

Canegrub Management and New Farming Systems

Helping growers manage canegrubs in new farming systems



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Introduction

Following many years of research by BSES Limited and other participants in the Sugar Yield Decline Joint Venture, three major strategies were identified to maintain productivity of cane farming land:

- Legume rotations
- Controlled traffic
- Reduced tillage

Many growers are now adopting one or more of these components of what has come to be known as the 'new farming system'.

Canegrubs can be a critical constraint on sugarcane farming systems in Australia, and it is vital that changes in agronomic practices are compatible with good control of these pests (as well as other pests, diseases and weeds).

Therefore, new farming systems should not only encompass sustainable agronomic practices but also include sustainable pest management practices, with greater emphasis on pest monitoring and targeted pesticide application than is the current rule.



Image 1 | Canegrub-damaged stool.

We believe that the following general principles should be a guide to sustainable pest management in sugarcane:

1. When adopting sustainable farming systems, avoid practices that increase grub numbers or exaggerate their effect on the crop
2. Apply canegrub control measures when justified by risk and by cost and expected benefits
3. Avoid applying insecticides when not required so as to:
 - Not waste the expense on unnecessary treatment
 - Minimise risk of environmental contamination
 - Delay development of pest resistance to insecticides or accelerated breakdown in soil

Monitoring is the key to achieving points 2 and 3.

Good canegrub management is readily achieved in new farming systems. This booklet outlines what we currently know of the effect of changing farming practices on canegrub populations and on their management, bringing together results of research and field observations from growers. It also outlines monitoring systems to allow more precise and cost-effective canegrub control.



Image 2 | Fig leaves eaten by greyback cane beetles.

Legume rotations

Summary

- Soybean in rotation with sugarcane does not create a grub problem
- Soybean crops are an opportunity to monitor fields for canegrubs
- Light infestations in soybean crops can be managed in the following cane crop
- Legume rotations may encourage diseases of canegrubs

Canegrubs are sometimes found in crops of soybean that are grown in rotation with sugarcane, and the grubs will feed on soybean roots.

For greyback canegrubs which have a 1-year life cycle, grubs will only be found in soybean crops if beetles lay eggs into that field.

Observations suggest that cane volunteers may attract additional egg-laying beetles to soybean, although there is no hard scientific evidence for this.



Image 3 | Yellowing soybean around volunteer cane stools, a result of root damage from greyback canegrubs.



Image 4 | Soybean root damaged by greyback canegrubs.

Actively growing crops of sugarcane are the most attractive places for greyback cane beetles to fly to and lay eggs. Table 1 below shows the average number of greyback canegrubs in plots comparing different fallowing systems. There were far fewer grubs in all the fallow treatments than under ratooning cane.

Table 1 | Numbers of greyback canegrubs in plots with different fallows, compared with plots of ratooning cane.

Treatment	Grubs / 8 holes
Cultivated fallow	0.0
Cultivated + soybean	0.3
Sprayout fallow	0.8
Sprayout + soybean	1.0
Ratooning cane	20.3

However, soybeans were not planted in this trial until January, which may have been too late for the main beetle flights.

Table 2 compares numbers of greyback canegrubs in a second trial, in plots with early- or late-plant soybean which were direct-drilled into sprayed-out cane, or no soybean. There appeared to be more grubs in plots with soybean than without, and in early- than in late-plant soybean, but differences were not statistically significant; numbers of grubs were very low in all treatments.

Table 2 | Numbers of greyback canegrubs in plots of sprayed-out cane with different soybean treatments; differences were not statistically significant due to low grub numbers.

Soybean planting	Planting date	Height on 9 January (cm)	Grubs / 8 holes
Early	28 Nov	30	2.3
Late	19 Dec	9	0.7
No soys	–	–	0.0

In fields near Bundaberg, there were fewer southern 1-year canegrubs (with a 1-year life cycle) and young Childers canegrubs (those in the first year of their 2-year cycle) in soybean fields than in adjacent canefields, as shown in Table 3.

Table 3 | Numbers of southern canegrub species in soybean fields and nearby canefields.

Canegrub	Number of fields	Average grubs / hole	
		Soybean	Canefields
Southern 1-year	2	0.4	4.7
Childers: 1 st year	8	0.7	1.8

Legume rotations may favour the occurrence of natural diseases of canegrubs. A survey of ratoon fields in far northern Queensland indicated that the percentage of greyback canegrubs that were infected with the pathogen *Adelina* was significantly greater where there had been a soybean crop prior to planting. A survey does not prove a cause-and-effect relationship, but it is reasonable that the shading and the additional organic matter provided by a soybean crop may encourage grub diseases such as *Adelina*.

Table 4 | Percentage of greyback canegrubs killed by *Adelina* in a survey of canefields with or without a soybean rotation before planting.

District	% grubs diseased (number of fields in brackets)	
	Soybean rotation	No rotation
Central	5 (4)	2 (17)
Herbert	26 (8)	11 (19)
Innisfail-Tully	14 (2)	16 (17)
Mulgrave	24 (9)	18 (25)
Combined	21 (23)	12 (78)



Image 5 | Soybean crop.

Controlled traffic and reduced tillage

Summary

- Canegrub diseases are concentrated around the cane roots, where grubs live
- Fields should be cultivated sufficiently to break up compaction and establish a seedbed, while keeping the pathogens that cause grub diseases concentrated around the root zone
- Do not intensively cultivate fields in an attempt to control canegrubs; even intensive cultivation will not reliably kill sufficient larvae or pupae to avoid the need to treat the next crop with insecticide

Controlled traffic

Controlled traffic has the potential to contribute to vigorous ratoons which may be more tolerant of low-moderate levels of canegrub damage. Harvesters must be correctly set up to harvest wide or dual rows to avoid aggravating effects of grub damage on stool loss.

Tillage and direct effects on canegrubs

Tillage, even if very intensive, will not eliminate existing canegrub infestations or prevent new ones.

For example, several types of canegrubs were sampled in soybean that had either been (i) direct-drilled into cane that had been sprayed-out with glyphosate or planted after cane stools had been disced-out; or (ii) planted after full cultivation (eg plough, disc and rotary hoe) – see Table 5. Prior intensive cultivation did not eliminate canegrubs from fields.

Table 5 | Numbers of canegrubs in soybean crops that were either direct-drilled or planted after discing, compared with planting after full cultivation.

Canegrub	Average grubs / hole (number of fields in brackets)	
	Direct-drilled or disced	Full cultivation
Greyback	0.9 (3)	0.0 (4)
Southern 1-year	0.6 (1)	0.4 (3)
Childers:		
1 st year grubs	0.9 (6)	1.1 (9)
2 nd year grubs	0.7 (6)	0.7 (9)

Tillage and grub diseases

Canegrubs are affected by several pathogens which kill them, including the fungus *Metarhizium* (the active component of BioCane™), the protozoan *Adelina* and the bacterium *Paenibacillus popilliae* which causes milky disease.

Metarhizium and *Adelina* commonly affect many canegrub species in far northern and southern Queensland, though the diseases are not currently abundant in central districts or the Burdekin.

A survey of ratoon fields in far northern Queensland indicated that the percentage of greyback canegrubs that were infected with *Metarhizium* was significantly greater in fields that had been prepared for planting with zonal tillage – cultivation of only the row and not the interspace – rather than conventional (full) tillage (Table 6).

Table 6 | Percentage of greyback canegrubs killed by *Metarhizium* in canefields prepared for planting by either zonal or conventional tillage.

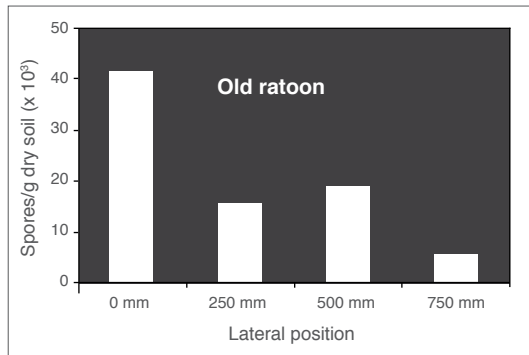
District	% grubs diseased (number of fields in brackets)	
	Zonal	Conventional
Innisfail-Tully	22 (4)	6 (14)
Mulgrave	11 (6)	6 (28)
Combined	15 (10)	6 (42)



Image 6 | Greyback canegrub infected and killed by *Metarhizium* fungus (CSIRO photograph).

We set up an experiment to test whether levels of *Metarhizium* in the soil could be increased by an appropriate cultivation and planting system.

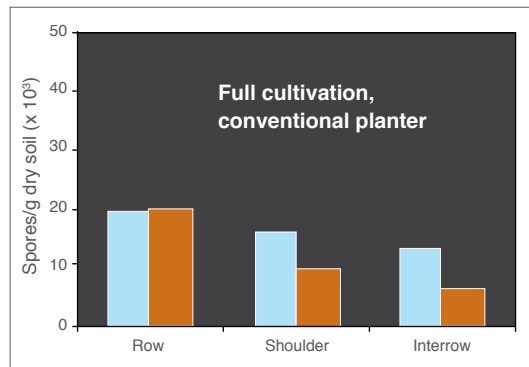
First, we sampled *Metarhizium* spores in an old ratoon in a field where we consistently found diseased greyback canegrubs. Most spores were under stools in the row, with fewer on the side of the row and very few in the interrow (Graph 1).



Graph 1 | Numbers of *Metarhizium* spores in an old ratoon crop, from the centre of the row (0 mm) to the centre of the interrow (750 mm); most spores were in the row – where canegrubs live.

The field was then sprayed-out, direct-drilled to soybean and planted to cane using different systems. Numbers of spores were assessed just after the plant crop harvest.

0-150 mm 150-300 mm

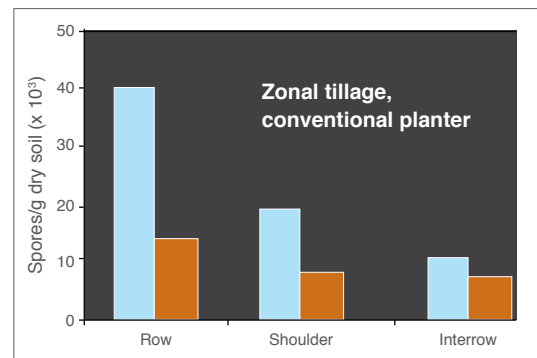
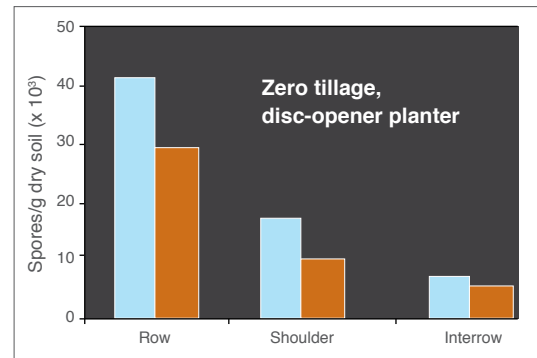


Graph 2 | Numbers of *Metarhizium* spores in the young first ratoon at three lateral positions and two depths, after ground was fully cultivated and planted conventionally; spore distribution was fairly even across the row, shoulder and interrow space.

With full cultivation (disc + ripper/rotary, twice) and a conventional planter, numbers of spores in the new cane crop were fairly evenly distributed across the row-shoulder-interrow, and between deep and shallow within the row - see Graph 2.

With zero tillage and a double-disc opener planter or with zonal tillage (rotary + ripper/grubber + rotary in 76 cm band) and a conventional planter, planting back into the old rows, spores in the new cane crop remained concentrated in the cane rows (Graphs 3 and 4).

0-150 mm 150-300 mm



Graphs 3 and 4 | Numbers of *Metarhizium* spores with zero- or zonal-tillage systems; spore distributions in the new first ratoon were similar to the old ratoon.

These apparent differences in *Metarhizium* spore distribution between planting systems are what we would expect from the action of different cultivation implements. Full cultivation mixes the soil both laterally and vertically.

Zero or zonal tillage will preserve spores and disease intensity where it matters – in the root zone.

Insecticides for new farming systems

Summary

- Effective rates of most insecticides in dual-row beds were similar to registered (label) rates in single-row beds when expressed per 100 metres of bed
- suSCon® (controlled-release) granules were effective when applied from double-disc opener planters in 6 cm-wide bands
- Liquid imidacloprid (Confidor® Guard, Senator®) applied to dual rows was slightly more effective using two coulters than one

Use of insecticides for canegrub control in new farming systems raises two questions relative to current registrations:

- *Must application rates be increased for dual rows?* Dual rows with 1.8 m between beds centre-to-centre contain 11,111 row metres per hectare, compared with 6,667 row metres in single rows at a 1.5 m spacing.
- *Are the narrow row-bands of insecticide from double-disc opener planters (see Images 7 and 8) as effective as bands in conventional planting furrows?* Because a double-disc opener planter does not leave a substantial furrow after planting, application at fill-in is usually not an option.

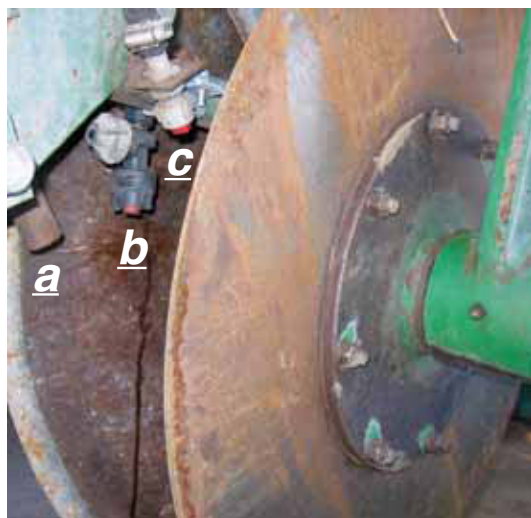


Image 7 | Double-disc opener planter used for planting BSES trials, with outlets for (a) suSCon® granules, (b) Confidor® Guard, and (c) Talstar® for wireworm control.



Image 8 | Band of suSCon® Blue granules about 6 cm wide created with a double-disc opener planter.

BSES Limited conducted trials from 2004-2007 to obtain efficacy data for insecticides in new farming systems. Equipment was designed to allow products and application rates to be varied during planting with a double-disc opener planter, and during treatment of crops after planting using coulters. Results are given on the following pages, but recommendations cannot be made until registration alterations are approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA).



Image 9 | Equipment used by BSES for planting insecticide trials with a double-disc opener planter; two granular products could be applied from the Microband boxes which were driven by an electric motor connected to either one with a removable collar, while four liquid treatments could be applied from the pressurised canisters.

Greyback canegrub - suSCon® Blue

Summary

- suSCon® Blue was effective against greyback canegrub when applied at planting in a 6 cm-wide band from a double-disc opener planter in single or dual rows
- The current application rate of suSCon® Blue against greyback canegrub, 315 grams per 100 metres of single-row bed, was also effective for dual-row beds, even though the granules were spread over two rows. This rate equates to a lower rate per hectare in dual rows (eg 17.5 kg/ha at a bed spacing of 1.8 m) due to the wider bed spacing
- Other products should be used when soil pH is near or above 6

The current registration for suSCon® Blue (Image 10) (140 g/kg chlorpyrifos in a controlled-release granule) against greyback canegrub in single rows is 21 kg/ha or 315 g/100 m of row for 1 year control. Granules should be applied in a band 15-20 cm wide across the centre of the row and covered by 15-20 cm of compacted soil once the row is finished.



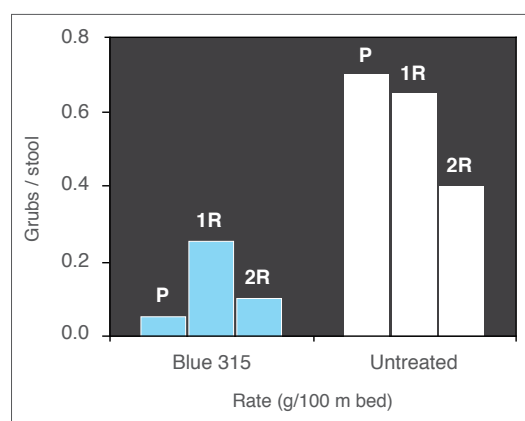
Image 10 | suSCon® Blue.

Data showing efficacy against greyback canegrub of suSCon® Blue applied in 6 cm-wide bands using double-disc opener planters in single or dual rows are available from two trials.

Double-disc opener planter, single rows at 1.65 m, Herbert

One trial near Ingham in single rows at a 1.65 m spacing was planted with a double-disc opener planter in May 2005. suSCon® Blue was applied between the discs during planting. Numbers of greyback grubs were low every year, even in untreated control plots, and differences between treatments were not statistically significant.

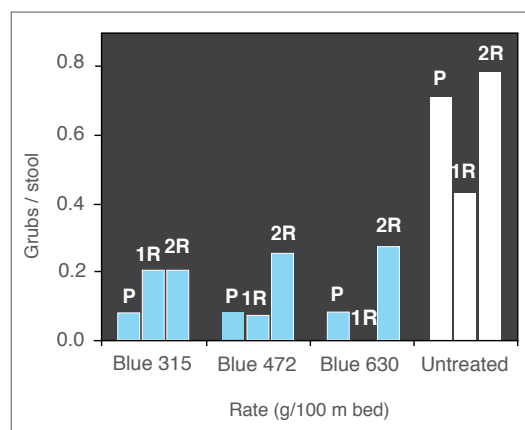
However, suSCon® Blue applied at 315 g/100 m of row seemed to give some grub control until the second ratoon - Graph 5. Yields were unaffected by treatments because of the low grub numbers.



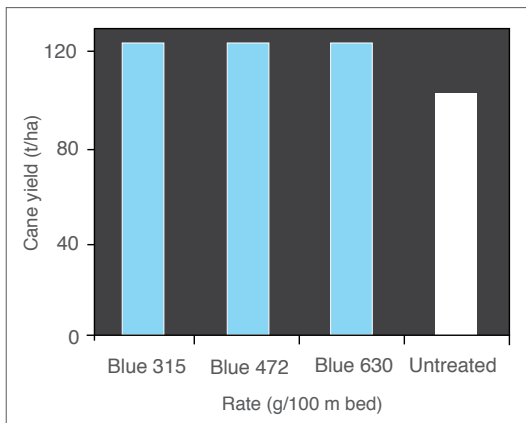
Graph 5 | Greyback canegrubs in plant, first- and second-ratoon crops near Ingham – suSCon® Blue applied in single rows with a double-disc opener planter.

Double-disc opener planter, dual rows 500 mm apart at 1.8 m centres, Proserpine

A trial near Proserpine in dual rows at 1.8 m centres was planted with a double-disc opener planter in September 2006. suSCon® Blue was applied into each of the dual rows during planting. Numbers of greyback grubs in the plant crop and the second ratoon were significantly reduced by suSCon® Blue at rates down to 315 g/100 m of bed, and cane yield was significantly increased in the first ratoon – see Graphs 6 and 7.



Graph 6 | Greyback canegrubs in plant, first- and second-ratoon crops near Proserpine – suSCon® Blue applied in dual rows with a double-disc opener planter.



Graph 7 | First-ratoon harvest yield.

Double-disc opener planter, dual rows 500 mm apart at 1.8 m centres, Proserpine

A second dual-row trial on a different farm near Proserpine in 2007 used the same planting system as in 2006. No results are available for the plant crop, but suSCon® Blue did not perform well in the first ratoon. Soil pH approached 6 in this trial, which is high for central Queensland and may explain the relatively poor result. The detrimental effect of high pH on suSCon® Blue is consistent with other research and field experience.

Conclusion

We confirm that suSCon® Blue is effective when applied in a 6 cm-wide band using double-disc opener planters. suSCon® Blue acts as a contact insecticide and canegrubs must come into very close contact with the granules to be affected. Therefore, we were concerned that the narrow granule bands from a double-disc opener planter might not give good grub control. However, suSCon® Blue worked satisfactorily in the two trials where soil pH was low – 4.5 at Ingham and 4.7 in the first trial at Proserpine.

The current application rate in single rows, 315 g/100 m of bed, was also effective in dual-row beds, even though the granules were spread over two rows. This rate equates to a lower rate per hectare in a dual-row system due to the wider spacing between beds.

suSCon® Blue was not effective in a second trial at Proserpine where soil pH was about 5.8. Chlorpyrifos breaks down more quickly when soil pH is high, and therefore suSCon® Blue granules lose their effectiveness more quickly. Other products should be used for canegrub control when soil pH is high.



Image 11 | Greyback canegrub damage in unprotected fields.



Image 12 | Adult greyback cane beetle.

Greyback canegrub - suSCon® Maxi

Summary

- suSCon® Maxi was effective against greyback canegrub when applied in a 6 cm-wide band from a double-disc opener planter in single or dual rows
- suSCon® Maxi was also effective when applied into dual, conventional planting furrows at fill-in
- The current high application rate of suSCon® Maxi against greyback canegrub, 225 grams per 100 metres of single-row bed, was also effective for dual-row beds, even though the granules were spread over two rows. This equates to 12.5 kg/ha in a dual-row system at 1.8 m centres

The current registration for suSCon® Maxi (Image 13) (50 g/kg imidacloprid in a controlled-release granule) against greyback canegrub in conventional planting systems is 10 or 15 kg/ha, or 150 or 225 g/100 m of row, for up to 2 years protection from root damage. Granules are to be applied in a band 15-20 cm wide across the centre of the row and covered by 15-20 cm of compacted soil once the row is finished.

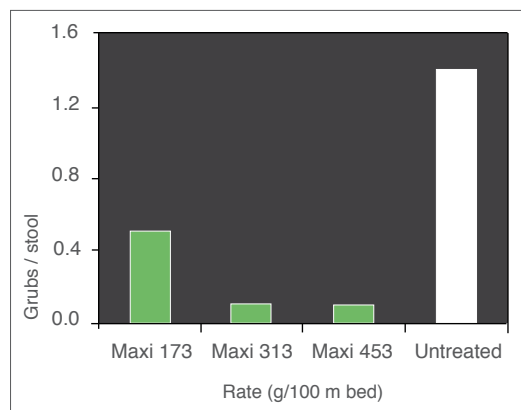


Image 13 | suSCon® Maxi.

Efficacy data for suSCon® Maxi against greyback canegrub using double-disc opener planters and/or dual rows are available from four trials.

Conventional dual furrows 500 mm apart at 1.8 m centres, Burdekin

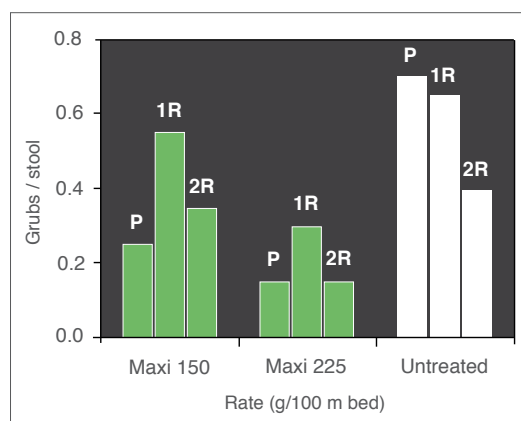
One trial was done near Ayr in 2005. Cane was planted in dual rows at a 1.8 m spacing using a planter with mouldboards, and suSCon® Maxi granules were applied into the furrows at fill-in. All rates down to 173 g/100 m of bed significantly reduced numbers of greyback canegrubs in the first-ratoon crop compared with untreated controls - see Graph 8 (no results are available for the plant crop).



Graph 8 | Greyback canegrubs in a first-ratoon crop near Ayr – dual conventional furrows treated with suSCon® Maxi at fill-in.

Double-disc opener planter, single rows at 1.65 m, Herbert

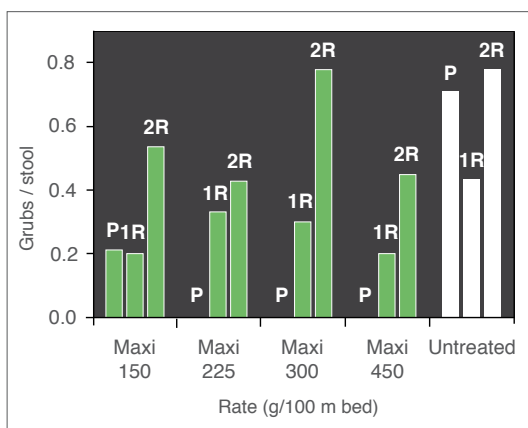
suSCon® Maxi was applied from a double-disc opener planter in single rows at 1.65 m centres near Ingham in May 2005. Numbers of greyback grubs were low every year, even in untreated control plots, and differences between treatments were not statistically significant. However, the lower rate of suSCon® Maxi, 150 g/100 m of row, seemed dubious for protection of ratoons – see Graph 9.



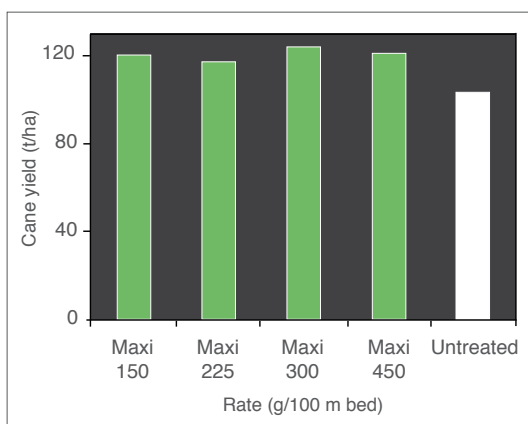
Graph 9 | Greyback canegrubs in plant, first- and second-ratoon crops near Ingham – suSCon® Maxi applied in single rows with a double-disc opener planter.

Double-disc opener planter, dual rows 500 mm apart at 1.8 m centres, Proserpine

A trial near Proserpine in dual rows at 1.8 m spacing was planted with suSCon® Maxi granules using a double-disc opener planter in September 2006. Numbers of greyback grubs were significantly reduced by all rates of suSCon® Maxi in the plant crop but there was not a significant reduction in the first or second ratoon (Graph 10). Cane yield was significantly increased by suSCon® Maxi in the first ratoon (Graph 11).



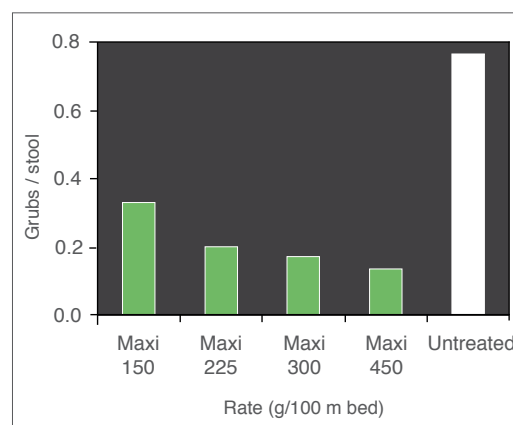
Graph 10 | Greyback canegrubs in plant, first- and second-ratoon crops near Proserpine – suSCon® Maxi applied in dual rows with a double-disc opener planter.



Graph 11 | First-ratoon harvest yield.

Double-disc opener planter, dual rows 500 mm apart at 1.8 m centres, Proserpine

Another trial was done on a different farm near Proserpine in 2007 using the same planting system. No results are available for the plant crop, but a light infestation developed in the first ratoon. Fewer greyback canegrubs were found in plots treated with suSCon® Maxi than in untreated plots (Graph 12) but the difference was not statistically significant.



Graph 12 | Greyback canegrubs in a first-ratoon crop near Proserpine – suSCon® Maxi applied in dual rows with a double-disc opener planter.

Conclusion

Two application rates of suSCon® Maxi applied to single rows are on the current label for greyback canegrub, for low and high canegrub pressure. The higher rate of 225 g/100 m of bed seems effective for double-disc opener planters in single or dual rows or conventional furrows in dual rows. In dual-row beds the granules are split between the two duals. This rate equates to 12.5 kg/ha in beds at 1.8 m centres.

Greyback canegrub - Confidor® Guard, at planting

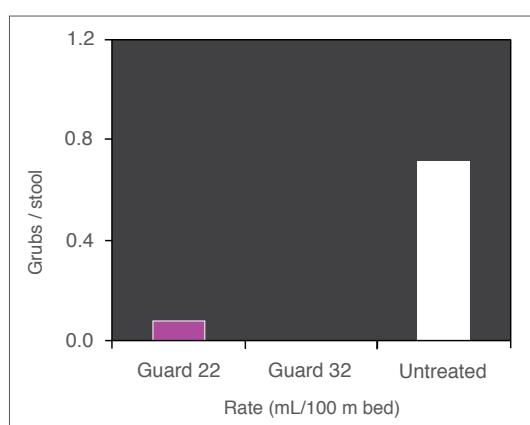
Summary

- Confidor® Guard was effective against greyback canegrub when applied in dual rows at planting from a double-disc opener planter
- Confidor® Guard was also effective when applied in dual rows using coulters in both plant and ratoon crops
- The current high application rate of Confidor® Guard against greyback canegrub, 22 mL per 100 metres of single-row bed, was also effective for dual-row beds
- Two coulters (stool-splitting) were more effective than one in dual-row beds, but a single coulters still gave significant control

Confidor® Guard (imidacloprid 350 g/L suspension concentrate) is registered for control of greyback canegrub in plant crops by application into the planting furrows from planting time to final hill-up. Application rates vary between 11 and 22 mL/100 m of row depending on pest pressure and time of application.

Results are available for one trial in dual rows.

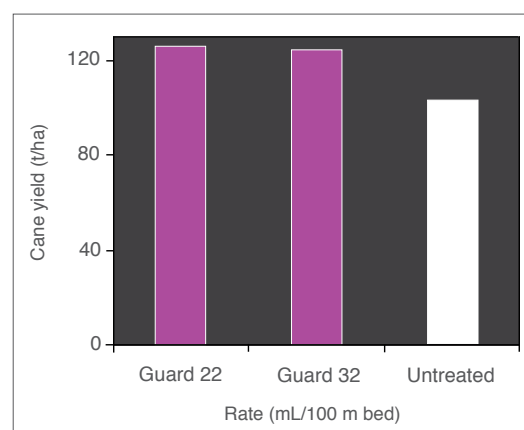
Double-disc opener planter, dual rows 500 mm apart at 1.8 m centres, Proserpine



Graph 13 | Greyback canegrubs in a plant crop near Proserpine – Confidor® Guard applied in dual rows with a double-disc opener planter.

A trial of Confidor® Guard in dual rows was planted near Proserpine in September 2006, using a double-disc opener planter at 1.8 m centres. The diluted insecticide was squirted from a simple orifice onto the soil between the discs. Numbers of greyback grubs in the plant crop were significantly reduced by Confidor® Guard at 22 and 32 mL/100 m of bed, with no significant difference between the two rates, as in Graph 13. Numbers of canegrubs were too low for plant crop yield to show the benefit of treatment.

The trial was only lightly infested with canegrubs in the first ratoon – 0.4 grubs/stool in untreated plots – and grub numbers were not significantly affected by the insecticide treatments. However, cane yield of the first ratoon was significantly increased by both rates of Confidor® Guard that had been applied at planting - see Graph 14.



Graph 14 | First-ratoon harvest yield.

There were significantly more gaps after the first ratoon harvest in untreated plots than in plots that had received Confidor® Guard at planting.

Conclusion

Confidor® Guard applied into dual rows at planting in September protected the plant crop when applied at 22 mL/100 m of bed - the same rate as the highest registered rate per 100 m of row in single rows. Yield was improved in the first ratoon, possibly reflecting reduced root damage in the first year.

Greyback canegrub - Confidor® Guard, coulters

Confidor® Guard is registered for control of greyback canegrub in ratoon crops by application using one or two coulters at 16-22 mL/100 m of row, equivalent to 1.05-1.44 L/ha for single-row cane with 1.52 m spacing between rows.

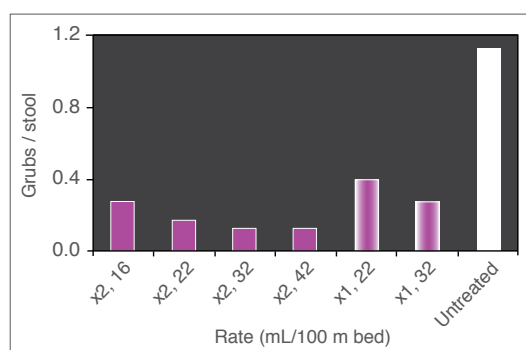
Efficacy data using coulters in dual rows are available from two trials.

Dual rows 500 mm apart at 1.8 m centres, Proserpine - plant cane

The first trial was done in 2006 in dual rows at a 1.8 m spacing that had been planted with a double-disc opener planter in September.

Confidor® Guard was applied to the plant crop in December. Either two coulters 400 mm apart or a single coulters were used, centred on the beds and running 100-150 mm deep. Four rates of Confidor® Guard were applied using the twin coulters and two rates using the single coulters.

By May 2007, numbers of greyback grubs were significantly reduced in all Confidor® Guard treatments in the plant crop. Twin coulters were slightly more effective than a single coulters at the rates of 22 and 32 mL/100 m of bed – see Graph 15.



Graph 15 | Greyback canegrubs in May after treatment of a dual-row plant crop with Confidor® Guard the previous December using either twin coulters (x2 in figure) or a single coulters (x1).

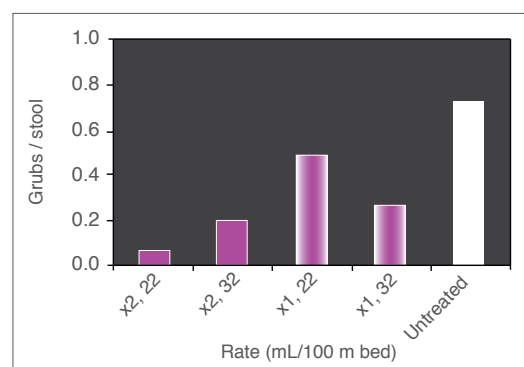
Measured yields were greater in plots treated with Confidor® Guard than in untreated plots in both the plant crop and first ratoon but were very variable because of harvesting difficulties, and differences between treatments were not statistically significant.

Dual rows 500 mm apart at 1.8 m centres, Proserpine - ratoon cane

In the second trial, dual rows that had been planted with a double-disc opener planter in 2006 were treated with Confidor® Guard using coulters in the second ratoon in November 2008.

Either two coulters 500 mm apart or a single coulters were used, centred on the beds and running 100-150 mm deep. Two rates of Confidor® Guard were applied using each configuration.

Numbers of greyback canegrubs the following May were significantly reduced by Confidor® Guard at 22 mL/100 m of bed (two coulters) and 32 mL/100 m of bed (one coulters). There was no statistical difference between results using one or two coulters although, as in the previous trial, two coulters seemed more effective – see Graph 16.



Graph 16 | Greyback canegrubs in May after treatment of a dual-row ratoon crop with Confidor® Guard the previous November using either twin coulters (x2 in figure) or a single coulters (x1).

Conclusion

The higher application rate of Confidor® Guard currently registered for application using coulters in single-row cane, 22 mL/100 m of row, was effective in dual rows at the same rate per 100 m of bed.

Two coulters were slightly more effective than a single coulters in dual rows.

Greyback canegrub - BioCane™

Summary

- BioCane™ did not control greyback canegrubs in plant cane when applied directly from a double-disc opener planter, in one trial
- Distribution of BioCane™ granules in soil may have been unsuitable; the fungicide used at planting was probably not responsible for this poor result
- Other application systems that obtain a better spread of BioCane™ granules in beds may be more effective
- There is potential for use of BioCane™ in permanent beds

BioCane™ (Image 14) is a biological product containing isolate FI-1045 of the fungus *Metarhizium anisopliae*. The spores of this fungus are able to infect and kill greyback canegrubs. Dead canegrubs then produce more spores that can infect other canegrubs. The BioCane™ product contains spores grown on rice which can be added to soil to start an infection cycle in canefields.



Image 14 | BioCane™.

BioCane™ is registered for control of greyback canegrubs in conventional planting systems at a rate of 33 kg/ha or 500 g/100 m of cane row (single rows).

BioCane™ can be applied from conventional planters, as previous work showed that the fungicides used at planting did not cause long-term harm to the fungal spores.

To test compatibility on double-disc opener planters, we applied BioCane™ granules at the same time as the billets were sprayed with several commonly used fungicides. Numbers of spores in soil were not significantly different when fungicides were used compared with water alone – see Table 7.

Table 7 | Numbers of live *Metarhizium* spores ($\times 10^4$ per gram of soil), 5 months after BioCane™ was applied in combination with different fungicides using a double-disc opener planter.

Shirtan®	Sportak®	Bumper®	Nil
11.0	46.0	11.6	24.9

However, when we applied BioCane™ in a field trial against greyback canegrub using a double-disc opener planter, results were disappointing. Two rates were used in dual-row beds, 600 and 1000 g/100 m of bed or 33 and 56 kg/ha; poor control was achieved in the plant crop and yields were not increased in the first ratoon.

A wider band of BioCane™ granules may be more effective. An option being used on the Granshaw farm in the Burdekin is to treat dual rows (800 mm apart in beds at 2.0 m centres) by applying bands across conventional furrows at 40 kg/ha during fill-in. BioCane™ is applied between 5 and 10 in the morning and immediately covered with soil – see Image 15. We measured greater numbers of *Metarhizium* spores in first-ratoon beds treated by this method than in neighbouring untreated ratoons. We have not assessed effectiveness against canegrubs, but canegrubs seem to be under control on this farm.

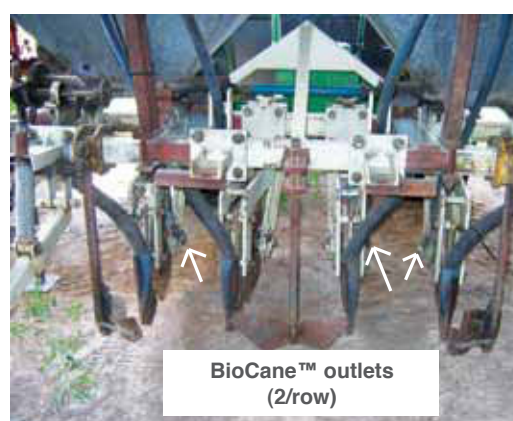


Image 15 | Implement used in the Burdekin (Granshaw farm) for applying BioCane™ in dual rows.

In permanent-bed systems, there is potential for maintaining elevated levels of the *Metarhizium* fungus between crop cycles if tillage is minimised.

Childers canegrub - suSCon® Maxi

Summary

- suSCon® Maxi was effective against Childers canegrub in dual rows when applied at fill-in of conventional planting furrows; no results are available for double-disc opener planters
- The current application rate of suSCon® Maxi against Childers canegrub, 150 grams per 100 metres of single-row bed, was also effective for dual-row beds, even though the granules were spread over two rows. This equates to a lower rate per hectare due to the wider bed spacing in a dual-row system (eg 8.3 kg/ha in beds at 1.8 m centres)

suSCon® Maxi is registered against Childers canegrub in conventional planting systems at a rate of 10 kg/ha, or 150 g/100 m of row, for 3-year protection from root damage.

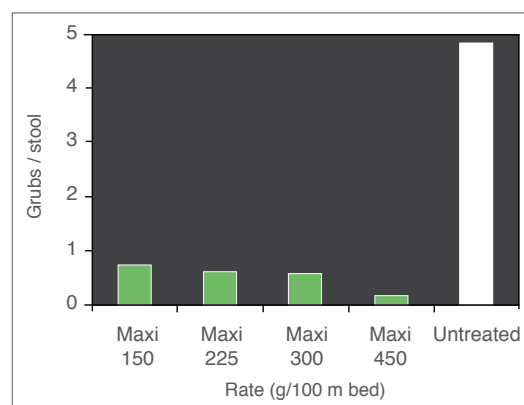
Efficacy data for suSCon® Maxi against Childers canegrub in dual rows are available from one trial in conventional planting furrows. No data were obtained from trials with double-disc opener planters.

Conventional dual furrows 800 mm apart at 2.1 m centres, Isis

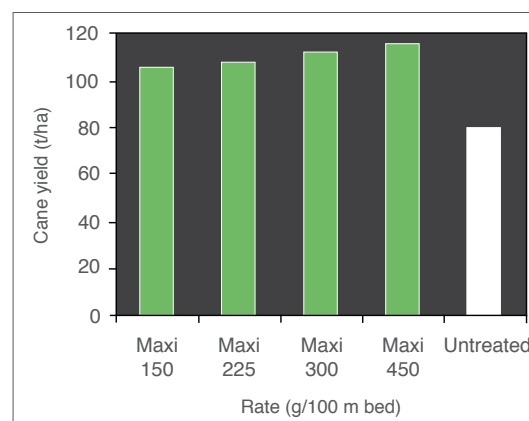
Dual rows were planted in September 2006 in conventional furrows. suSCon® Maxi granules were then applied in November in bands about 15 cm wide in the planting furrows and covered with soil.

Numbers of Childers canegrubs in the young second ratoon in December 2008 were significantly reduced by all rates of suSCon® Maxi down to 150 g/100 m of bed, and cane yields were significantly increased at the next harvest – see Graphs 17 and 18.

Numbers of canegrubs did not differ significantly among treatments in the young third ratoon in November 2009.



Graph 17 | *Childers canegrubs in a young second-ratoon crop near Childers – suSCon® Maxi applied in dual conventional furrows at fill-in.*



Graph 18 | *Second-ratoon harvest yield.*

Conclusion

The application rate of suSCon® Maxi registered for Childers canegrub in single rows, 150 g/100 m of row, was effective in dual rows when this rate was applied per 100 m of bed, split between the two duals at fill-in.

Protection was measured up to the second-ratoon crop, which agrees with the current registration for 3 years' protection against root damage by Childers canegrubs.

Childers canegrub - Confidor® Guard, fill-in

Summary

- Confidor® Guard was effective against Childers canegrub when applied to dual, conventional planting furrows at 17 mL per 100 metres of dual-row bed, at fill-in

Confidor® Guard (Image 16) is registered for plant crops against Childers canegrub in conventional planting systems at rates of 11-16 mL/100 m of cane row, equivalent to 0.72-1.05 L/ha for single-row cane with 1.52 m spacing between rows.



Image 16 | Confidor® Guard.

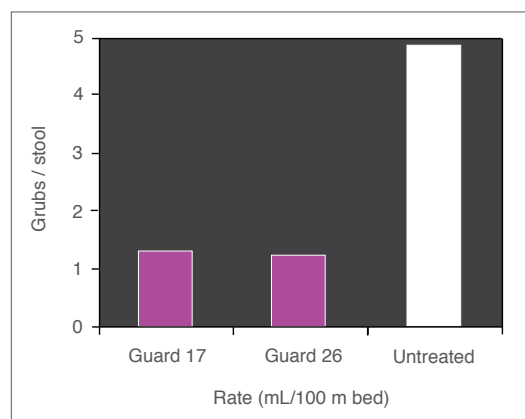
Efficacy data for Confidor® Guard against Childers canegrub in dual-row plant cane are available from one trial in conventional planting furrows. No results were obtained for double-disc opener planters.

Conventional dual furrows 800 mm apart at 2.1 m centres, Isis

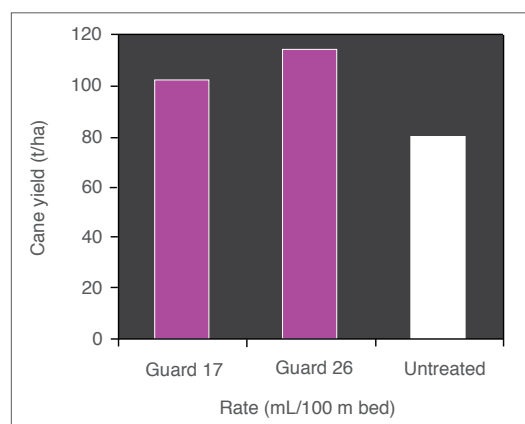
Dual open furrows were planted in September 2006 and Confidor® Guard was then applied in November in bands about 15 cm wide into the open furrows and covered with soil.

Numbers of Childers canegrubs in the young second ratoon in December 2008 were significantly reduced

by 17 and 26 mL of Confidor® Guard per 100 m of bed and cane yields were significantly increased at the next harvest – see Graphs 19 and 20.



Graph 19 | Childers canegrubs in a young second-ratoon crop near Childers – Confidor® Guard applied in dual conventional furrows at fill-in.



Graph 20 | Second-ratoon harvest yield.

Numbers of canegrubs did not differ significantly among treatments in the young third ratoon in November 2009.

Conclusion

Confidor® Guard was effective against Childers canegrub in dual rows when applied at 17 mL/100 m of dual-row bed at fill-in. This is similar to the current high label rate of 16 mL/100 m of single-row bed.

Protection seemed to remain effective for 12-14 months.

Childers canegrub - Senator[®], coulters

Summary

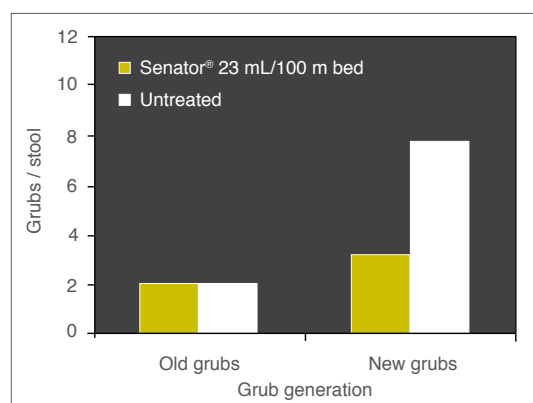
- Senator[®] was effective against Childers canegrub when applied in a dual-row ratoon using twin coulters
- The application rate tested was 23 mL per 100 metres of dual-row bed; the currently registered rate against Childers canegrub in single rows is 11-16 mL per 100 metres of bed
- Senator[®] was more effective at controlling the next year's generation of grubs than the generation present and feeding at the time of treatment

Senator[®] (imidacloprid 350 g/L suspension concentrate) is registered for coulters application against Childers canegrub at rates of 11-16 mL/ 100 m of cane row, or 0.72-1.05 L/ha for single-row cane with 1.52 m spacing between rows. Results are available for one trial in dual rows.

Dual rows 500 mm apart at 1.8 m centres, Isis

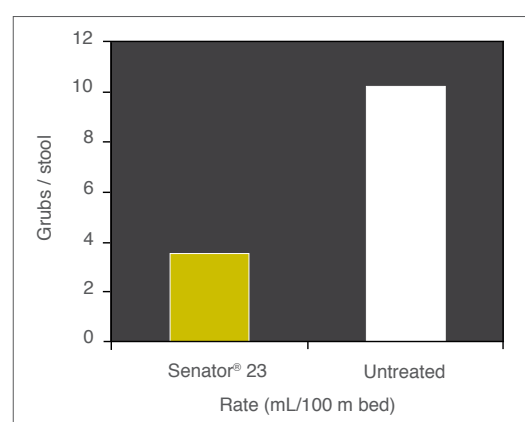
A dual-row third-ratoon crop was treated with twin coulters (300 mm apart and 125 mm deep) in November 2006. Senator[®] was applied at 23 mL/100 m of bed.

In March 2007 there were two generations of Childers canegrubs in the trial, from eggs laid 1 year apart. Senator[®] was not very effective against the older (third-stage) grubs – there were two grubs/stool in both treated and untreated plots – but significantly reduced numbers of the new generation (first- and second-stage grubs) - see Graph 21.

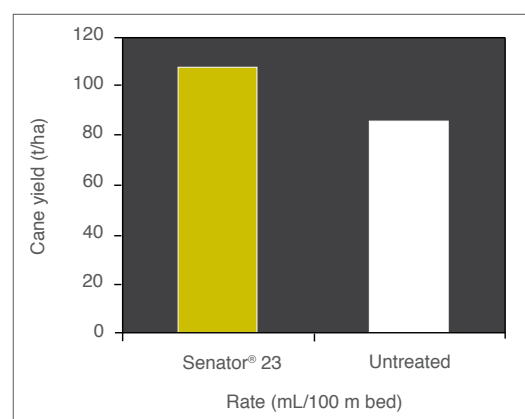


Graph 21 | Childers canegrubs in March after treatment of a dual-row ratoon crop with Senator[®] using twin coulters the previous November.

By November 2007, the grubs that were the old generation in March had turned into pupae or beetles while those that had been young first- and second-stage grubs in March were now large third-stage grubs capable of causing serious damage. Numbers of these grubs were significantly reduced by Senator[®] applied the previous year, and cane yield was significantly increased at the 2008 harvest – see Graphs 22 and 23.



Graph 22 | Childers canegrubs in November 2007 after treatment of a dual-row ratoon crop with Senator[®] using twin coulters in November 2006.



Graph 23 | Cane yield the following year (2008).

Conclusion

Senator[®] was effective against Childers canegrub when applied to a ratoon crop using twin coulters at 23 mL/100 m of dual-row bed. Senator[®] was most effective against the next generation of canegrubs which developed following the beetle flight in spring, rather than the large grubs present at the time of treatment.

Southern 1-year canegrub - Confidor® Guard, coulters

Summary

- Confidor® Guard was effective against southern 1-year canegrub when applied in a dual-row ratoon using twin coulters
- The current high application rate of Confidor® Guard against southern 1-year canegrub, 16 mL per 100 metres of single-row bed, was also effective for dual-row beds
- Significant control was obtained using either one or two coulters, although we believe that twin coulters (stool-splitting) are more effective in dual rows

For control of southern 1-year canegrub in ratoon crops, Confidor® Guard is registered for coulters application at rates of 11-16 mL/100 m of cane row, equivalent to 0.72-1.05 L/ha for single-row cane with 1.52 m spacing between rows.

Results for coulters in dual rows are available for one trial against southern 1-year canegrub.

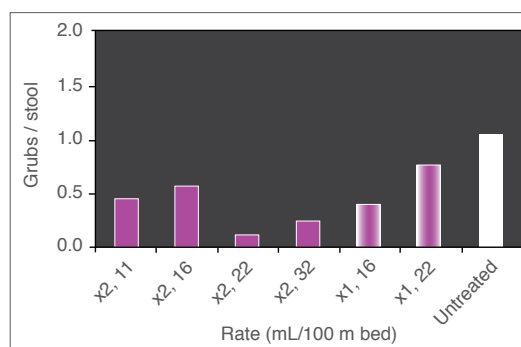
Dual rows 500 mm apart at 1.8 m centres, Bundaberg

Confidor® Guard was applied to a third-ratoon crop in November 2006. Either two coulters 500 mm apart (stool-splitting) or a single coulters were used, centred on the beds and running 150 mm deep. Four rates of Confidor® Guard were applied using the twin coulters and two rates using the single coulters.

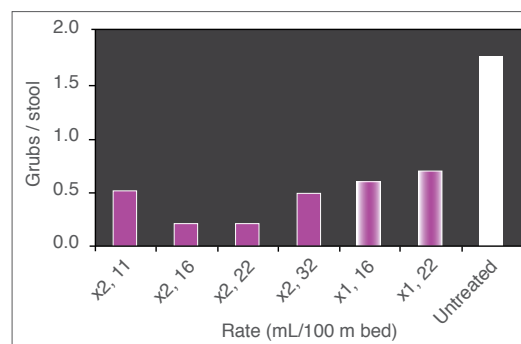
Numbers of southern 1-year canegrubs in April 2007 were significantly reduced by Confidor® Guard at 22 and 32 mL/100 m of bed using twin coulters and 16 mL/100 m of bed using a single coulters – see Graph 24.

Numbers of southern 1-year canegrubs again differed significantly among treatments in March of the following year (2008), with most Confidor® Guard treatments (including 16 mL/100 m from twin coulters) having significantly fewer grubs than untreated controls – see Graph 25.

Cane yield did not differ among treatments, probably because grub numbers were low even in untreated plots.



Graph 24 | Southern 1-year canegrubs in April after treatment of a dual-row ratoon crop with Confidor® Guard the previous November using either twin coulters (x2 in figure) or a single coulters (x1).



Graph 25 | Southern 1-year canegrubs in March, 2 years after treatment of a dual-row ratoon crop with Confidor® Guard in November using either twin coulters (x2 in figure) or a single coulters (x1).

Conclusion

The higher application rate of Confidor® Guard registered for southern 1-year canegrub in single rows, 16 mL/100 m of row, was effective in dual rows when applied per 100 m of bed.

The difference in results between single and twin coulters, although not statistically significant, is similar to that measured for Confidor® Guard against greyback canegrub, and suggests that twin-coulters application is the more effective method.

Monitoring greyback canegrubs

Summary

- Greyback canegrubs can be monitored in canefields from February to April-May
- Root pruning and gouging of stools will confirm that damage symptoms in standing crops (yellowing, lodging) and after harvest (gaps) were due to presence of grubs earlier in the year
- Canegrub numbers and damage in the current year indicate likely infestation levels in the next year

The aim of a monitoring program is to collect sufficient information on current grub status and trends to allow informed decisions on future canegrub management.

Monitoring allows growers to avoid incorrect decisions where:

- Fields that should have been treated for canegrubs are not, and cane is lost; or
- Fields that did not need treatment are treated anyway, and money is wasted.

Monitoring could involve counting numbers of canegrubs, checking for signs of their presence (damage), or (ideally) both.

Greyback canegrubs, which have a 1-year life cycle, can be monitored in fields once they are large enough to be found under cane stools, usually in February (Burdekin), March (north Queensland) or April-May (central Queensland). Timing is important: too early and grubs will be small and hard to find; too late and some may have moved away from the stools or been killed by diseases. In either case the result may be misleading.

Damage can be assessed as visible symptoms in cane before harvest – yellowing, lodging – and as gappy ratoons after harvest. Although the canegrubs may have moved away by then, root pruning and gouging of stubble will help confirm that cane symptoms were caused by grub damage.

The results of these observations or measurements come in too late to prevent damage in the current crop, other than indicating a change of harvest schedule to minimise cane loss.

However, this does not mean that monitoring, and particularly grub sampling, is not worthwhile. Monitoring in the current year is **essential** for deciding what to do to prevent damage the next year.

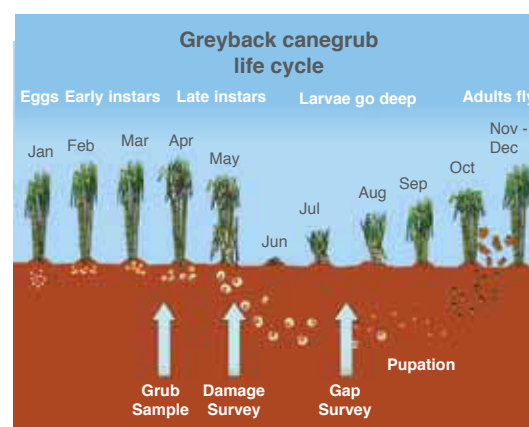


Diagram 1 | Timing of monitoring and damage assessment for greyback canegrub in sugarcane (central district).

Given sufficient information for the current year, it is possible to predict risk from canegrubs in individual fields for the next year. Such predictions are not perfect, but they are better than arriving at management decisions by guesswork alone.

Using monitoring data from 2003 to 2006, we developed models to predict risk from greyback canegrubs 1 year ahead. We then tested the prediction system in collaboration with grower groups at Mulgrave and Mackay during 2008 and 2009.

Results from Mackay are given on the next page for a model which predicts the infestation intensity – light (fewer than 0.5 grubs per stool), moderate (0.5-2 grubs per stool) or heavy (more than 2 grubs per stool). Light infestations should not have an appreciable effect on crop productivity, moderate infestations will reduce yield and ccs while heavy infestations may necessitate plough-out after harvest.

Predictions generally matched what actually happened, as shown for 2009 in Table 8. The only errors were on the conservative side, that is, there were no fields that had a much heavier infestation than expected. Of 22 fields predicted to have a light (or zero) infestation in 2009, all were indeed light. Of 11 fields predicted to have a moderate infestation, three were moderate while eight were light. Of five fields predicted to have a heavy infestation, two were moderate and three were light.

Importantly, then, decisions were also on the conservative side, favouring more treatment than necessary but avoiding unexpected cane damage.

Table 8 | Number of canefields falling into predicted and observed greyback canegrub infestation classes near Mackay in 2009; 38 fields total.

Observed class	Predicted class		
	Light	Moderate	Heavy
Light	22	8	3
Moderate	0	3	2
Heavy	0	0	0

The most important indicators for predicting numbers of greyback canegrubs next year were:

- Estimates of grub density in the current year in individual fields and across the district
- Presence of damage in the current year in each field and in neighbouring fields

Additional predictors were the status of the crop – whether it was a plant crop or ratoon, fallow or replant, protected by insecticide or not – and the level of the grub disease *Adelina* across the district.

Tall cane at the time when beetles are flying is also at greater risk of greyback canegrub attack, particularly where cane is cut early for plants.

More detail on monitoring and risk assessment for greyback canegrub (see Diagram 2) is available in the GrubPlan 2007 booklet, available on the BSES website (bses.com.au).

Prediction systems are still under development for greyback canegrubs, and models will be continuously fine-tuned. Up-to-date information can be obtained from BSES entomologists.

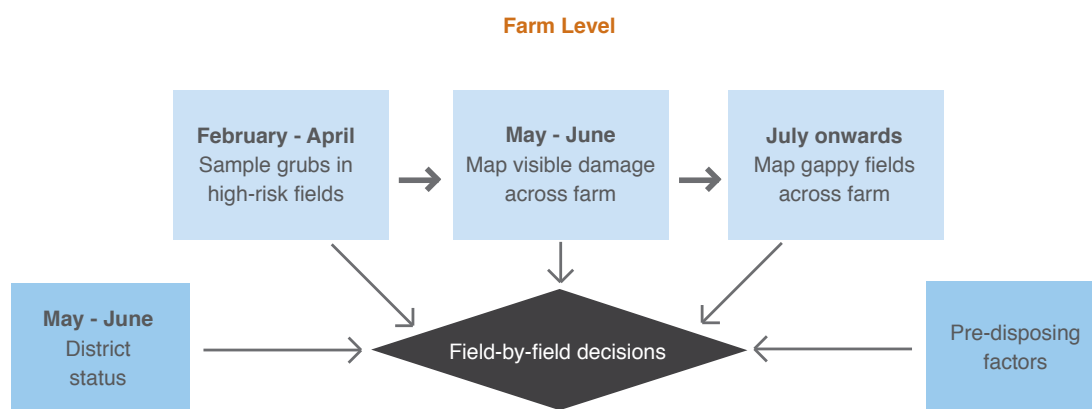


Diagram 2 | Monitoring and risk assessment for greyback canegrub.

Monitoring canegrubs in southern Queensland

Summary

- Fields can be monitored in autumn to allow time to plan for grub management strategies in spring
- Autumn numbers of Childers canegrub agree well with numbers in the following spring-summer; the same applies to other 2-year species
- Although autumn numbers of southern 1-year canegrub do not directly indicate numbers the next season (because of the 1-year life cycle), infestations tend to increase from year to year
- A sampling plan and action thresholds are suggested on pages 21 and 22

As with greyback canegrub, monitoring of canegrubs in southern Queensland allows growers to plan canegrub management and make timely and informed management decisions.

Here we focus on the two most problematic canegrubs in southern Queensland, Childers canegrub and southern 1-year canegrub, although there are numerous other species, including negatoria, noxia, picticollis and crinita or Bundaberg canegrubs.

Childers canegrub has a 2-year cycle and its damage becomes evident in spring and summer. Southern 1-year canegrub has a 1-year cycle (similar to greyback canegrub) and damages cane in late summer or autumn.

They also have very different raster patterns which are different again from those of the other species in the district, and from harmless organic-matter feeders with no pattern. A leaflet depicting the raster patterns on all southern canegrubs is available from BSES Limited.

Childers canegrub

Recently we have been testing a monitoring system which relies on sampling Childers canegrubs in standing cane in autumn and early winter – see Diagram 3.

This is to overcome the main drawback of the past system of monitoring for grubs or signs of damage in ratoons during spring, after harvest. By that time there is little scope for planning the best management strategies, and significant crop damage may have occurred by the time grubs are detected.

Also, treatments with liquid imidacloprid (Confidor® Guard, Senator®, etc) are most effective against Childers canegrub if applied early in the grub's life cycle and soon after the standing crop is harvested. Early detection is vital to get the best result.

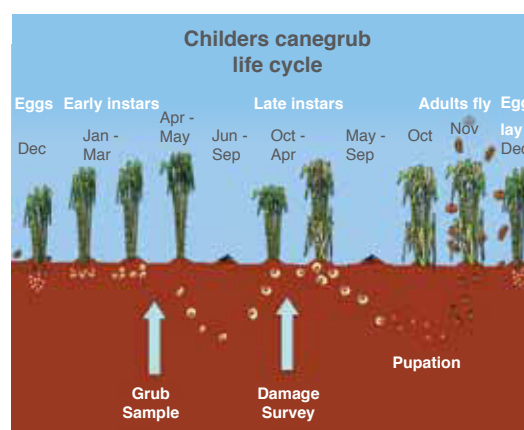


Diagram 3 | *Timing of monitoring and damage assessment for Childers canegrub.*

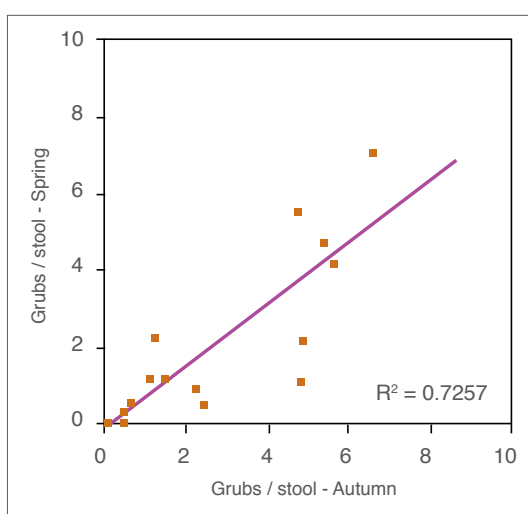
Detection of grubs in autumn gives plenty of opportunity to decide on the most cost-effective option (treat or not treat, or fallow-crop) and to coordinate harvest date with the chosen treatment option as well as other cropping activities such as fertilising, irrigation and weed management.

Large numbers of Childers canegrubs in autumn indicate a strong need to harvest that block reasonably early and then to treat it immediately, or to develop an alternative cropping plan.

The system was first tested in 2005. Autumn sampling was carried out in April-May, when most of the 2005-generation larvae had reached their final (third) stage; mature grubs from the 2004 generation were also present in smaller proportions. Summer sampling started in early December. There was a moderately good relationship between Childers grub numbers in autumn and the following summer. This was repeated in other fields in 2006, with good correlation between autumn and spring sampling – see Graph 26 on page 21. The sampling program was again validated in 2007.

Sampling in autumn or early winter identified:

- Grub-infested fields where insecticide treatment or alternative management or cropping plans may be needed
- Fields with a very low risk of damage in the coming spring, and not needing treatment



Graph 26 | Relationship between numbers of Childers canegrubs counted in canefields in autumn and the following spring-summer, 2006.

Significantly, there were no serious false negatives, ie fields with more grubs in spring than expected. There appeared to be several false positives, indicating natural grub mortality or, perhaps, that some grubs matured to adults within 1 year.

Southern 1-year canegrub

Monitoring results for this species with a 1-year life cycle must be interpreted differently from results with Childers canegrub. With southern 1-year canegrub, the grubs counted in autumn are different individuals from those that will damage cane the next season.

However, experience suggests that canegrub numbers usually increase from year to year, so moderate numbers in the current year usually result in higher numbers the next year.

A practical monitoring program

A sampling plan that has so far proved reliable for southern canegrub species is given below.

Only a small number of cane stools need to be sampled to identify infestations that are either very light or very heavy, but more sampling is needed at intermediate grub densities or if numbers of grubs vary greatly between stools.

1. Count grubs under five stools through the field, eg one from each corner and one in the centre.
2. If there are grubs under four or five stools and there is a total of seven or more grubs then the infestation may require attention; stop digging. Calculate average number of grubs per stool.
3. If there are no grubs in five holes then there is no immediate risk; stop digging.
4. If there are fewer than seven grubs and/or grubs were localised in only one or two holes, then dig at least five more holes to obtain an average number per stool.

The risk of future grub damage can be judged by the average number of grubs per stool in the field and also by the risk from beetles flying in from nearby damaged fields. Decisions on grub management then depend on grub risk as well as economic factors – whether or not the crop is already damaged and the number of years the crop is to be kept in the field. Remember, infested fields become a threat to non-infested fields.

A decision-making process for ratoons that uses these criteria is given on page 22.



Image 17 | Canegrubs found during monitoring of ratoons.

Decision-making process for southern canegrubs in ratoons

Little grub damage so far, crop has good ratooning potential

- *If two or more ratoon crops expected after next harvest*
 - More than one grub per stool – treat with imidacloprid next spring - see * below
 - Grubs present but fewer than one grub per stool – do not treat but monitor again next year
 - No grubs – monitor again in 2 years time; or monitor next year if there is a threat from nearby damaged fields (especially if these are to be ploughed-out, which may drive beetles into adjacent fields)
- *If only one ratoon planned after next harvest*
 - Treat with imidacloprid next spring if numbers exceed these thresholds
 - > Childers and Bundaberg canegrub, three new-generation grubs per stool
 - > Negatoria canegrub, 1.5 new-generation grubs per stool
 - > Southern 1-year canegrub, one grub per stool

Crop already significantly damaged

- A damaged crop may not be able to give an economic response to insecticide treatment; a fallow or break-crop rotation strategy may provide greater and longer-term benefit

-
- * One grub per stool may not cause measurable damage to the next ratoon but experience shows that such a population is likely to increase sharply after the next beetle flight in the coming summer, leading to damage in subsequent ratoons. Preventive application of liquid imidacloprid at the start of the next generation seems to give greater benefit than waiting until the following spring to treat.

Conclusion

The components of ‘new farming systems’ – legume rotations, controlled traffic and reduced tillage – are compatible with good canegrub management. Natural control of canegrubs may be enhanced by adoption of these practices.

Existing insecticides are effective in dual rows and/or in narrow bands from double-disc opener planters. We did not test insecticides in all of the planting systems being adopted. For example, many growers are planting controlled-traffic systems (usually a bed spacing of 1.8 m or greater) using a wide planting chute rather than dual rows. However, our results suggest that existing insecticide recommendations are robust, despite changes in planting systems.

Efforts are underway to alter registered insecticide recommendations on product labels to reflect newer planting systems.

Monitoring of canegrubs or signs of their presence (visible damage to cane, gappy ratoons) can, and should be used to achieve better targeting of insecticide application in all farming systems. The availability of an effective treatment (liquid formulations of imidacloprid) for ratoons means that growers have considerable flexibility in their grub-control program if they adopt a monitoring strategy.

This booklet summarises current knowledge on canegrub management in new farming systems. Additional information will be collected as more growers adopt different agronomic practices.



Image 18 | *Negatoria canegrub* in cell.

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