid-October were infested. All five sites were in trash-blanketed, rain-grown cropping environments, but one (Rankine) was overhead-spray-irrigated. At all sites the centre-split application reduced populations to a similar degree as the side-dress application, at product rates 340-450 g ai /ha (1.7-2.2 L/ha). This effect was statistically significant (P = 0.008, 0.027) at the two most infested sites, but less pronounced (P = 0.21, 0.0634, 0.55) at other three sites.

Table 15 - 2000-established replicated-block small-plot field trials. Influence of treatment date and rate and method of application on crop yield in 2001.

Stockdale (Home Hill)

Application date	Rate (g/ha) and method	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
12/12/00	## 295	67.9	14.6	9.9
01/10/00	# 400	66.3	15.6	9.9
27/07/00	# 588	64.7	14.9	9.8
01/10/00	# 600	62.9	15.4	9.7
12/12/00	## 440	62.5	15.6	9.8
27/07/00	# 264	61.7	15.3	9.4
01/10/00	* 435	57.8	15.6	9.0
-	0	55.2	14.8	8.16
P		0.48	0.40	0.45

Scougall, Green Hill

Application date	Rate (g/ha) and method	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
03/08/00	# 320	83.2 a	15.05	12.4 a
03/08/00	# 460	77.6 ab	15.86	12.3 a
11/10/00	# 520	76.8 ab	15.36	11.8 ab
11/10/00	# 380	76.3 ab	15.71	12.1 a
11/10/00	* 320	72.6 abc	15.77	11.4 abc
-	0	65.2 bc	14.39	9.33 bc
15/02/01	## 280	59.8 c	15.32	9.06 c
15/02/01	## 390	59.0 c	15.61	9.26 bc
P		0.011	0.59	0.036

Side-dressing with over-row equipment
* In a single slot by stool-splitting with over-row equipment
Side-dressing with inter-row equipment

Influence of application methods on crop yield in 2001. In a randomised-block trial at Home Hill (Table 15), treatment by side dressing at 400 g/ha in October appeared marginally (P = 0.45) more beneficial (1.7 t sugar per ha increase) than by stool-splitting at 435 g/ha (0.8 t sugar / ha increase). At Green Hill, the effect (P = 0.036) of side dressing at 380 g/ha (2.8 t sugar/ha increase) was slightly but not significantly greater than of stool splitting at 320 g/ha (2.1 t sugar per ha increase); although the (20%) higher application rate for the side-dressed treatment could confound that conclusion.

Harvest assessment of yield was carried out at five strip-plot sites (Table 16). There was no measurable yield benefit from treatment at Celotto, despite a reduction in grub numbers. Of the other four, there was no consistent difference between methods. At the relatively dryland site at Abergowrie (Vella), stool splitting (48% benefit) appeared more beneficial than side-dressing (8% benefit), whereas at the spray-irrigated site (Rankine) side-dressing (+68%) may have been more beneficial than stool splitting (+52%). Perhaps under moisture-stressed dryland conditions, stool-split application positions the chemical where it is more critical for grub control or, more likely to be effectively absorbed by roots. Observations before ploughout at Rankine's on post-harvest ratooning indicated that plots treated by either method produced equally vigorous ratoon shoots. Two less-infested sites showed similar, but lesser, benefits from both treatment methods.

Table 16 - 2000-established replicated large-plot trials in non-irrigated northern regions. Influence of application methods (by side dressing or stool splitting) for Confidor on crop yield in 2001.

Farm	Rate (g ai /ha)	Method	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
Blanco (Ingham)	0		73.4	16.6	12.2
	450	centre-split (11/09)	80.5	16.3	13.3
	450	side-dressed (11/09)	84.1	16.7	14.0
			P = 0.52	P = 0.75	P = 0.50
Lamari (Bambaroo)	0		31.7	13.7	4.4
	380	centre-split (10/09)	37.1	15.9	5.9
		side-dressed (10/09)	37.4	15.5	5.8
			P=0.48	P = 0.16	P = 0.29
Celotto (Abergowrie)	0		96.0	17.2	16.5
	440	centre-split (12/09)	94.2	17.2	16.2
	440	side-dressed (12/09)	86.6	17.5	15.2
			P = 0.75	P = 0.64	P = 0.85
Vella (Abergowrie)	0		86.2	15.7	13.5
	420	centre-split (12/09)	131.8	15.1	20.0
	420	side-dressed (12/09)	96.2	15.1	14.6
Rankine (NE Tableland)	0		90.0	9.2	8.3
	355	centre-split (13/10)	85.7	14.6	12.6
	355	side-dressed (13/10)	97.0	14.5	14.0
			P = 0.73	P = 0.099	P = 0.29

Table 17a - 1999-established replicated block trial – Roberts site. Body weight of live grubs collected in Confidor-treated and untreated plots on 4 July 2000.

Treatment #	Mean weight (g) ± SEM	Number weighed (/15 stools)
0 (untreated)	3.93 ± 0.12	27
5 (500 g ai / ha)	4.27 ± 0.16	12
8 (500 g ai / ha)	4.29 ± 0.17	12
14 (500 g ai / ha)	4.27 ± 0.17	9

Table 17b - 2000-established replicated trials in irrigated Burdekin fields. Body weight of live grubs collected in Confidor-treated and untreated plots in February 2001.

	Lyons (a) (strip)			Young (replicated-block)			Saunders (strip)			Stockdale (replicated-block)			Boatfield (strip)		Boatfield (replicated-block)		
Rate (g ai/ ha)	0	260	410	0	210	395	0	260	360	0	400	600	0	375	0	257	460
Mean weight (g)	3.89 a	4.42 b	4.57 b	4.59	5.31	4.89	5.43	4.62	4.26	5.5	5.2	5.2	4.79	5.39	4.68 b	4.91 b	5.88 a
SE (mean)	0.11	0.14	0.15	0.30	0.33	0.48	0.32	0.53	0.72	0.26	0.43	0.46	0.52	0.11	0.25	0.17	0.19
N	67	41	30	18	8	7	12	6	5	64	18	7	7	14	57	14	19
P	0.0003			0.36			0.23			0.52			0.33		0.0012		

4.1.3 Conclusions on rate and timing, and method of application of Confidor

- Product rates as low as 300g a.i. / ha (1.5 L/ha) are reasonably consistently effective. Rates of 360-400 g a.i. / ha (1.8-2.0 L/ha) are slightly and more consistently effective, but benefit: cost analysis (Fig. 1), indicates all benefit ratios of 2.0 or more occur at rates less than about 360 g a.i. / ha (1.8 L).
- Treatment by side dressing is the most flexible and consistently effective treatment, but stool splitting can be effective and application machinery is cheaper in that configuration.
- Side-dressing application of Confidor between September and December can be very effective.
- Application with inter-row or high-clearance equipment in the later portion of this period, even with the inherent expense and difficulty, is possible, and could have practical and economic advantages. Provided there is an adequate awareness system, treatment of unprotected fields that experience unexpected beetle infestation is possible, and the expense of treatment can be confined to only those fields that are subject to infestation.

4.2. Secondary effects of Confidor

4.2.1 Effect on grub weight

A census of grubs collected by digging stubble from treated and untreated plots at the Roberts site in July 2000 suggested that survivors in the untreated plots were lighter (Table 17a). Severe damage to untreated stubble also indicated that food was more limiting in untreated plots than in treatments. Many more grubs were collected from the 15 stools in the controls (27) than from the treatments (9-12). However, regardless of the possibility of that food constraint was limiting growth, the greater and generally normal weight of those from the treatment plots suggests any influence of the chemical was over, or was not harmful to third instars.

In February 2001, grubs collected from untreated plots were also more numerous than from plots treated in September 2000 (Table 17b), and so, competition for food could also have resulted in lower body weight in those from treated plots. However, grubs from treated plots appeared healthy and active; their weights similar (unpublished data) to many collected (and weighed) from other untreated sites for BSES bioassays.

These differences in numbers suggest that the chemical is acting as toxicant, whether long-term or short-term is unknown. The weight observations suggest that there is little persistent activity from imidacloprid after 5 months, or that third instars are no longer susceptible to whatever levels remain. Another interpretation of these data is that reduction of the grub population in treatment plots most likely occurred early, probably in the earlier growth stages. Whatever its effect, no definitive conclusions on the mode of action of Confidor can be drawn from this type of observation on grub weight.

Table 18 - 1999-established replicated small-plot trials. Post-harvest retention of root and stubble mass (mean, rated 1–9) after pre-emptive treatments with Confidor (500 g ai / ha) prior to greyback grub infestation.

Treatment	Kelly	Roberts	Combined rating*
0 (untreated)	2.39	3.74	1.8 a
5 (Sept stool-splitting)	3.83	4.81	4.2 b
8 (Sept side-dressing)	3.93	5.05	4.0 b
14 (Nov side-dressing)	3.22	5.4	3.5 b
			P = 0.0048

*Friedman non-parametric comparison of combined ratings.

Table 19 - 1999-established replicated small-plot trials. Ratoon shoots emerged (/40m) post-harvest at the Kelly site on 27 September 2000.

```
STATISTIX FOR WINDOWS
ONE-WAY AOV FOR SHOOTS/40M BY TREAT
            SOURCE     DF       SS          MS          F         P
            BETWEEN    12       659824    54985.4     3.91    0.0031**
            WITHIN     21       295086    14051.7
            TOTAL      33       954910

                                   CHI-SQ    DF        P
BARTLETT'S TEST OF EQUAL VARIANCES  15.98    12     0.1921

COCHRAN'S Q                     0.4623
LARGEST VAR / SMALLEST VAR      2127.5

COMPONENT OF VARIANCE FOR BETWEEN GROUPS    16568.4
EFFECTIVE CELL SIZE                             2.5

LSD (T) COMPARISON OF MEANS OF SHOOTS/40M BY TREATMENT
      #     TREAT        g/ha  date         MEAN            GROUPS
      3     single-slit  937   16/9         596.50          I
      1     single-slit  312   16/9         512.50          I I
      14    side-dress   670   9/12         482.00          I I
      6     twin-slit    937   16/9         474.50          I I I
      2     single-slit  570   16/9         431.50          I I I I
      9     side-dress   930   16/9         416.00          I I I I
      15    side-dress   996   9/12         383.50          I I I I
      13    side-dress   290   9/12         376.00          I I I I
      8     side-dress   625   16/9         373.00          I I I I
      4     twin-slit    312   16/9         310.50         .. I I I I
      5     twin-slit    500   16/9         234.50         .... I I I
      7     side-dress   312   16/9         208.50         ...... I I
      0     untreated    0     0            167.00         ........ I

THERE ARE 5 GROUPS IN WHICH THE MEANS ARE NOT SIGNIFICANTLY DIFFERENT
CRITICAL T VALUE 2.080   REJECTION LEVEL 0.050
STANDARD ERRORS AND CRITICAL VALUES OF DIFFERENCES
VARY BETWEEN COMPARISONS BECAUSE OF UNEQUAL SAMPLE SIZES.
```

4.2.2 Influence of Confidor treatment on root damage and ratooning ability

Ratings from two of the replicated-block trial sites (Kelly(a) and Roberts; Table 18) indicate that Confidor-treated plots retained significantly greater amounts of underground stubble and root mass after harvest than untreated plots, with little difference between treatments. However, Confidor-treated plots also showed damage to the root mass, although it is not certain how much the symptoms reflect damage inflicted in the previous crop. Ratoon-shoot counts in September at the Kelly (1999-2000) site (Table 19), and in another trial at Kelly's in 2001 (Table 20c) confirm increased ratooning due to Confidor treatment. Vastly improved ratooning (more and bigger shoots and better vigour) was also evident post-harvest in treatment sections of many other trial plots, eg at Kelly (b) and Gibson in 2000, and at Vella, Rankine, Lamari, Romeo, and Saunders and Baldotto in 2001. Many other examples may have been evident if fields had not been ploughed out for replanting.

4.3. Synergy from Confidor with BioCane™

4.3.1 1999-established trial

In one trial (Sgarbossa (a)- EA99-07) FI1045WP spore suspension, equivalent to the number of spores supplied in the BioCane rice-granule formulation (33 kg of $2 * 10^9$ spores/g), sprayed in twin vertical bands behind coulters passed through previously unprotected ratoon rows (Table 2e) appeared to reduce grub numbers ($P = 0.13$, Table 20a). Addition of Confidor to the BioCane spore suspension appeared to further reduce numbers ($P = 0.13$, Table 20a). However, grub numbers were generally low (about 1 per stool) and unevenly distributed, suggesting little chance of any measurable effect on yield. Thus, this trial was afforded low priority; it was not assessed for yield and was ploughed out after harvest.

4.3.2 2000-established trials

Kelly (BioCane applied 1999 to plant cane, ratoons treated with Confidor 2000). Grub populations were assessed in the mature first ratoon in March 2001. Numbers were low (0.7 / stool). In analysis of individual treatments, BioCane alone reduced grub numbers ($P = 0.0110$), but no effect could be detected from Confidor alone ($P = 0.796$) (Table 20b). The BioCane plus Confidor treatment combinations had the lowest means (0.3-0.4). Crop-yield assessment revealed significant effects on ccs, cane and sugar yield (Table 20b), and significant residual benefit from increased shoot production by the better-grown plots. There is an indication that Confidor treatment is more effective than BioCane, and there is a slight additive effect as combination treatments tended to yield more than individual treatments. This site was not infested (24 stools, 1 grub) in 2002.

Langdon (BioCane applied 1999 to plant cane, ratoons treated with Confidor 2000). First-ratoon grub populations at this site were generally lower in the BioCane-treated sector (1.1-1.8 per stool) than in the sector with no BioCane (1.7-4.3 per stool), for all rates of Confidor (Table 20c). Yields were consistently higher in the BioCane-treated sector for all rates of Confidor (Table 20c). Yield also increased for increasing rates of Confidor within the BioCane and non-BioCane sectors, suggesting their effects are additive, rather than synergistic. The site was not suitable for counts in 2002, having been over-treated with Confidor.

Table 20a - 1999-established replicated block field trial, Sgarbossa. Effects of Confidor and BioCane treatments applied to ratoons on grub numbers.

#	Treatment	Grubs / stool	Grubs $^{(0.44)}$ /stool
1	FI1045WP low rate (=17 kg/ha BioCane)	1.43	0.73
6	untreated	1.06	0.67
3	Confidor 2.5 L/ha	0.87	0.57
4	#1 plus #3	0.68	0.48
2	FI1045WP full rate (=33 kg/ha BioCane)	0.5	0.33
5	#2 plus #3	0.18	0.19
			P = 0.13

Table 20b - BioCane and Confidor synergy trial, Kelly 2001. Grub numbers, crop yields and post-harvest ratoon-shoot count.

#	BioCane (kg/ha)	Confidor (g ai/ha)	Grubs (/ stool)	Sugar content (CCS)	Cane yield (t/ha)	Sugar yield (t/ha)	Shoots (/30m)
6	33	400	0.4	17.8a	118.5a	21.1a	285 a
4	33	260	0.3	17.8a	113.7abc	20.2ab	251 ab
5	0	400	0.75	17.5a	113.7ab	19.9abc	234 bc
3	0	260	0.6	17.4a	106.5bc	18.6bc	187 de
10	33	0	0.5	17.1b	94.3ef	16.2de	167 ef
7	0	450	0.45	17.7a	-	-	226 bc
8	33	450	0.3	17.8a	-	-	248 bc
9	0	0	0.7	16.9b	83.1f	14.1e	149 f
P				0.023	0.0002	0.0009	< 0.05

- missing data

Table 20c - BioCane and Confidor synergy trial, Langdon. Grub numbers, and crop yield 2001.

<table>
<tr><th rowspan="3">Confidor (g ai/ha)</th><th colspan="2">Grub numbers</th><th colspan="2">Cane yield (t/ha)</th><th colspan="2">Sugar content (CCS)</th><th colspan="2">Sugar yield (t/ha)</th></tr>
<tr><th colspan="2">BioCane (kg/ha)</th><th colspan="2">BioCane (kg/ha)</th><th colspan="2">BioCane (kg/ha)</th><th colspan="2">BioCane (kg/ha)</th></tr>
<tr><th>0</th><th>33</th><th>0</th><th>33</th><th>0</th><th>33</th><th>0</th><th>33</th></tr>
<tr><td>0</td><td>3.8 a</td><td>1.1</td><td>118.5 c</td><td>142.7</td><td>16.2</td><td>16.0</td><td>19.2</td><td>22.8</td></tr>
<tr><td>134</td><td>4.3 a</td><td>1.6</td><td>138.3 ab</td><td>152.6</td><td>15.1</td><td>15.5</td><td>20.7</td><td>23.7</td></tr>
<tr><td>268</td><td>2.8 a</td><td>1.1</td><td>134.1 b</td><td>144.0</td><td>15.7</td><td>15.8</td><td>21.1</td><td>22.8</td></tr>
<tr><td>391</td><td>3.9 a</td><td>1.1</td><td>147.8 a</td><td>163.3</td><td>14.5</td><td>15.2</td><td>21.4</td><td>24.6</td></tr>
<tr><td>536</td><td>1.7 b</td><td>1.8</td><td>148.5 a</td><td>166.8</td><td>16.1</td><td>15.9</td><td>24.0</td><td>26.1</td></tr>
<tr><td>P</td><td>0.0078*</td><td>0.10</td><td>0.0019*</td><td>0.075</td><td>0.47</td><td>0.75</td><td>0.11</td><td>0.27</td></tr>
</table>

*Means within a column followed by the same letter are not significantly different (P=0.05)

Table 20d - BioCane @ 33kg/ha and Confidor synergy trial, Raitelli. First-ratoon crop yield 2001.

Confidor (g ai / ha)	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
0	124.9 a	14.6	17.3
264	146.9 b	13.6	20.0
604	139.5 b	13.8	19.7
P	0.039	0.20	0.16

Table 20e - BioCane @ 33kg/ha and Confidor synergy trial, MacDonald. Plant-crop yield 2002.

#	BioCane (kg/ha)	Confidor (g ai /ha)	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)
7	66	200	183.9 a	14.9 cd	27.4 a
9	66	400	165.7 bc	15.6 a	25.9 ab
8	33	400	169.2 ab	15.0 bcd	25.4 ab
5	0	400	160.3 bcd	15.6 a	25.0 abc
3	66	0	152.6 bcd	15.4 ab	23.8 bcd
6	33	200	159.3 bcd	15.2 abc	23.5 bcd
2	33	0	159.5 bcd	14.7 cd	23.5 bcd
4	0	200	148.9 cd	14.8 cd	21.9 cd
1	0	0	145.4 d	14.4 d	21.1 d
P			0.0042	0.0018	0.0068

Table 20f - Combinations of BioCane and Confidor, and ratoon yields at Ingham, 2002.

Site	Plant-crop treatment 2000	Ratoon treatment 2001	Ratoon yield (t sugar / ha)
Cervellin Q138	BioCane	1 L Confidor	8.4
	BioCane	2 L Confidor	7.7
	BioCane	0	8.1
Cervellin Q179[A]	BioCane	1 L Confidor	7.3
	BioCane	2 L Confidor	8.0
	BioCane	0	7.4
Morley Q174[A]	untreated	untreated	14.2
	untreated	1 L Confidor	17.1
	BioCane	1 L Confidor	17.7
	BioCane	untreated	16.4

Raitelli (a) (BioCane applied 1999 to plant cane, ratoons treated with Confidor 2000). First-ratoon crop yield was assessed by bin weights in 2001 (Table 20d). The lower rate of Confidor (264 g/ha or 1.3 L/ha) appeared (P = 0.03) to yield more cane than the high rate. There was an additive effect from Confidor in the BioCane plot, but no conclusions as to the benefit of BioCane alone are possible from this design.

Raitelli (b) (BioCane applied 8/99 to plant cane, ratoons treated with Confidor 2000). First-ratoon grub populations were sampled from this site in 2001, but numbers were very low (0.25-0.7 per stool in non-BioCane sectors and 0-0.3 per stool in the BioCane sectors). Numbers appeared (P = 0.36) to decrease with increasing doses of Confidor. Yield assessments were not made.

4.3.3 2001-established trials

One trial at ***Sgarbossa (2001)*** was not infested in 2002 (16 holes, 0 grubs).

A trial at ***McDonald*** was only lightly (0.65 grubs per stool, n = 20 stools) infested. There were no significant effects of Confidor (P = 0.47) or BioCane (P = 0.14), nor was there any interaction between effects of the two products (P = 0.96) (Samson *et al*. 2002). Harvest yields showed marked (+25%) increases in cane yield (P = 0.0042) and CCS (P = 0.0018) due to treatments. The responses (Table 20e) seem above what would normally be expected from controlling such an infestation in plant cane under irrigated conditions (e.g. Chandler 1993). Combinations gave greater responses than individual treatments for both products. As concluded by Samson *et al.* (2002), the effects seem to be additive rather than synergistic.

Selected BioCane treatments in the McDonald and Sgarbossa sites will have Confidor treatment superimposed in the ratoons in October 2002.

Two grower trials at Ingham (***Morely*** and ***Cervellin***, Table 20f) were lightly infested (0.5 per stool) with grubs in 2001-2002. Crop yields (Table 20f) suggest that BioCane is still active and over-treatment of ratoons with Confidor at either 200 or 400 g/ha gave grub control additional to that from BioCane applied to the plant crop at Morely's (+3 t sugar/ha). There appears to be no added benefit from Confidor at two sites at Cervellin, although layout and treatments applied at those sites did not allow any effect from BioCane to be assessed.

At Mulgrave and Innisfail, two replicated-block plant-cane sites to test for interactions between Confidor and BioCane were not infested (32 stools, 0 grubs); ratoon treatment of some plots with Confidor will occur in October-November 2002.

4.3.4 Tentative conclusions on synergy from Confidor with BioCane™

The evidence is that low rates of Confidor (200 g/ha) produce a large response in the presence of BioCane, and joint treatments are more effective than either product alone. However, there is no obvious evidence of synergy between the two products. Both seem compatible and combinations seem worthy of further evaluation as cost-effective preventatives in high-pressure plant-cane situations.

Results with the wettable powder formulation of FI1045 spores indicate considerable potential for this formulation to improve flexibility, both for the growers to treat ratoons, and for Bio-Care Technology another formulation to utilise the large volume of loose spores produced. Liquid suspensions are much easier to direct from an applicator than granules, and WP formulations are probably more conveniently packaged, stored and distributed than the rice-granule product.

Combined BioCane (wettable-spore formulation) and Confidor treatment of ratoons by dual-slot stool treatment is worthy of further investigation, considering the considerable additive effects from some trials (eg McDonald).

4.4 Economic evaluation of Confidor treatment of ratoons: 2001 crop

4.4.1 Results

Net gain or loss from insecticide treatment ($ per ha) was calculated (Table 21) at 14 sites evaluated in 2001 for all the treatment and untreated plots. Assumptions were:

- cost of Confidor - $165 / L;
- application cost - $25/ha (contractor price at Gordonvale);
- sugar price - $340/t sugar;
- harvest costs and levies and $6.50/t.

The formula:

[0.009(sugar price (ccs-4.0)) + 0.578 - harvest costs and levies]* t cane/ha

was used to calculate net cane payment ($/ha) to the grower. Net funds per hectare after insecticide and application costs were then calculated. The difference between net funds after costs for treatments, and net funds from untreated control plots, is the estimate of gain or loss from insecticide treatment.

In 2000-2001, there were eight sites with monetary gains due to treatment, five with losses, and one with neutral revenue (Tables 21-22). However, a high proportion of the losses were in situations where the value of treatments was compromised by factors other than the insecticide performance. Two (Boatfield) were adjacent and in the same field, which was lightly infested (1.0-1.5 grubs per stool) but watered very regularly and produced a large crop; presumably crop tolerance and regular adequate moisture has masked any benefit. One (Stockdale) was moderately infested (1.7 grubs per stool) but poorly grown and could not reach its potential due to poor irrigation and lack of weed control, despite cane being visibly much greener in treated plots. At Celotto, lightly infested (1.2 grubs per stool) cane with a large stool (Q115) in moist and very fertile alluvial loam under rain-grown conditions expressed little evidence of grub damage, and was probably able to tolerate damage in untreated plots. The Blanco site was moderately infested (2.5 grubs per stool) in one portion and treatment plots were clearly better than untreated plots at one end of the field; however, yield estimates taken over the full plot length, the majority of which was not damaged, have diluted any estimate of benefit.

Table 21 - Estimated gain or loss ($/ha) as a result of treatment of ratoons in 2000 with the insecticide Confidor 200 SC.

Farm	g ai/ha	Grubs/ stool	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)	Net cane payment ($/ha)	Treatment costs ($/ha)	Net funds after treatment ($/ha)	Gain/loss from treatment ($/ha)
Boatfield	0	1.0	122.1	17.8	21.7	4433	0	4433	-
	375		117.5	17.9	21.0	4302	334	3968	-465
Saunders	0	0.8	51.4	12.8	6.6	1080	0	1055	-
	260		70.1	14.2	10.0	1773	239	1533	479
	360		53.8	14.9	8.0	1476	322	1154	99
di Bella	0	2.4	86.9	12.9	11.2	1852	0	1827	
	400		98.8	14.5	14.3	2589	355	2234	407
Lyons	0	4.6	65.8	13.3	9.0	1473	0	1473	-
	260		97.6	16.5	16.2	3146	239	2907	1434
	410		82.5	15.2	12.5	2326	363	1963	490
Stockdale	0	1.7	55.2	14.8	8.2	1497	0	1497	-
	295		67.9	14.6	9.9	1800	268	1532	34
	400		66.3	15.6	9.9	1961	355	1606	108
	588		64.7	14.9	9.8	1775	510	1265	-233
	600		62.9	15.4	9.7	1822	520	1302	-195
	440		62.5	15.6	9.8	1848	388	1460	-37
	264		61.7	15.3	9.4	1768	243	1525	28
	435		57.8	15.6	9.0	1709	384	1325	-172
Scougall	0	2.0	65.2	14.4	9.3	16	0	1687	-
	320		83.2	15.1	12.4	2320	289	2031	345
	460		77.6	15.9	12.3	2357	404	1952	265
	520		76.8	15.4	11.8	2215	454	1761	74
	380		76.3	15.7	12.1	2282	338	1944	257
	320		72.6	15.8	11.4	2185	289	1896	209
	280		59.8	15.3	9.1	1717	256	1461	-226
	390		59.0	15.6	9.3	1747	347	1400	-287
Boatfield	0	1.6	106.2	17.3	18.8	3693	0	3693	-
	980		113.7	17.4	19.8	3989	833	3155	-538
	460		117.4	16.9	19.8	3939	404	3534	-159
	320		111.1	16.9	18.9	3727	289	3439	-255
	225		108.2	16.9	18.4	3630	211	3420	-273

Farm	g ai/ha	Grubs/ stool	Cane yield (t/ha)	Sugar content (CCS)	Sugar yield (t/ha)	Net cane payment ($/ha)	Treatment costs ($/ha)	Net funds after treatment ($/ha)	Gain/loss from treatment ($/ha)
	0		106.2	17.3	18.8	3693	0	3693	-
	260		101.0	17.0	17.1	3420	239	3180	-513
Lyons	0	0.75	96.1	14.8	14.4	2607	0	2607	-
	489		104.5	15.6	16.3	3090	428	2662	55
	135		94.4	16.2	15.3	2965	136	2829	222
	237		93.7	16.0	14.9	2886	220	2665	58
	190		93.2	15.4	14.5	2699	182	2517	-89
	339		81.2	15.8	12.9	2451	305	2146	-460
Romeo	0	5.0	70.0	6.8	5.4	185	0	185	
	640		92.6	11.1	10.0	1463	553	910	725
	250		82.7	8.9	8.2	750	231	519	334
	415		75.9	8.9	7.3	688	367	321	136
	295		70.9	9.9	6.9	860	268	592	406
	170		69.6	8.2	6.1	482	165	317	1326
Blanco	0	2.5	73.4	16.6	12.2	2395	0	2395	
	450		80.5	16.3	13.3	2553	396	2157	-238
	450		84.1	16.7	14.0	2770	396	2374	-21
Lamari	0	0.5	31.7	13.7	4.4	753	0	753	-
	380		37.1	15.9	5.9	1131	338	793	40
Celotto	0	1.2	96.0	17.2	16.5	3309	0	3309	-
	440		94.2	17.2	16.2	3242	388	2854	-455
	440		86.6	17.5	15.2	3065	388	2677	-632
Vella	0	4.5	86.2	15.7	13.52	2570	0	2570	
	420		131.8	15.2	19.96	3712	371	3341	770
	420		96.2	15.1	14.55	2705	371	2334	-237
Rankine	0	3.5	90.0	9.2	8.32	885	0	885	--
	355		85.7	14.6	12.62	2272	318	1954	1069
	355		97.0	14.5	13.98	2542	318	2224	1339

Table 22 - Insecticide rates, costs, and benefits and benefit-cost ratios of all treatments in 2000.

Farm	Rate (g ai/ha)	Grubs (/stool)	Cost ($/ha)	Benefit ($/ha)	B/C ratio
Boatfield	375	1.0	334	-465	-1.39
Saunders	260	0.8	239	479	2.00
Saunders	360	0.8	322	99	0.31
diBella	400	2.4	355	407	1.15
Lyons a	260	4.6	239	1434	6.00
Lyons a	410	4.6	363	490	1.35
Stockdale	295	1.7	268	34	0.13
Stockdale	400	1.7	355	108	0.30
Stockdale	588	1.7	510	-233	-0.46
Stockdale	600	1.7	520	-195	-0.38
Stockdale	440	1.7	388	-37	-0.10
Stockdale	264	1.7	243	28	0.12
Stockdale	435	1.7	384	-172	-0.45
Scougall	320	2.0	289	345	1.19
Scougall	460	2.0	404	265	0.66
Scougall	520	2.0	454	74	0.16
Scougall	380	2.0	338	257	0.76
Scougall	320	2.0	289	209	0.72
Scougall	280	2.0	256	-226	-0.88
Scougall	390	2.0	347	-287	-0.83
Boatfield	980	1.6	833	-538	-0.65
Boatfield	460	1.6	404	-159	-0.39
Boatfield	320	1.6	289	-255	-0.88
Boatfield	225	1.6	211	-273	-1.29
Boatfield	260	1.6	239	-513	-2.15
Lyons rep	489	0.75	428	55	0.13
Lyons rep	135	0.75	136	222	1.63
Lyons rep	237	0.75	220	58	0.26
Lyons rep	190	0.75	182	-89	-0.49
Lyons rep	339	0.75	305	-460	-1.51
Romeo	640	5.0	553	725	1.31
Romeo	250	5.0	231	334	1.45
Romeo	415	5.0	367	136	0.37
Romeo	295	5.0	268	406	1.51
Romeo	170	5.0	165	1326	8.04
Blanco	450	2.5	396	-238	-0.60
Blanco	450	2.5	396	-21	-0.05
Lamari	380	0.5	338	40	0.12
Celotto	440	1.2	388	-455	-1.17
Celotto	440	1.2	388	-632	-1.63
Vella	420	4.5	371	770	2.08
Vella	420	4.5	371	-237	-0.64
Rankine	355	3.5	318	1069	3.36
Rankine	355	3.5	318	1339	4.21

4.4.2 Conclusions

Economic evaluation of only the crop to which treatment is applied is deficient in that it does not account for the benefit of improved ratooning and added yield in subsequent years as a result of treatment. Attempts to gain further production data from different treatment categories in the year following each field trial were not successful; all growers elected to plough out fields where there had been sufficient infestation to register any treatment effect in the small field-trial portion.

Any relationship between product rate and economic benefit is difficult to define from these data (Table 22). However (Fig. 1), the greatest economic benefits are almost all with the lower rates, 200-350 g ai/ha (1.0-1.7 L Confidor 200 SC).

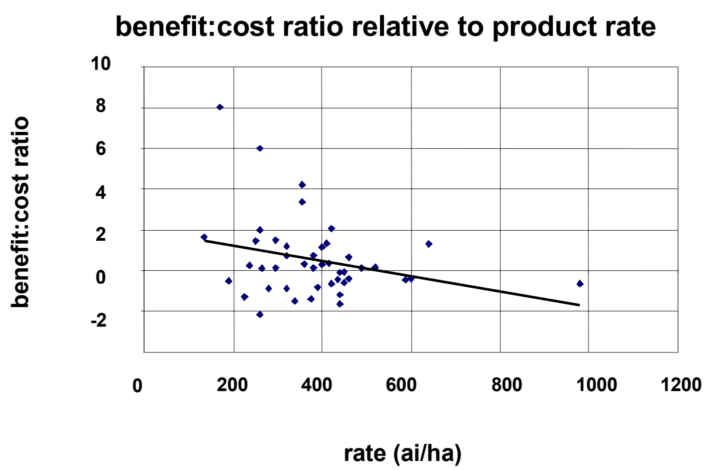

Figure 1. Relationships of benefit:cost ratio and product rate for all Confidor treatments in 2000.

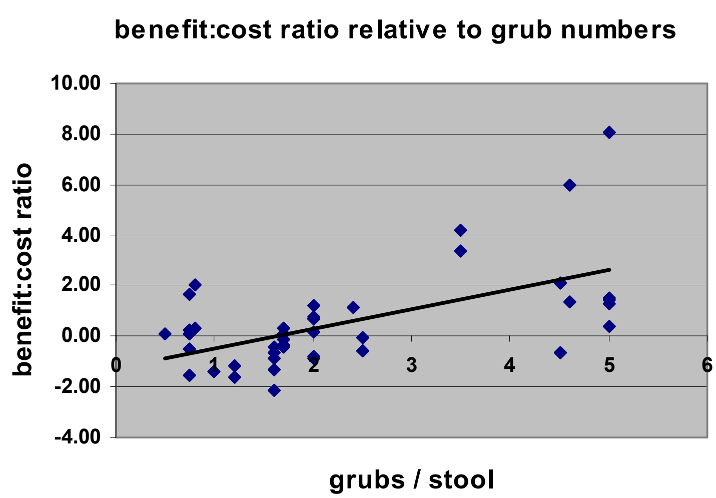

Figure 2. Relationships of benefit:cost ratio and grub numbers for all Confidor treatments in 2000.

Benefits due to cane yield are obvious, but benefits due to increased sugar content in treatments appear equally or more important contributors to economic benefit (see Table 21). Most positive benefits appear to occur where there is a significant increase in sugar content of treatments.

There does not seem to be a consistent economic threshold between grub numbers and profitability of treating with Confidor (Fig. 2).

Profitability of this treatment can be highly dependent on management. For example, at Saunders and Boatfield, numbers and locality were similar, but returns are vastly different. Confounding effects of crop tolerance (varietal and previous damage conditions), and soil moisture and fertilising regimes, probably all influenced the benefit:cost ratio; the smaller crop showed the greater benefit, and the larger crop that was able to tolerate the infestation through crop management showed a negative return on treatment. Another grower (Stockdale) failed to apply a consistent watering regime. Although treatment controlled grubs, the crop failed to produce sufficient benefit from the outlay. The farmer took the view that the trap-crop had served its purpose (of protecting the adjacent block), and from that point he applied minimal maintenance to the 'trap' site as it achieved its role in helping to protect the neighbouring late-cut ratoon (i.e. the potential insecticide treatment benefit in the trial site was of little interest, as he had decided that the product was too expensive).

Generally, the opportunity for economic gain was greatest under irrigated conditions (e.g. Lyons, Romeo, Rankine), but even weak crops (irrigated and non-irrigated) with potential to yield 40-70 t/ha (e.g. Lamari, Scougall, Vella, Romeo, Saunders, Stockdale) can benefit cost-effectively in the treated-crop year, provided that the application rate is not excessive and if the benefit in sugar content (CCS) is allowed to maximise.

4.5 Selection of fields for treatment

4.5.1 Probability of selecting fields prone to infestation

Of the nine field-sites selected in 1999, five were heavily-moderately infested, two unevenly but moderately infested, and two not infested in 2000. These sites had been selected on the basis of existing infestation or nearby infestation, and harvest before September 1999. Seventeen of the 25 trial sites for 2000 were sufficiently infested (at least 1 grub per stool) to warrant sampling the populations, and another site (Pitiris) had a large portion of the early harvested section severely infested, but not in the small trial section. Based on previous experience with establishing field trials into plant cane, 7 out of 9 (75%) and 18 out of 25 sites (72%) infested is a high success rate. Thus, the sum of the selection criteria used, including early harvest, resulted in at least 70% probability for infestation. This compares favourably with results by Horsfield *et al.* (2002), who by selecting very early harvested 'trap-crop' portions, had all sites with some infestation and 12 out of 15 sites (80%) with >1.0 grubs per stool, sufficient to cause an effect. These same criteria could be used to identify fields where treatment is appropriate; or even to predispose areas to be selectively treated as 'trap-crops'.

4.5.2 Effectiveness of early-harvested ratoons for aggregating greyback beetles

1999-2000. At the Kelly, and Gibson sites, aerial photographs of damage symptoms and grub populations indicated that the early harvested trap-cropping tactic aggregated far greater infestations than the later-harvested comparison. Both early harvested sectors were severely damaged (2-3 grubs per stool, Table 5), whereas late-cut sectors had 0.07 and 0.1 per stool, respectively. Note that three features distinguish these two fields and their trap crops from the other five (below) that were infested. Firstly, the 20 and 14 rows wide, respectively, early harvested 'trap' strips were ratooned very early, either as a seed-cane source or in the first week of the harvest season. Secondly, and probably as a direct consequence of the first, both had an obvious growth advantage (0.83 and 0.8 m tall, +0.56 and +0.5 m taller) over the adjacent later-harvested portions of fields and both were growing vigorously when beetles were flying. Thirdly, neither of these crops had been infested the previous year.

At five sites (Roberts, Mau, Milburn, Poli, Sgarbossa), early harvested 'trap-sectors' were not very effective at aggregating infestations. Although each was infested, the severity was little different from adjacent, later-harvested ratoons. All were harvested in August, not particularly 'early'. At each, earliest-harvested ratoon sectors formed large portions (3-8 ha, of up to 100 rows wide). Each had been infested in the previous crop, and some fields (Mau, Roberts, Sgarbossa) were gappy and lacking 'vigour', and any height difference over adjacent later-harvested fields was generally less than 0.4 m. The remaining two sites (Rossiter and Blaik) were not infested, although both had been infested in the previous crop; both were gappy and grew weakly, being about 0.6 m when beetles flew in December, and continued to grow poorly.

2000-2001. It was possible to compare numbers of grubs and/or damage symptoms (Table 23) in both early harvested (almost all harvested before August) and later-harvested portions at 13 sites in 2001. As determined from aerial photographs and/or or grub numbers, there was greater symptom expression in early harvested sectors at eight sites. There was no difference in the extent of damage symptoms between early or later-harvested ratoons at five sites. This ratio suggests that harvest date and/or crop size difference are only partial determinants of site and crop category selection by beetles.

The combined data from 2000 and 2001 suggest the likelihood that general distribution of damage to the previous crop lowers the probability of the next generation of greyback beetles aggregating almost exclusively in early harvested portions of that field rather than later-harvested portions. That is, the greater and more widespread the symptoms of damage to the prior crop, the less the likelihood of infestation being restricted to early cut trap-crop portions. Note that in all cases (five in 1999-2000 (see above) and five in 2000-2001 (Boatfield, diBella, Lyons (a), Celotto, Vella) (Table 23)) where infestation was similar in early- and late-harvested portions of fields, that those fields had been at least moderately infested the previous year. Conversely, most cases where there was a large difference in infestation between early- and late-harvested portions (Gibson, Kelly in 1999-2000 and Saunders, Pitris, Scougall, Lyons (b), Romeo in 2000-2001 (Table 23)) were in fields with nil or only slight previous infestation. At both the Kelly and Romeo sites, the concentration of insects in the early-harvested sector was about 30 and 28 times, respectively, the number in the later-harvested cane.

Table 23 - 2000-established field trials. Summary of information on 12 sites with early harvested and late-harvested portions suitable for comparison.

Site	Infested 1999	Height (± SE) of ratoons from early cut sectors, in Nov. 2000 (mm)	Height increase over late-cut (mm)	Growth increase over late-cut (Nov.)	Grubs per stool (early-cut)	Grubs per stool (late-cut)	Visible increase in damage: early-cut over late-cut
Saunders	moderate	645-727 (35)	340-597	moderate	0.8; N=24	-	high
Stockdale	moderate	400-665 (25)	205-215	moderate	1.8; N=56	-	high
Pitiris	slight	513-530 (22)	265-300	moderate	0.9; N=12	-	moderate
Scougall	slight	500*	200*	slight	2.0; N=20	-	high
Boatfield	moderate	760-850 (35)	95-280	slight	1.6; N=20	-	nil
Young	moderate	1110	340	moderate	0.8; N=16	0.3; N=1	slight
diBella	moderate	600*	250*	moderate	2.4; N=16	-	nil
Lyons (a)	moderate	650*	250*	moderate	4.6; N=16	4.2; N=2	nil
Lyons (b)	slight	650*	250*	moderate	0.9; N=16	0.1; N=1	moderate
Romeo (a)	nil	750*	350*	moderate	5.3; N=20	0.6; N=2	high
Romeo (b)	slight	750*	300*	moderate	1.9; N=16	0.8; N=1	v. slight
Celotto	slight	650*	300*	slight	1.3; N=28	1.5; N=1	nil
Vella	slight	700*	350*	slight	4.5; N=10	5.0; N=1	nil

- data not collected
*estimated height and differences

Two possibilities could explain a difference in the aggregation effect in early harvested portions, between fields previously infested or not previously infested. Firstly, weakened stools and a gappy stand of plants resulting from a previous infestation could render plants unable to grow sufficiently well to create a pronounced difference in attractiveness between early and late-harvested portions of a field. Secondly, there could be some factor that induces beetles to return previously infested sectors, perhaps regardless of the plant-growth status or whether early- or late-harvested, e.g. an odour left by the emerging insects, or a 'homing' ability innate in the emerging beetles.

The consequences of (i) a high probability (0.7) of further damage once a field becomes infested and (ii) the apparent tendency for damage intensity to increase, regardless of early-cut or late-cut status, in the following year, are that these fields must be considered either for treatment with insecticide or another management option such as fallowing. In deciding the alternatives, economic analysis of benefit:cost ratios outlined above, and broader-consideration farm-management tactics may provide a more cost-effective and sustainable decision, rather than basing the decision solely on the insecticidal and population dynamics approach.

4.6. Criteria for field selection, and specification of Confidor-treated trap-crops

In summary, net returns on treatment costs with Confidor suggest criteria to decide if particular fields should be treated. Effectiveness of treatment in different situations suggests probabilities to decide where to apply Confidor, or other products, for greyback control. Together, probability and effectiveness at aggregating beetles form the basis for suggesting to what extent to create trap crops, whether or not treated with Confidor or other products, for greyback control.

In estimating the necessary extent of a trap-crop, we assume hat the ‘attractiveness’ of an early-harvested ‘trap-crop’ ratoon, combined with its extent (area) will govern the area for which the ‘trap’ will effectively reduce infestation pressure on other fields. From the data (see above for 2000 and Table 23 for 2001), populations in early-harvested ‘trap’ areas were commonly increased 2.5 times that of the later-harvested sectors. Thus, for the given number of beetles operating in a sector, the ‘trap’ could effectively halve the population in the non-trap portion, for an area between 1-7 times the area of the trap. In the majority of cases detailed in this report, halving could be sufficient to reduce greyback grub populations below a critical threshold of about 1 grub per stool. Obviously the reduction would need to be greater than half for population densities > 2 per stool. With refinement, the effectiveness of the trap-cropping tactic could be increased to aggregate beetles 20-30-fold as at Kelly and Gibson and Romeo. However, we have no indications of the distance over which a sugarcane ‘trap’ sector may aggregate beetles: this unknown issue is at the heart of the assumption alluded to above, and needs to be researched before the trap-crop concept can be empirically applied.

The following decision rules are proposed:

Risk assessment criteria allow decisions on where and when grub management is needed.

1. Fields with prior evidence of infestation or close to prior infestation, and which are harvested early (before August?), have at least 0.7 (25 out of 34 total for 1999-2001 in this study) probability of infestation, and potential for a trap-crop treatment to be beneficial. This applies in all cases, independent of whether management conditions (e.g. irrigation or soil moisture) will create a major growth differential between ratoons from early and late-harvested sugarcane, and also if dryland conditions prevail. Success rate is greater (e.g. Horsfield *et al.* 2002) under ideal conditions. Observations at Mulgrave in 2002 (see below) suggest this probability can also be achieved in a non-irrigated region.

   From the economic assessment, two criteria indicate whether to treat a vulnerable field or portion of a field with Confidor, especially on a whole-field basis. Other assessments should be used for decisions on protected or ‘sacrificial’ trap-crops, or other situations such as using the ‘trap’ method to lower infestation in surrounding BioCane-treated areas. Alternatively, other tactics may be more appropriate.

2. The crop must have good prospects of being able to reach its yield potential. It should not be constrained by deficient irrigation, insufficient soil moisture, or excessive root damage to the crop before treatment, nor over-irrigated or fertilised to the extent that treated cane does not maximise its sugar content. Weak crops should not be treated.

3. The crop must have reasonable vigour and prospects for making at least one further healthy ratoon crop after the one to which the treatment is applied.

4. If the field does not satisfy (2) and (3), then consider alternative tactics, e.g. a fallow; or an alternative crop as a trap, or an early-harvested sacrificial trap, but do not waste resources and expect a miracle rejuvenation following Confidor treatment.

   Observations on trial sites detailed herein suggest the extent of treatment for particular fields to create insecticide-treated trap-crops:

5. Employ the low-proportion trap-crop tactic (i.e. manage < 50% and perhaps only 20% of a field as ratoons from early harvested portions), only where growing conditions will enable the early harvested portion to develop a substantial growth advantage over the later-harvested portion. Generally such a field will not have prior infestation, or have been only very lightly infested, and will have a high-risk predisposition, such as a source of infestation along one or more boundaries. Protect this most vulnerable and valuable portion of the field as a 'lethal trap' with insecticide and generally lower the probability of damage to the untreated remainder by harvesting that portion later e.g. mid-season.

6. Employ the high-proportion trap-crop tactic (i.e. manage > 50% and perhaps the entire field as ratoons from early harvested portions), where poor spring-growth potential (e.g. low rainfall or soil moisture) and other conditions (e.g. previous root damage) may restrict an early-harvested portion from gaining a substantial growth advantage. Generally, fields that were noticeably infested in the previous crop will be managed with this tactic. Protect the whole 'trap' (often, the whole field will be the 'trap') with insecticide and generally lower the probability of damage to the untreated remainder by harvesting that portion much later e.g. last.

7. Whether a high-proportion or low-proportion treatment strategy is employed, it is probably better to recommend creating a number of strategically positioned, early harvested 'traps', rather than creating a single larger 'trap'. Future observation may allow us to measure the distance over which a trap area protects non-trap areas.

4.7 Assessment of 2001-2002 farmer interaction addressing objective 3

Workshops on whole-farm IPM planning for Confidor use. Workshops to plan Confidor use as part of an integrated greyback grub management plan were conducted in all northern, Herbert, Burdekin and Central mill areas in 2001 (Hunt *et al.* 2002). Outputs from the present project were tentatively incorporated into the decision-making process used in those workshops. For example, the activity of growers using their farm maps to identify risk and thus determine where to apply Confidor for greatest benefit and, for deciding if and where and when to employ other tactics such as trap-cropping, was developed to implement outcomes of this project. Also, tentative decision rules (see above) about categories of trap crops worth treating, and the size of traps to create, and risk-assessment as determined from the crop history and observations on dispersal patterns of greyback grub, were partly developed from interpretation of results from this project. Almost all farmers initiating large-scale field trials of Confidor in 2001 had attended 2001 GrubPlan workshops on integrating this chemical into their revised strategy. Subsequent to the workshops, many BSES extension and research staff and four Bayer representatives and CPPB staff expended considerable time and effort with growers and their contractors in assisting growers to implement their plans. Bayer provided about 400 L of Confidor as incentive to participants.

Regional assessment of treatments. About 4,100 ha (total) (BSES data supplied to NRA) was treated with Confidor for greyback grub control under either the emergency use permit in 2001 or the experimental permit from NRA in 1999 and 2000. Confidor, alone, was the most frequently employed tactic. Although there are no data, farmers seemed to place more emphasis on treating at-risk fields, and lesser emphasis on the concept of combining Confidor with trap cropping. However, most were certainly not applying the product indiscriminately.

At Mulgrave, 35 growers applied 1780 L to 1271 ha of ratoons: including seven who 'topped-up' suSCon Blue treatments that were known to be degraded, probably due to unsuitable soil-pH conditions. Sampling by Mulgrave CPPB staff during February 2002 in 14 Confidor-treated fields revealed four with infestation at 2.0 grubs per stool, and six with 1-2.0 grubs per stool, and four with 0.5 grubs per stool. However of these, none were suitable for yield-assessment by the bin-weight method; either there was no comparable untreated or infestation was evident in only small portions of the untreated section. Thus, 100% of these growers were able to accurately predict the likelihood of infestation. About 30% of treated fields had grub infestation at or above the threshold of 2 grubs per stool (Fig. 2), and probably will derive direct monetary benefit from Confidor treatment. In addition, it is highly probable that the 40% of sites with 1-2 grubs per stool have recouped the cost of chemical and avoided crop loss plus substantial loss of root-deficient stools at harvest and subsequent gappy ratooning, a secondary cost not accounted for. Crops with lower infestation possibly benefited slightly, particularly in the following ratoon.

From Innisfail to Tully growers established Confidor treatments on 225 ha. Two that had untreated areas suitable for comparison were not infested (Todd, Garradunga: 16 stools, 0 grubs; Cecci, Coorumba: 20 stools, 0 grubs). In addition, Cecci had attempted full-rate and half-rate treatments superimposed on BioCane applied the previous year (20 stools, 0 grubs).

At Ingham, nine growers established Confidor treatments on 40 ha.; seven sites were treated with Confidor alone, and two with combinations of Confidor and BioCane. Five sites (Minato, Vella, Balanzategui, Elortegui, APIK farming) were not infested (total 40 stools, 0 grubs). Four sites (Morley, Cervellin, Spina, Rapisada) were lightly infested (0.25-1.0 grubs per stool; 61 stools, 31 grubs). Two (Morley, Cervellin), showed interest and participated in establishing and monitoring Confidor and BioCane combinations (reported above).

In the Burdekin region about 1985 ha was treated with Confidor. At least 21 Inkerman farms (13 growers) had untreated portions of fields. Untreated areas at seven of the most suitable sites were monitored for grubs - Stockdale a: 12 stools, 0 grubs; Stockdale b: 12 stools, 0 grubs; Ahern: 12 stools, 0 grubs; Schultz: 12 stools, 8 grubs; Poli: 6 stools, 0 grubs; Rapisada: 6 stools, 0 grubs; Callow: 12 stools, 2 grubs. None of these were followed up for yield assessment. Three replicated block trials combining Confidor and BioCane

(MacDonald, 0.65 ± 0.28 grubs per stool, 20 stools; Sgarbossa, 16 stools, 0 grubs; Kelly, 24 stools, 1 grub) were not sufficiently infested to warrant sampling.

At least 23 Tableland growers established treatment on 560 ha, five of which had untreated comparisons. Of these, there was a strong treatment benefit evident in infested portions of three (O'Shea (Joe Bianco), Emerald Ck; Cabassi, Chewko Rd; Price, Chewko), of which only one (O'Shea) was suitable for yield assessment by the bin-weight method. That site (1-2 grubs per stool, 6 stools) yielded 15.4 t sugar/ha in the treated area and 14.4 t sugar/ha in the untreated, which is a disappointingly meagre result considering the vast reduction in crop quality adjacent to the small treated area. Nevertheless, the untreated portion has failed to ratoon satisfactorily.

4.8 Stool-splitting with wide tine-shoes for row-banding in ratoons

In the preliminary strip-plot assessment at Ayr of broad tine-shoes for spraying an underground band of Regent, or other soil-immobile agents such as BioCane, into ratoons, there were insufficient grubs in the untreated (8 stools, 1 grub) to assess efficacy of Regent. However the absence of infestation provides opportunity to further assess the effect of the two application methods in ratoons on crop yield. In September 2001, the single, inverted-T tine (with a 150 mm-wide shoe) following a coulter in the middle of the row when shoot height was about 0.5 m caused moderate (up to 10%) slicing and or breakage of shoots. In October 2001 in the same field, the twin, narrow, inverted-T tines (with 75 mm wide shoes) set 350 mm apart, damaged about 20% of shoots. Visible effects of this damage quickly disappeared. However, yield assessment from treated and untreated sectors is not yet (September 2002) available.

5.0 OUTPUTS

5.1 General

- Conclusions on product rates, application methods and treatment dates are sufficiently consistent to allow growers to confidently use Confidor 200 SC as recommended to protect ratoon crops from greyback grubs.

- Planning rules are now available to allow decisions on whether to consider integrating trap-cropping, and trap-crops treated with Confidor into the local management plan, and if so, the site and nature and extent of treatment.

5.2 Technical output summary

1. Conclusions on Confidor rates, application methods, and treatment times are:
   - Rates as low as 300g a.i. / ha (1.5 L/ha) are reasonably effective, but 360-400 g a.i. / ha (1.8-2.0 L/ha) are more consistently effective, especially with high grub populations.
   - Rates of about 360 g a.i. / ha (1.8 L/ha) or less (Fig. 1) give the highest benefit:cost ratios.

- Side dressing with over-row machinery is the generally useful application method, and stool splitting is as effective.
- Application is effective between September and December.
- Side dressing with inter-row machinery in December is very effective.

2. Planning rules are now available to allow decisions, by July, on plans for integrated trap-cropping and Confidor treatment in the local management plan.

(a) In both irrigated and dryland conditions, fields with residual damage or which are close to prior infestation have at least a 0.7 probability of infestation if harvested by early August.

(b) To provide direct economic benefit from Confidor, the crop must have good prospects of being able to reach its yield potential. i.e. it should not be constrained by deficient irrigation or insufficient soil moisture, or severe root damage to the prior crop.

(c) To provide long-term economic benefit from Confidor, the crop must have potential to make at least one further healthy ratoon for the following crop

(d) If the field does not satisfy (b) and (c) then consider alternative tactics, e.g. a fallow; but do not waste resources and expect a miracle rejuvenation of weak plants following Confidor treatment.

(e) Employ the low-proportion trap-crop tactic (i.e. manage < 50% and perhaps only 20% of a field as ratoons from early-harvested portions), only where early harvest and good growing conditions will enable the early harvested portion to develop a substantial growth advantage over the later-harvested portion. Suitable fields will generally not have been infested, or have been only very lightly infested, and will have a strong source of infestation nearby. Protect the 'trap' with insecticide and lower the probability of damage to the untreated remainder by harvesting that portion much later.

(f) Employ the high-proportion trap-crop tactic (i.e. manage > 50% and perhaps the entire field as ratoons from early-harvested portions), where lack of soil moisture or previous root damage may prevent the early harvested portion from being substantially taller than a later-harvested portion and other crops when beetles are flying. If a field was infested in the previous crop, early harvest the whole field to create a large 'trap' treated with insecticide, provided it satisfies (b) and (c). Or, treat a large portion at the highest risk as the early harvested trap and harvest the untreated remainder much later e.g. last.

(g) It is probably better to recommend creating a number of strategically positioned early-harvested 'trap' strips, rather than a single larger 'trap'. Future observation may allow us to measure the distance over which a trap area protects non-trap areas.

6.0 EXPECTED OUTCOMES

The process of improving strategy planning for greyback canegrub control has begun for canegrowers and their support staff. This project has been a major incentive for that process.

Grower interest in the prospect of a new product, albeit perhaps for a less sustainable tactic, has been ‘the carrot before the donkey’ that engendered this progress. Other chemicals and biological agents, and other tactics not reliant on chemicals, will all become more readily accepted by canegrowers through the availability of a relevant framework of options, and a fundamental decision tool with which to combine them into strategy, both of which have significantly advanced as a result of this project.

Growers are now far more willing to decrease routine treatment of plant cane with controlled-release insecticide than they were in the absence of any alternative tactic, with attached economic, environmental, and community consequences. Greater discrimination in deciding tactics and strategy is now possible, and furthering this process should (profitably) continue.

Many growers who have experienced using Confidor as part of this project increasingly recognise the need to integrate grub management with other farming practices. For example, the lack of positive benefit from Confidor treatment of some crop categories and situations highlights the need to closely evaluate the economic merit of any such treatment. Thus, whilst Confidor is a potentially extremely valuable and effective tool, its high cost has further demonstrated the merits of sustainable greyback grub control by methods other than killing grubs in the crop, such as alternative farm management practices that reduce population growth. Thus the need for carefully targeted ratoon treatment tactics remains relevant.

A new, alternative chemical tactic, within the necessary management planning system, will enable canegrowers to make greater, and more effective, and more reliable use of ratoons than before. More economical and environmentally sustainable consequences could flow, without periodic disastrous outbreaks of greyback grub infestation. Examples of the benefits of new tactics and strategy include:

- better profitability through reducing costs where chemicals are not necessary;
- greater profitability through efficient and high-yielding ratooning;
- less unnecessary use of chemicals;
- greater demonstrability of responsible stewardship of chemicals;
- less soil loss due to ploughing to replant damage areas during erosion-prone periods;
- less disturbance of natural biological agents in the soil that assist with nutrient cycling and water infiltration and canegrub control; and
- better agricultural practice of planned fallowing in the absence of forced replanting.

Bayer CropScience has applied to the National Registration Authority (NRA) to register Confidor SC for greyback canegrub control. This project supplied almost all the efficacy data required. However, Confidor SC is not presently registered for use against canegrubs, due to concerns from Environment Australia about water solubility of the product, and possible environment contamination.

7.0 FUTURE R,D&E NEEDS

Vigorous extension is needed to address two issues. Firstly, we must continue to develop and improve the effectiveness and efficiency of grub management using selective ratoon treatments with Confidor SC. In conjunction, a new product that will fulfil the same role could be the instrument in maintaining grower interest, acceptance, and adoption of the ratoon and whole-farm management process.

Secondly, even if information is available to indicate there is no likelihood of water-soluble insecticide such as Confidor contaminating groundwater, and enabling the product to be registered, there needs to be a good deal of industry awareness of this risk, and implementation of 'good stewardship' management plans to ensure contamination does not occur and registration of Confidor continues for the industry's benefit.

There are other associated, more 'research-oriented' needs.

The need for effective risk assessment and prediction systems at the farm and district level has increased greatly due to the greater availability of options, not only for management of greyback canegrub. This need is being partly addressed through the current GrubPlan2 project, but further fundamental research into cane-beetle preference for oviposition sites, the key to risk prediction, is needed to increase precision of assessments.

The seemingly inconsistent results (e.g. low rates seeming to be more effective than higher rates) indicate there is a number of factors underlying the interaction of imidacloprid and greyback canegrub, which if understood and resolved could result in far greater efficiency, consistency and benefit.

There is a non-conventional, but perhaps even greater opportunity, to lessen chemical use by planting imidacloprid-treated (using formulation Gaucho WS) seed. The seedlings (e.g. wheat, ryegrass, barley or another non-competitive grass) might act as a selective lure and systemically deliver the toxic chemical. Based on current registrations for this product, as little as 20-60 g ai/ha, a fifth of the conventional rate, could be effective.

There is a need to identify and evaluate the potential of other products and application processes to control greyback grubs in ratoons.

- Data in this project suggest that the potential of applying a liquid suspension of BioCane spores dispersed into vertical bands through ratoon rows is worthy of more trials.
- Concerns over the use of water-soluble chemicals, including Confidor, which disperse in soil reasonably easily and have potential to contaminate groundwater and waterways, could limit their future. Hence, application methods that disperse stable (non-soluble) products in a manner likely to control greyback (and other canegrubs) are needed.

8.0 RECOMMENDATIONS

1. BSES and Bayer CropScience continue to collaborate on improving efficacy of treatments through better understanding of the mechanics of the interaction between the imidacloprid treatment and canegrubs in the soil-plant environment.

2. BSES to investigate potential of a novel method for delivery of imidacloprid against white grubs, via coated seeds (eg wheat) and systemic activity in the resultant seedlings; this treatment has proven effective against other insects at very low rates.

3. BSES to obtain definitive information on the extent of the influence of early-cut 'trap-crops' on canegrub populations; how far apart, and what size is necessary?

4. BSES, Bayer CropScience and Bio-Care Technology to continue to look for any synergy between Confidor and BioCane.

5. BSES and Bio-Care Technology collaborate to research potential of treating ratoons with vertically aligned bands of FI1045 spores, using equipment, and site-identification strategies, and management plans developed in IPB001.

9.0 PUBLICATIONS

Hunt, W.D., Chandler, K.J., Horsfield, A., Cocco, R. and Sgarbossa, P.J. (2002). Developing and extending 'GrubPlan' for management of greyback canegrub damage in Queensland sugarcane. *Proc. Aust. Soc. Sugar Cane Technol*. 24: 207-212.

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11.0 REFERENCES

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