Queensland Government

Sugar Research Australia

GREYBACK CANEGRUB MANAGEMENT

BAYER CANEGROWERS Australian Cane Farmers Nufarm

This booklet is an updated version of the BSES publication GrubPlan 2012, originally authored by Peter Samson, Keith Chandler and Nader Sallam.

Considerable changes have occurred since then, most noticeably the almost total reliance on the insecticide imidacloprid for canegrub control, and much heightened scrutiny of the impact of all pesticides on water quality.

This booklet deals only with greyback canegrub, *Dermolepida albohirtum*. This is the major species occurring from Plane Creek north to Mossman.

This publication has been produced as part of the project *Reviving GrubPlan to ensure appropriate use and application of imidacloprid for control of cane grubs.* This project is a collaboration between Sugar Research Australia Limited, the Queensland Department of Agriculture and Fisheries, CANEGROWERS, the Australia Cane Farmers Association, Bayer Crop Science and Nufarm Limited. It is funded by the Queensland Reef Water Quality Program through the Enhanced Extension Coordination project.

We acknowledge the contributions to this publication by the following:

Bayer Crop Science

Burdekin Productivity Services Limited

Farmacist Pty Ltd

Herbert Cane Productivity Services Limited

Mackay Area Productivity Services limited

Mossman Agricultural Services Limited

Nufarm Limited

Plane Creek Productivity Services Limited

Sugar Research Australia Limited

Sugar Services Proserpine Limited

Sugar Research Australia Limited

Brisbane Office 50 Meiers Road, Indooroopilly QLD 4068 Australia
Postal Address PO Box 86 Indooroopilly QLD 4068 Australia

T 07 3331 3333
E sra@sugarresearch.com.au
sugarresearch.com.au

ISSN 2203-7705 (Print)

INTRODUCTION

Sustainable canegrub management

Canegrubs are currently the major economic pest of sugarcane in Australia.

With the advent of water quality monitoring in most Queensland sugarcane production regions (Reef 2050 Water Quality Improvement Plan), the environmental impact of using pesticides has come under increasing scrutiny.

Use of the insecticide imidacloprid is currently the main method of canegrub control. In many catchments, imidacloprid concentrations in local waterways often exceed the guideline value for protection of aquatic organisms. The guideline concentration value to protect 95% of freshwater aquatic organisms in Queensland is 0.11 micrograms per litre (0.11 µg/L or 0.11 parts per billion) imidacloprid.

In late 2019 the Australian Pesticides and Veterinary Management Authority (APVMA) also began a review of neonicotinoid insecticides, which includes imidacloprid. At the time of publication, it is not yet clear what label changes will eventuate.

It is timely for all production sectors of the sugar industry to review how chemical control of canegrubs is managed.

Continued access to chemical control for canegrubs may well depend on growers, advisors and agribusiness pulling together to ensure insecticides are only used when necessary and are applied correctly.

Imidacloprid

The insecticide imidacloprid has been the mainstay of canegrub management since its introduction to sugarcane in 2001.

Imidacloprid is a very effective insecticide and belongs to the neonicotinoid group of compounds.

It is a systemic insecticide meaning it is also taken up by cane roots. It primarily works by impacting the canegrub's nervous system.

Mode of action

- Absorption into the canegrub's body by direct contact as they move through treated soil
- Ingestion when canegrubs consume treated soil
- Ingestion when canegrubs eat roots that have taken up imidacloprid through its systemic action
- Imidacloprid also has an anti-feeding effect, meaning canegrubs will move away from the treated root zone. As they limit their feeding on cane roots, they become stunted and either die or fail to complete pupation.

Degradation

Imidacloprid is not affected by high soil pH. It can therefore be used in both alkaline and acidic soils with no detrimental effects on performance.

Imidacloprid is also compatible with conventional liming and mill mud practices.

Imidacloprid has a low vapour pressure, so there is negligible loss through volatilization; however the product needs a minimum 100 mm of soil cover for UV protection and to ensure it remains in the correct location.

Formulations

For sugarcane, imidacloprid comes in two formulations:

1. controlled release granule (suSCon maxi Intel®)
2. suspension concentrates (SC) (e.g. Confidor® Guard, Nuprid® 350 SC). These are commonly called liquid formulations.

suSCon maxi Intel is applied directly as a granule into the soil whilst the SC formulation is mixed with water and applied into the soil as a diluted solution.

Both formulations are applied subsurface with precision applicators.

Note: There are many different brands of liquid imidacloprid marketed.

Clothianidin

An alternative insecticide, Sumitomo Shield Systemic Insecticide®, is also registered for greyback canegrub control. The active ingredient is clothianidin (200 g/L). It is also a neonicotinoid and is a suspension concentrate formulation. It is not widely used in sugarcane.

Predictive risk-based treatment decisions

Greyback canegrub has a one-year lifecycle with egg-laying and subsequent canegrub feeding activity taking place when the crop growth stage is too advanced to allow machinery access. It also means that the grubs you see this year, will not be the same grubs infesting your blocks next year - they will be the next generation.

Consequently, this means that insecticide treatments are generally made before eggs are laid, meaning that growers have to anticipate whether or not a canegrub infestation will occur.

CONTENTS

BIOLOGY AND ECOLOGY OF GREYBACK CANEGRUBS

Identification of greyback canegrubs

The greyback raster consists of two nearly straight single rows, each with 20-28 short hairs. The three larval stages, or instars, are distinguished by the size of their head capsule, which gets noticeably larger at each moult. Checking the raster pattern is necessary to distinguish greyback canegrubs from other grubs that may be present, such as French's canegrub.

The adult beetles are large (35 mm long) and have wing covers coloured by a coating of grey scales (which can be rubbed off). The sexes are distinguished by the number of plates on their antennae – the males have five plates and the females have four.

Life cycle of greyback canegrubs

Greyback canegrubs have a one-year life cycle consisting of egg, larva, pupa and adult stages. The cycle begins with eggs being laid between October and February, depending on the district and the seasonal conditions.

Eggs

Eggs are laid in clutches of 23-36 in a soil chamber, at a depth of 220-450 mm. Eggs incubate over 14 days, and hatch with first-instar larvae emerging.

First-instar larvae

First-instar larvae tunnel upwards to feed on organic matter and the roots of sugarcane and grass weeds. After four weeks of feeding, larvae moult to the second instar.

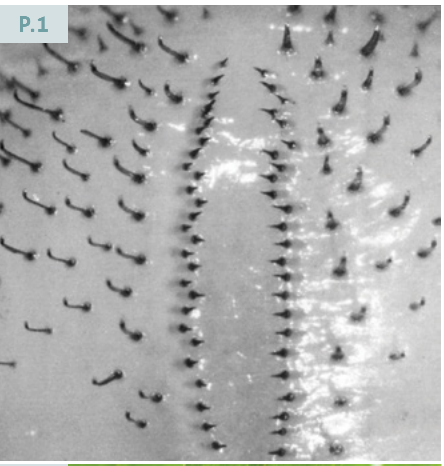
Second-instar larvae

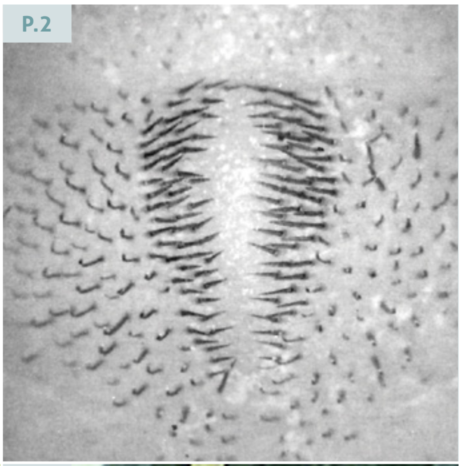
Second-instar larvae aggregate under the stool and feed on cane roots. After five weeks of feeding, the larvae moult to the third instar.

Third-instar larvae

Third-instar larvae cause the most damage to cane. They feed heavily on roots and stool and grow rapidly. Active feeding continues for about four months during the period of February to August, depending on district and s easonal conditions Once the larvae have accumulated

Photo 1 - *Greyback canegrub hair pattern.* ***Photo 2 -*** *French's canegrub hair pattern.*
Photo 3 - *Adult greyback beetle.* ***Photo 4 -*** *Egg cluster – note the match head for size comparison.*

P.1


P.2


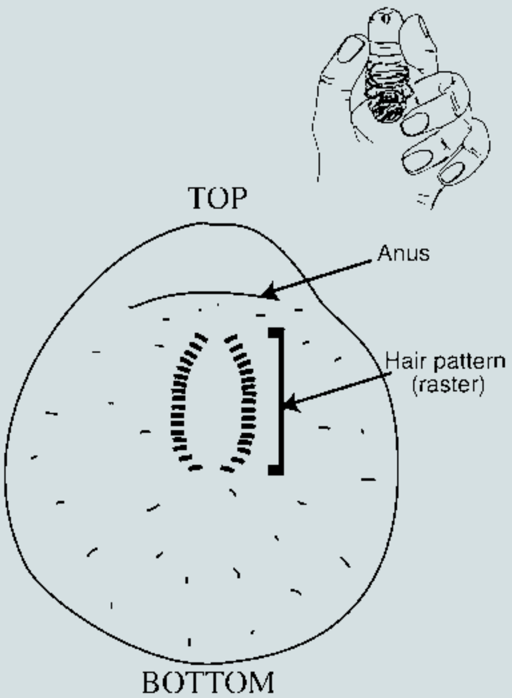
P.3


P.4


F.1

CANEGRUB IDENTIFICATION:

HOLD GRUB TAIL-END FACING YOU WITH ITS HEAD DOWNWARDS. USE THE SHAPE OF THE HAIR PATTERN – TWO SINGLE ROWS – TO DISTINGUISH GREYBACK FROM MOST OTHER NORTHERN SPECIES.



enough fat, they burrow downwards and pupate. The third instar occupies about seven months up to the time of pupation.

Pupae

Pupation occurs between July and October at a depth of 150-400 mm depending on soil moisture and type. The pupal stage lasts about five weeks.

Adults

Adult emergence is dependent on temperature and is triggered by rainfall or irrigation. Emergence usually commences in early October in the Burdekin, but may not begin until December in other districts. Beetles emerge at dusk, crawl around the soil surface and prepare for flight. Flights begin around 7.00 pm and can last for several hours.

Beetles are readily attracted to light. The maximum flight range for adults has been recorded at 1.6 km.

Warm and dark nights tend to favour beetle flights. Beetles settle in taller feeding trees of 4-6 m in height.

Feeding trees include figs, palms, wattles and bananas. However, beetles will also feed on cane leaves when feeding trees are not available. Mating also takes place in the trees. Female beetles may feed for up to two weeks as their eggs mature.

Eggs are laid following dawn flights. Female beetles are capable of laying three clutches of eggs, but most field populations probably lay fewer than this. The lifecycle then starts again as the newly laid eggs incubate.

Photo 5 - *Third instar.* ***Photo 6 -*** *Pupae.* ***Photo 7 -*** *Adult greyback beetles.*
Photo 8 - *Emergence holes of adult beetles.*

P.5

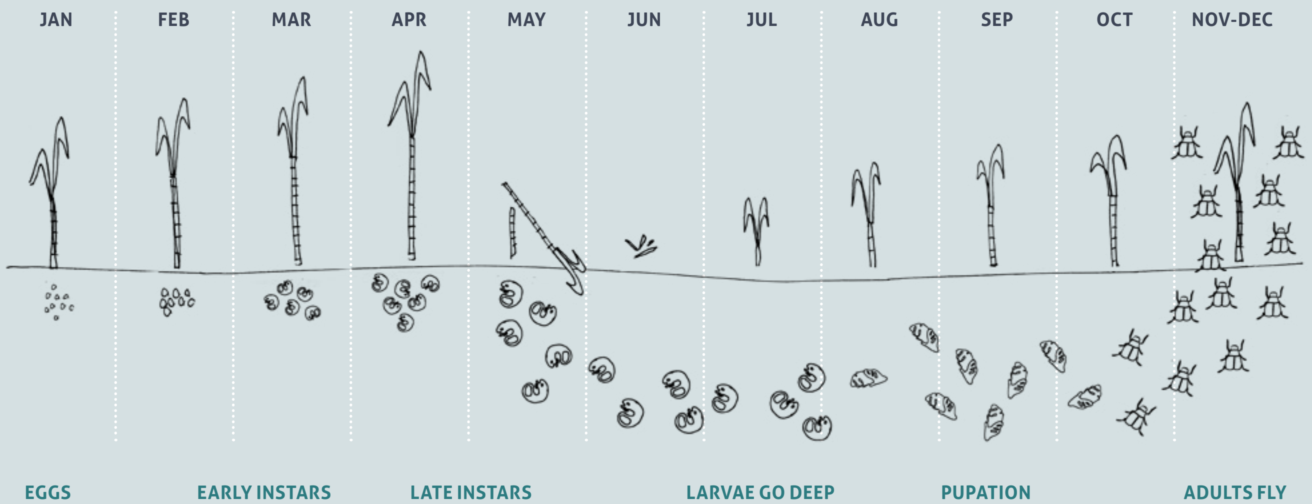

P.6


P.7


P.8


F.2

GREYBACK CANEGRUB LIFE CYCLE



MONITORING AND RISK ASSESSMENT

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

Incorrect decisions could mean:

- fields that should have been treated for grubs are not treated, and cane is lost
- fields that did not need treatment are treated anyway, money is wasted and unnecessary applications may contribute to insecticide contaminating waterways.

Without a monitoring system, decisions on which fields need treatment become largely guesswork.

Research has shown that in almost every case where grub damage occurred in a specific year, grubs were present in those same fields the year before.

In other words, grub damage did not suddenly descend on fields. The signs of grub build-up were there at least one year earlier, although they were often not visible – stools had to be dug to see if grubs were present or not.

P.9

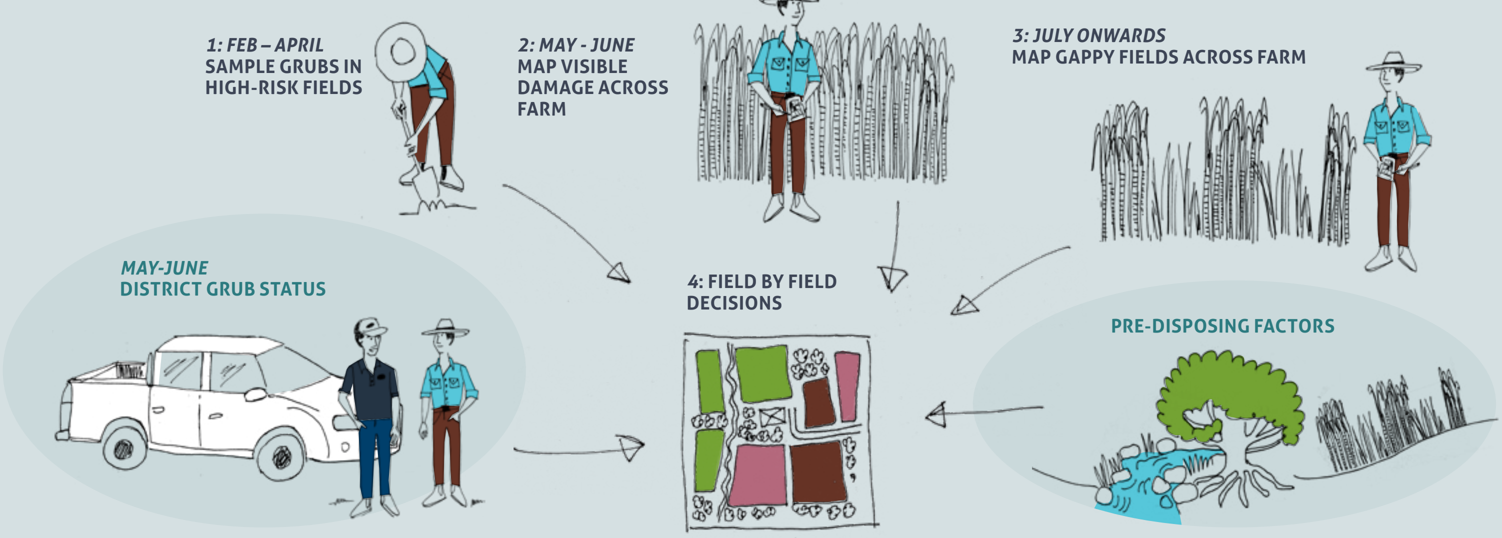
Process

The steps required for a monitoring program that will give growers sufficient information to make good decisions on greyback canegrub management are:

- damage, showing as both visible symptoms in cane before harvest and gaps in ratoons after harvest, should be assessed farm-wide and mapped every year
- in addition, in fields considered at high risk of grub attack, grubs should be sampled to determine the current grub density (dig out cane stools)
- information should be sought on the district-wide grub status. If reliable district information is not available, try to establish canegrub pressure in your immediate neighbourhood
- decisions on grub management for each field should be based on this grub information, together with other factors that may pre-dispose fields to grub attack.

F.3

PROCESS FOR FARM-LEVEL DECISIONS



1. Sample grubs in high risk fields

Knowledge of the number of grubs in a field this year is important in predicting the likely infestation level next year. Other observations such as visible damage are no substitute for actually counting grubs. The presence of visible damage means that numbers of grubs are already too high.

Sampling every block on a farm is neither practical nor necessary. We suggest a multi-stage procedure:

- firstly, identify fields that might be at risk – those susceptible to greyback grubs and not currently protected by insecticide
- secondly, prioritise those fields in order of risk. High-risk fields will be close to fields damaged last year, have a history of damage, be close to creeks and hillsides, or will already show signs of damage
- thirdly, sample a selection of the high-risk fields until a decision can be made to continue sampling additional fields (as long as grubs are being found) or stop.

2. Map visible damage across farm

A map of damage across the farm is extremely valuable and serves many purposes:

- the presence of light damage symptoms in a field may indicate the presence of grubs, which should be checked by examining a few stools for root pruning – these fields may need treatment to prevent damage increasing next year
- the presence of severely damaged fields may indicate the need for a change in harvest scheduling, to minimise crop and stool losses in those blocks
- severely damaged fields will produce beetles later in the year, and so are a major risk factor that determines the need for insecticide treatment of nearby blocks.

A drive along headlands can show up damage symptoms (May-June). Heavy infestation can be confirmed by giving stools the 'pull-test' (i.e. can stools be pulled from the ground by hand, and if so, are the roots pruned and is the stubble gouged: Photo 14).

Good growing conditions, e.g. good soil moisture, may mask crop symptoms, despite grubs being present. This is another reason why it is important to dig up stools in at-risk blocks to access grub populations.

Much more can be seen from the air. Technology is rapidly advancing in the areas of aerial imagery and aerial platforms. Unmanned Aerial Vehicles (UAVs), known as drones, are now available with fitted cameras and user-friendly software. Aerial images can be used to identify areas within cane blocks that may have grub damage. Ground-truthing by sampling those zones is still necessary to confirm that canegrubs are the cause of the problem. Images from platforms like Google Earth can also be used to identify problem areas on a farm or neighbouring property, but ground-truthing is still essential.

Photo 9 - *Crop suffering canegrub infestation.* ***Photo 10 -*** *Canegrubs uncovered after the cane stool is dug out.* ***Photo 11 -*** *Early signs of canegrub damage – note the cane is sprawling and is yellowish.* ***Photo 12 -*** *Advanced signs of canegrub damage – the cane stools are completely tipped out of the ground.*

3. Map gappy fields across farm

Gaps in ratoons may indicate the presence of grubs, particularly if gaps were not present the previous year. If grubs were the cause, then root and stubble damage will be apparent on those stools that remain.

4. Field-by-field decisions

Critical factors in predicting grub infestations next year include:

- field location, history of damage, crop age and insecticide protection
- number of grubs and/or presence of damage in the field this year
- presence and severity of infestations in nearby fields
- grub forecast for the district
- for heavily irrigated districts such as Burdekin farms, time of planting/harvest.

Outside the Burdekin, there is little evidence that time of harvest is a critical risk factor, except where cane is cut early for plants. Early-plant cane may be at greater risk than other crops in all districts because of its greater height and attractiveness during beetle flights.

Given the predicted likelihood of grub infestations next year, the expected return on insecticide treatment depends on economic factors – the expected number of harvests before plough-out, expected yields, the cost of replacing crops if they are prematurely ploughed-out due to damage, the sugar price, and the cost of treatment.

KEY MESSAGES

- **By the time you see visual damage, canegrubs have already established**
- **Unless you monitor you will not know what your infestation risk is, and you will not be able to make an informed decision to treat or not**
- **Unnecessary treatment contributes needlessly to waterway pollution and wastes money**
- **Canegrubs prefer some soil types over others – lighter soils are prone to heavier infestations**
- **Electromagnetic Mapping (EM) mapping is useful in showing where soil type boundaries are on your farm.**

Photo 13 - *Gaps in ratoons are an indication of earlier greyback canegrub activity, but are unlikely to be visible when the crop is ratooning after harvest, so check the remaining root system for root pruning and gouging.* ***Photo 14 -*** *Washed ratoon root system showing damage caused by canegrubs.*

INSECTICIDE FORMULATION OPTIONS

If choosing to treat cane, the first decision growers need to make is whether to use the controlled release formulation (suSCon maxi Intel) or one of the liquid formulations (e.g. Confidor Guard, Nuprid 350 SC)

The decision will depend on canegrub pressure, length of control desired, equipment used and the intended month of application.

Sumitomo Shield Systemic Insecticide is included in the table as it is registered for use in sugarcane, but is not used by growers.

PRODUCT	ACTIVE INGREDIENT	FORMULATION	LENGTH OF CONTROL FOR GREYBACK CANEGRUB	REGISTERED FOR USE IN
suSCon maxi Intel	Imidacloprid	Granule (controlled-release)	up to 4 years	Plant cane
Confidor Guard/Nuprid 350 SC	Imidacloprid	Suspension concentrate	1 year	Plant and ratoon cane
Sumitomo Shield Systemic Insecticide	Clothianidin	Suspension concentrate	1 year	Plant and ratoon cane

F.4

RECOMMENDED TREATMENT WINDOWS FOR PLANT CANE

TIMING OF EGG LAYING DEPENDS ON SEASONAL CONDITIONS

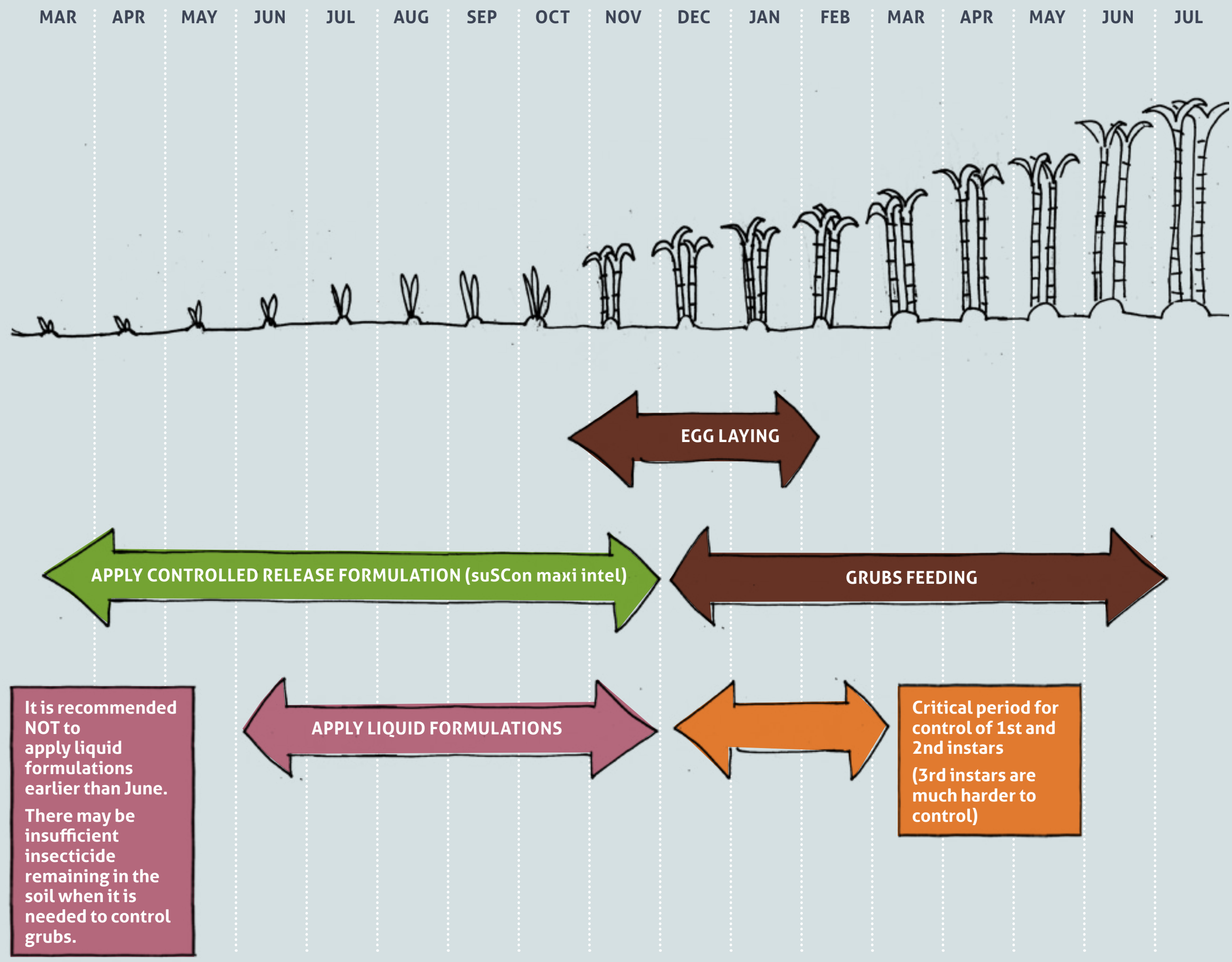
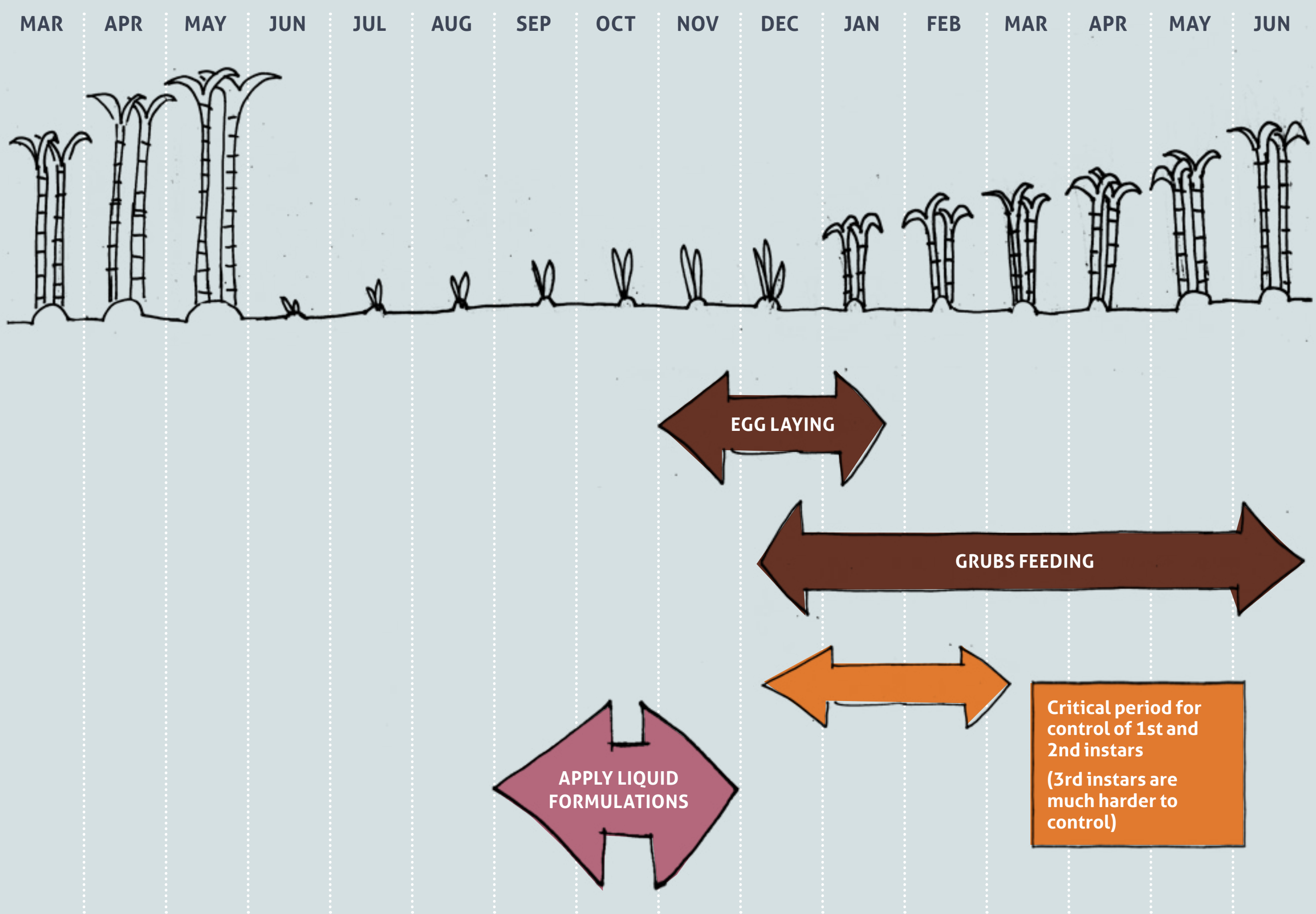


Photo 15 - suSCon maxi Intel granules.

F.5

RECOMMENDED TREATMENT WINDOWS FOR RATOON CANE

TIMING OF EGG LAYING DEPENDS ON SEASONAL CONDITIONS



P.15

suSCon maxi Intel

suSCon maxi Intel is a controlled-release granule containing 50 g/kg imidacloprid. It is registered only for use in plant cane.

Registered rates for greyback canegrub

Conventional planting in single rows

- 150 or 225 g/100 m row

Use the higher rate for high yielding sugarcane crops when heavy infestation is expected.

Dual rows and/or double disc opener planters

- 225 g/100 m of bed

In dual-row beds split the rate between the two duals (112.5 g/100 m row).

Length of control

suSCon maxi Intel provides protection for up to four years against greyback, French's, Childers and Southern one-year canegrubs, up to three years protection for consobrina, Bundaberg and negatoria canegrubs, and up to two years protection against rhopaea canegrub.

Method of application

Conventional planters

Application procedures are as shown for application of suSCon maxi Intel on page 14. suSCon maxi Intel can be applied at any time from planting to drill fill-in, with the preferred timing dependent on the canegrub species being targeted. It is crucial that a consistent band of granules is established 150-200 mm wide and about 150-200 mm below the surface of the completed hill.

Note: check placement of granules in large crops at fill-in stage to ensure granules are not caught in leaf axils or deflected out of the furrow by leaves. The best crop size to apply suSCon maxi Intel after planting is when the main shoots are 300-400 mm in height to the top visible dewlap (TVD).

Double disc opener planters

Granules should be delivered between the discs of either a single- or dual-row planter so they are in a band or bands at least 70 mm wide. In dual rows the registered rate (225 g/100 m of bed) should be split between each pair of discs. Granules should be covered by 100-150 mm of soil when planting is completed.

Calibration

Calibration of application equipment is extremely important to ensure the desired rate of suSCon maxi Intel is applied.

Conducting calibration in the field under normal working conditions is recommended to account for wheel-slip.

For further information on calibration, refer to the Nufarm suSCon maxi Intel® Technical Manual.

Soil cover

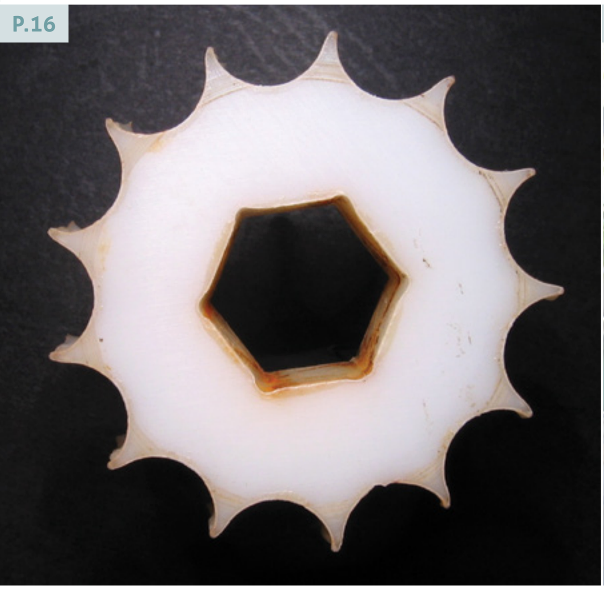
It is very important to cover suSCon maxi Intel granules with at least 50 mm of soil straight after application to prevent loss by photodegradation.

Application systems for suSCon maxi Intel

Microband fluted boxes were commonly used to apply suSCon® Blue (chlorpyrifos based - now discontinued) and suSCon® maxi (imidacloprid based- also discontinued and superseded with suSCon maxi Intel).

Most of these boxes have already been converted to suit suSCon maxi Intel. A replacement flute is needed compared to the old chlorpyrifos products.

P.16

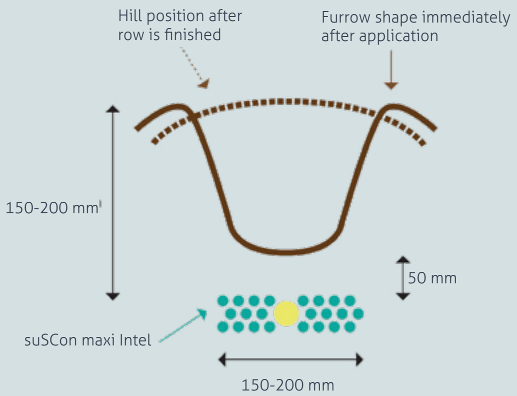


P.17

***Photo 16 -** Replacement flute for Microband box, for use with suSCon maxi Intel.* ***Photo 17 -** Twin hopper delivery system for dual row planter. Application rate is split evenly between the two planted rows on the bed.*

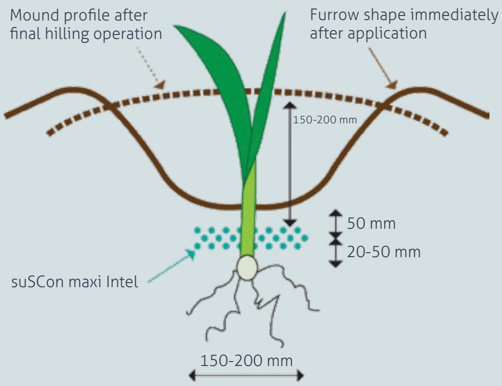
F.6

APPLICATION AT PLANTING (NUFARM AUSTRALIA)



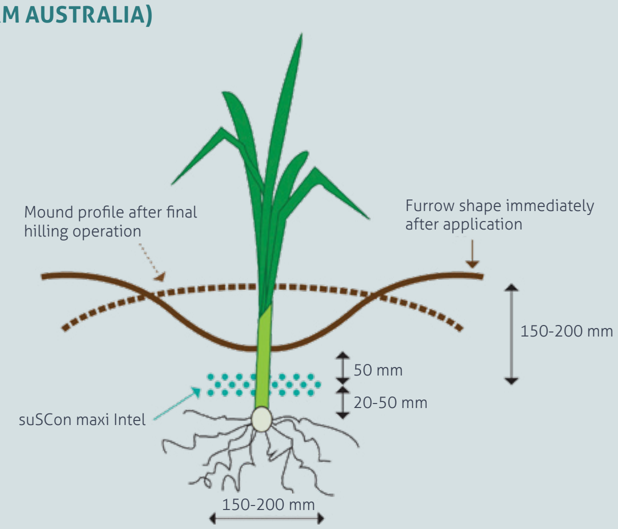
F.7

APPLICATION INTO THE FURROW AT FIRST WORKING (NUFARM AUSTRALIA)



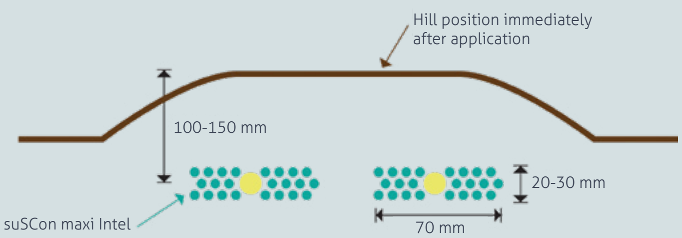
F.8

APPLICATION INTO THE FURROW AT CUTAWAY OR FILL-IN (NUFARM AUSTRALIA)



F.9

EXAMPLE OF DUAL ROW APPLICATION WITH DOUBLE DISC OPENER PLANTER (NUFARM AUSTRALIA)



Application systems for use at planting

Applying suSCon maxi Intel at planting Conventional planters (Figure 6)

Mix granules with incoming soil behind the planter boards to form a layer 20-30 mm deep and 150-200 mm wide across the row. Granules may safely touch the sett.

This method is most suitable where there is 200 mm or less soil above the sett in the finished hilled row, and especially where two-year lifecycle species (such as French's, or negatoria canegrubs) are a major local pest.

Applying suSCon maxi Intel into the furrow at first working (Figure 7)

Apply granules in a band 150-200 mm wide across the centre of the furrow, and 20-50 mm above the sett.

This method is most suitable where planting depth is 170 -200 mm and when both one and two-year lifecycle species are present.

Applying suSCon maxi Intel into the furrow at cutaway or drill fill-in (Figure 8)

Apply granules in a band 150 -200 mm wide across the centre of the furrow and between 50 -150 mm above the sett, depending on planting depth.

This method is recommended for moderate to deep planting where there will be more than 200 mm of soil above the sett in the finished hilled row, and where one-year lifecycle canegrub species (e.g. greyback or consobrina canegrubs) are the predominant species being targeted.

Double disc opener planters (Figure 9)

Apply granules in bands at least 70 mm wide and 20 – 30 mm thick in each planting row.

Granules need to be covered by 100 – 150 mm of soil when planting is completed.

Do not remove soil or disturb granules in subsequent cultivation.

Application systems for use at later workings in plant cane

KEY MESSAGES

Application depth and soil coverage is critical

Furrow planting:

- **50 mm soil coverage immediately after application**
- **150 - 200 mm soil coverage after final hill-up**

Double-disc opener planting:

- **100 – 150 mm soil cover**

Photos 18 & 19 - *Over the row applicator with deflector for use after planting (Nufarm Australia).* ***Photo 20 -*** *Under-the-canopy applicator for use after planting (Nufarm Australia)*

Suspension Concentrates

Liquid formulation products that are registered for use in both plant and ratoon cane include Confidor Guard and Nuprid 350SC.

Note: not all liquid formulation products are registered for use in **both** plant cane and ratoon cane, so check the label of the product you are looking to purchase.

***Image 21 -** Confidor Guard. **Image 22 -** Nozzle set-up for liquid imidacloprid delivery with double disc planter (second nozzle for liquid fertilizer). This setup is not ideal as it would result in contamination of the discs and therefore the soil surface.*

Registered rates for greyback canegrub control

Single row systems

Plant cane

Low pest pressure (fewer than two grubs/stool expected), September-November applications at fill-in and hilling-up only.

- 11 mL/100 m of cane row

Moderate to high pest pressure (2 grub or more grubs/stool expected), recommended to apply no earlier than June through to November, which accounts for application from mid-season planting to hilling-up.

- 16-22 mL/100 m of cane row.

Use the heavier rate where high grub populations are expected.

It is not recommended to apply liquid formulations at early planting as there may be insufficient active remaining in the soil when it is needed to control grubs.

Ratoon cane

- 16-22 mL/100 m of cane row.

Use the heavier rate where high grub populations are expected and in dual-row bed systems.

Dual row systems

Dual row systems are not explicitly covered by the current label. Bayer Crop Science recommendations for Confidor Guard are:

Early Plant

Application at final hilling-up before sugarcane gets too big.

1.8 m (or less) bed centres with less than 500 mm wide rows

- When low insect pressure is expected apply 16 mL/100 m cane row in a narrow spray band or stool splitter to each planted row and cover immediately with at least 100 mm soil.

P.21

P.22

- When moderate to high insect pressure is expected apply 16-22 mL/100 m cane row in a narrow spray band to each planted row or stool splitter and cover immediately with at least 100 mm soil.

1.8 m (and wider) bed centres with 500 mm or wider rows

- Apply 16-22 mL/100 m cane row in a narrow spray band or stool splitter to each planted row and cover immediately with at least 100 mm soil.

Late Plant

Application at planting OR Final pass before sugarcane gets too big.

1.8 m (or less) bed centres with less than 500 mm wide rows

- When low insect pressure is expected apply 11 mL/100 m cane row in a narrow spray band to each planted row or stool splitter and cover immediately with at least 100 mm soil.
- When moderate to high insect pressure is expected apply 16-22 mL/100 m cane row in a narrow spray band to each planted row or stool splitter and cover immediately with at least 100 mm soil.

1.8 m (and wider) bed centres with 500 mm or wider rows

- apply 16-22 mL/100 m cane row in a narrow spray band or stool splitter to each planted row and cover immediately with at least 100 mm soil.

Ratoons

1.8 m (or less) bed centres with less than 500 mm wide rows

- When low insect pressure is expected apply 16 mL/100 m cane row with a stool splitter into the centre of each cane row (not the centre of the bed) then cover immediately with at least 100 mm soil.
- When moderate to high insect pressure is expected apply 16-22 mL/100 m cane row with a stool splitter into the centre of each cane row (not the centre of the bed) then cover immediately with at least 100 mm soil.

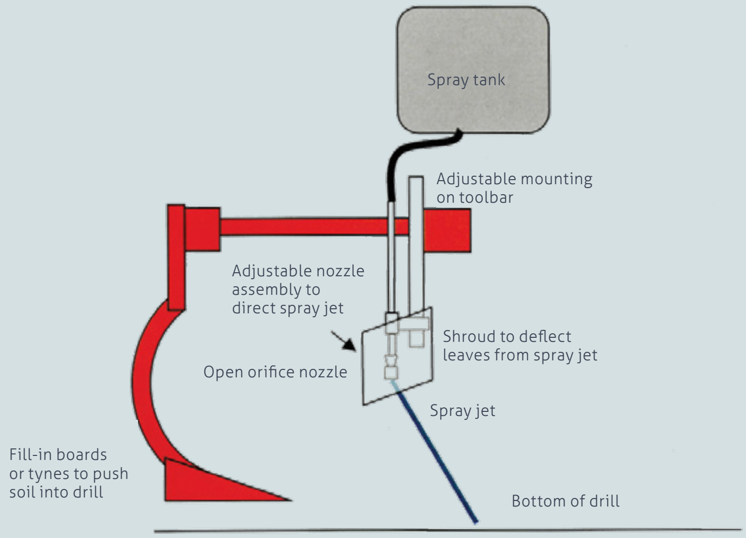
1.8 m (and wider) bed centres with 500 mm or more wide rows

- Apply 16-22 mL/100 m cane row with a stool splitter into the centre of each cane row (not the centre of the bed) then cover immediately with at least 100 mm soil.
- All applications to be made directly to the base of the furrow or slot to a depth of 100-150 mm below the final soil surface.

***Image 23 -** Liquid imidacloprid delivery on dual row double disc planter.*

F.10

PLANS FOR ATTACHMENT OF SPRAY LEGS TO FILL-IN IMPLEMENTS (BAYER CROP SCIENCE)



P.24

Mound with full plant cover across the bed (mainly Herbert region)

The use of Confidor Guard in this planting system has not been evaulated and therefore cannot be recommended. Seek advice from your Productivity Services Advisor or Bayer Representative.

Method of application in plant cane

Soil moisture is needed to allow the band of insecticide to move into the root zone.

Liquid imidacloprid formulations must be covered immediately with soil; it begins to degrade by exposure to sunlight and is also prone to loss in rainfall or irrigation run-off if left exposed on the soil surface

Confidor Guard and Nuprid 350SC can be applied at any time from planting to final hilling-up, provided due attention is paid to application rates, timing and soil cover. Application at planting is not recommended where very deep planting is practiced, as the product may be placed below parts of the root zone, which would be left unprotected.

Confidor Guard should be applied in a narrow spray band 50-100 mm wide in the centre of the planted row.

For Nuprid 350SC, the recommendation is a band 150- 200 mm wide.

The treated band of soil should be at least 50 mm above the level of the setts and must be covered immediately with at least 50 mm of soil. There should be at least 100 mm of soil cover over the treated layer after the final cultivation or hilling-up operation.

Apply in no less than 1.5 L of water/100 m of cane row.

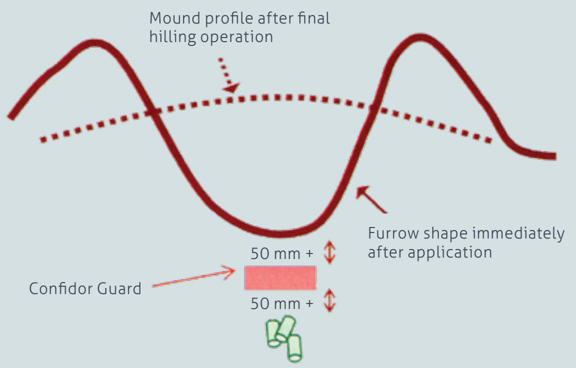
Crops must not be harvested, grazed or cut for stockfeed within 21 weeks of application.

Photo 24 - *Simulated application into furrow during fill-in. Note liquid stream should target base of plant.*

Placement of liquid imidacloprid in plant cane

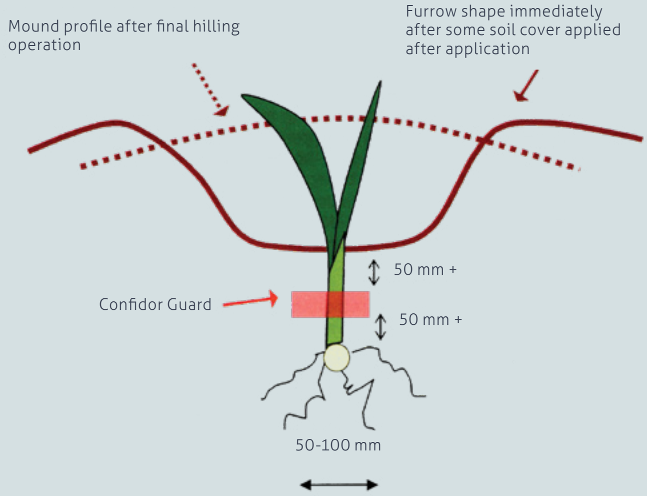
F.11

PLACEMENT AT PLANTING (BAYER CROP SCIENCE)



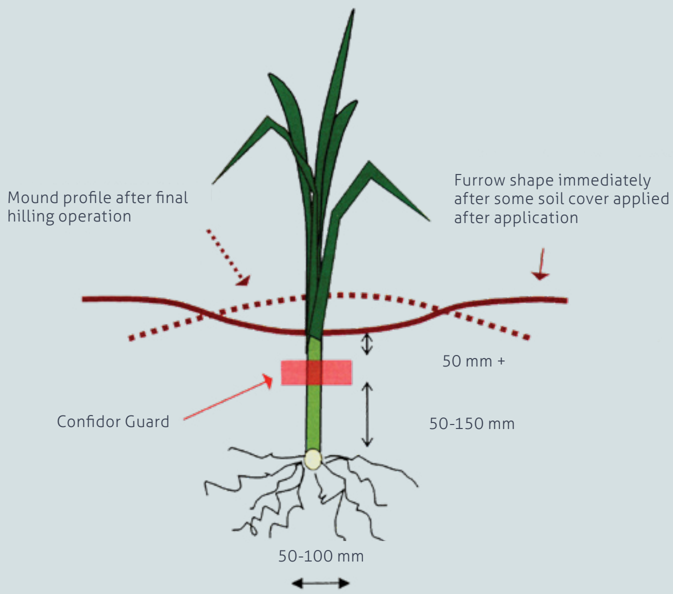
F.12

PLACEMENT AT FIRST WORKING. (BAYER CROP SCIENCE)



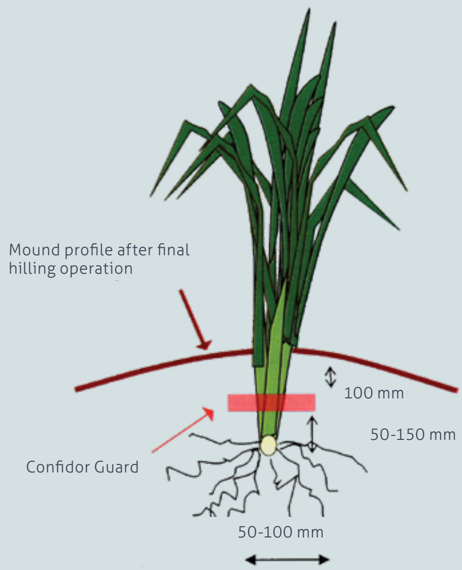
F.13

PLACEMENT AT HILLING-UP (BAYER CROP SCIENCE)



F.14

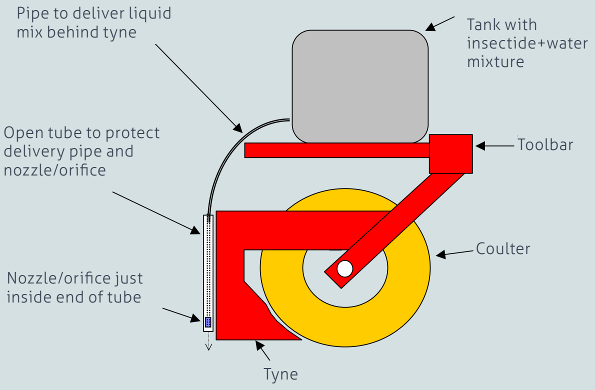
PLACEMENT AT FILL-IN (BAYER CROP SCIENCE)



F.15

SIDE VIEW OF POSSIBLE CONFIGURATION OF COULTER + TYNE IMPLEMENT FOR APPLICATION OF IMIDACLOPRID LIQUID IN RATOONS (BAYER CROP SCIENCE)

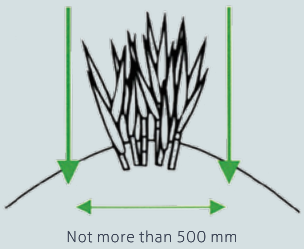
ALSO FIT A SLOT CLOSURE MECHANISM.



F.16

TWIN COULTER METHOD (SIDE-DRESSING)

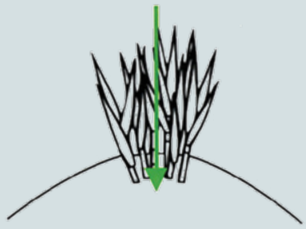
- Two slits in soil beside stool NOT MORE THAN 500 mm apart
- Depth 100-125 mm
- Can be applied later than other methods



F.17

SINGLE COULTER METHOD (STOOL SPLITTING)

- Single slit in centre of stool
- Depth 100-125 mm
- Not possible in advanced ratoons



Method of application in ratoon cane

Imidacloprid must be applied beneath the soil surface as it is harmed by exposure to sunlight, and can be lost in rainfall or irrigation run-off.

It should be applied behind coulters to a depth of 100-125 mm. Two methods are recommended:

- Twin coulters spaced 220-500 mm apart depending on ratoon growth. Coulters must not be wider than 500 mm
- Single coulter (stool split).

Apply in no less than 1.5 L of water/100 m of cane row

Soil should have moisture at coulter depth or should be irrigated within 1 week (but no sooner than 48 hours after application).

Placement of liquid imidacloprid in ratoon cane

Twin coulter method ('side dressing')

- Two slits in soil beside stool not more than 500 mm apart
- Depth 100-125 mm
- Can be applied later than other methods

Single coulter method ('stool splitting')

- Single slit in centre of stool
- Depth 100-125 mm
- Not possible in advanced ratoons

Regardless of the application method, the coulter or tyne slot must be completely filled in.

Timing of application to ratoons

Imidacloprid liquid is preferably applied to ratoons before they are too advanced, or the coulters may cause crop damage. Imidacloprid is most effective against young grubs. Hence, there is an optimum time window for application; if too early, some of the chemical will have degraded before the grubs arrive; if too late, grubs will be larger than desirable and there may also be coulter damage to crops.

The optimum window for application is September to November.

Growers should aim to apply imidacloprid either before or very soon after the adults fly. Apply earlier (e.g. September) in areas where early beetle flights occur, such as the Burdekin.

KEY MESSAGES

Soil cover, application depth and slot closure are critical.

Plant cane

- **50 mm soil cover immediately after application (planting to fill-in)**
- **100 – 150 mm soil cover after final hill-up**

Ratoon cane

- **100 – 150 mm applied depth**
- **Coulter / tyne slots completely filled in**

CULTURAL CONTROLS

Figure 18 - *Burdekin data showing canegrub damage vs time of harvest.* ***Photo 25 -*** *Early-cut strip to be used as a trap and protected by imidacloprid.* ***Photo 26 -*** *Trap crops (arrowed) established in the Burdekin. These were not protected with imidacloprid, but could have been. Note how uniformly green the non-trap areas are, although these areas were also not protected by insecticide.*

Trap cropping: Manipulating harvest and planting sequence to attract beetles

Trap cropping is rarely practiced today as growers find it simpler to treat all blocks at risk of canegrub infestation. However, it is still a strategy to use where growers wish to reduce the number of blocks treated with insecticide, especially in the Burdekin.

Trap cropping arose from observations that egg-laying beetles were attracted to early-harvested seed-cane strips that were significantly taller than surrounding cane. While the exact reason for selection of taller crops is not certain, growers can turn this beetle behaviour to their advantage.

Data collected in the Burdekin district in 1993/4, when grub damage was severe, indicated that there was a very high chance that a block of cane in a grub-affected area, and cut in the first round of harvest would receive grub damage. Later-cut blocks were less likely to be attacked

Planting and/or harvesting dates can be manipulated for areas on the property as part of a whole-farm plan for grub management.

The greater the height difference between the trap block/ strip of cane and the remaining crop, the more effective the trap is likely to be.

Trap crops can still be treated with insecticide to protect them from canegrub damage.

In some situations, growers may not only have to plant or cut cane early, but may also have to accelerate the growth of the trap sections through the use of irrigation and/or fertilisers to create an effective trap.

Plant cane as trap crops

Adopting an early-plant rotation can focus grub pressure into early-planted fallow cane, which should be treated with insecticide.

Ratoon cane as trap crops

Trap crops that are created by early-harvesting blocks or sections within a block are termed 'ratoon trap crops'.

Plough-out crops, such as sections of lower value/older ratoons, can be used as traps and may not be worth treating with insecticide.

Imidacloprid offers protection of ratoon trap crops, so young vigorous ratoon blocks or strips can also be used.

Ratoon trap crops should be close to sections known to suffer grub damage. A minimum of eight rows is necessary for an effective trap. The number of trap crops a farm will require is dependent on the grub population within an area, that is, the more grub damage an area suffers, the more trap crops are required for effective grub management.

The required number of trap crops also depends on terrain. A farm in open country might require one trap crop every 150-400 m. In more broken country, the frequency of trap crops may need to be higher.

Sorghum trap crops

Plantings of sterile varieties of forage sorghum can also be used as trap crops. Sorghum traps can be cultivated in February-March to kill grubs, but be aware of potential erosion issues.

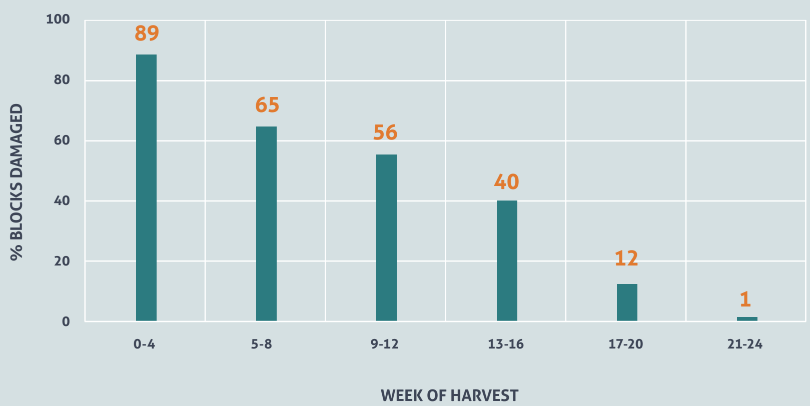
KEY MESSAGES

Trap crops can focus grub pressure into:

- **Treated early-plant fields**
- **Early-cut ratoons treated with imidacloprid liquid**
- **Early-cut older ratoons due for plough-out the following year.**

F.18

GRUB DAMAGE VS. TIME OF HARVEST



P.25

P.26

*Photo 27 - Greyback canegrub infected with **Metarhizium** (photo CSIRO).*
*Photo 28 - Healthy canegrub (left) compared to **Adelina** infected canegrub (right).*
Photo 29 - Healthy canegrub (left) compared to canegrub with milky disease (right)

Naturally occurring biological controls

Biological controls do exist naturally in soils. The presence and effectiveness of these naturally occurring organisms differs from region to region. Biological organisms are most prevalent in the wet tropic region.

Pathogens

Metarhizium anisopliae

Metarhizium is a soil borne fungus and is prevalent in the Wet Tropics and to a lesser extent Central, Bundaberg and Burdekin regions. There is a specific *Metarhizum* strain that infects greyback canegrub. It tends to maintain a fairly constant level of infection within a canegrub population and does not increase the infection percentage when canegrub populations are high. This means that, by itself, it cannot control an exploding canegrub population.

Metarhizium has been used in the past as a commercial biological control as a product called BioCane™. A specific strain of the fungus was grown on sterile rice grains and mass produced. BioCane™ is no longer marketed.

Adelina sp.

Adelina is a protozoan and again is most prevalent in the Wet Tropics. It differs to *Metarhizium* in that it can respond to increases in canegrub population and cause mortality rates of up to 100% in canegrub populations. Pathogen incidence can increase rapidly as canegrub populations increase. The downside to this is that the pathogen may die out following the complete mortality of a canegrub population, resulting in a lag time in re-populating soil in response to a subsequent canegrub infestation.

Paenibacillus popilliae

This is a bacterium and causes the disease commonly called milky disease. It is most prevalent in the Wet Tropic and Central regions. It usually only causes a low mortality rate in third-instar grubs (2 – 5% mortality).

KEY MESSAGES

Improving soil condition by reducing compaction, reducing tillage and increasing organic matter helps to maintain naturally occurring pathogens of canegrubs

Photo 30 - *Digger wasp,* ***Campsomeris sp****.*
that parasitises canegrubs.
Photo 31 - *Canegrub damaged soybean next to infested cane volunteers*

P.30

P.31

Predators

There are numerous predators that feed on either canegrubs or the adult beetle. These include birds such as Ibis, bandicoots and pigs. However, they are unlikely to make any significant differences on infestation numbers.

Parasitoids

There are some wasps that dig down into the soil, paralyze the canegrub and lay their eggs on the larvae. The wasp larvae then feed on the paralyzed canegrub. One example is the digger wasp ***Campsomeris*** spp. These wasps can sometimes be seen but are less common than they used to be. They are unlikely to make a significant difference to infestation numbers.

Tillage

Tillage does not eliminate existing canegrub infestations or prevent new ones.

Tillage does however affect the level of natural pathogens present in cane fields. Surveys 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 rather than full tillage.

Metarhizium spores are most prevalent under stools in the row with fewer on the sides of the row and very few in the interrow. Research has shown that full cultivation disperses the *Metarhizium* spores where-as zonal tillage preserves the spores within the root zone.

An integrated system for canegrub control should include trash retention and minimum tillage.

Legume rotations

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 one-year lifecycle, grubs will only be found in soybean crops if beetles lay eggs into that field.

Cane volunteers may attract additional egg-laying beetles to soybean Although this is not proven, damage to soybean is sometimes more prevalent adjacent to cane volunteers.

Legume rotations may also favour the occurrence of natural canegrub diseases such as *Adelina*. Surveys in far northern Queensland indicated that the percentage of greyback canegrubs that were infected with *Adelina* was significantly greater where there had been a soybean crop prior to planting.

IMIDACLOPRID AND THE ENVIRONMENT

Imidacloprid in our waterways

Imidacloprid is considered to be highly soluble in water and moderately mobile in soil (moderate soil adsorption). It also has moderate to high toxicity to a range of aquatic organisms. (source: Pesticide Properties Database – University of Hertfordshire) These characteristics make it a relatively high risk to aquatic organisms.

The Australian and Queensland governments have developed the Reef 2050 Plan, which is the overarching framework for protecting and managing the Great Barrier Reef until 2050. A component of this plan is the Reef 2050 Water Quality Improvement Plan.

This plan has a target of protecting at least 99% of aquatic species at the end of catchments (basically in the estuaries). All catchments within the Great Barrier Reef zone are included.

To achieve this, a freshwater imidacloprid concentration level has been set that aims to protect at least 95% of freshwater organisms. This freshwater protection concentration (PC) is relevant to farmers as it relates to the concentration of imidacloprid found in the freshwater reaches of the creeks and rivers that are adjacent to cane fields.

The draft national concentration level for protection of 95% (PC95) of freshwater aquatic organisms is 0.11 micrograms per litre (0.11 µg/L) of the active ingredient imidacloprid (or 0.11 parts per billion).

A canegrub management water quality risk framework has also been developed under the Reef Plan 2050. It describes the risk attached to various canegrub management practices. For canegrub management, the Sugarcane Water Quality Risk Framework 2017-2022 is:

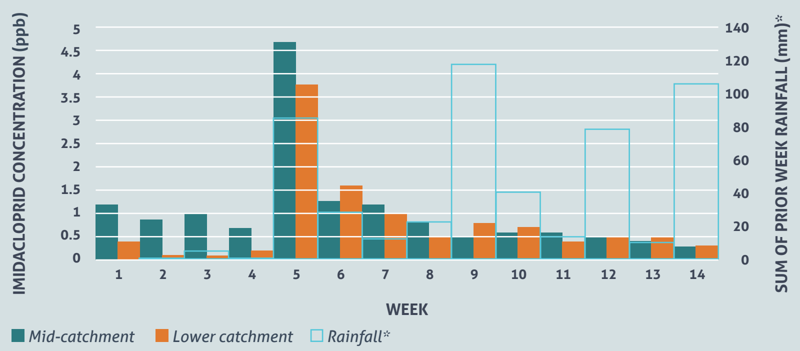
RISK CATEGORY	PRACTICES
Lowest risk (Innovative)	Control of canegrub is based on monitoring plant damage and risk assessments of likely pressure. An integrated pest management approach and participation in a district monitoring program informs grub management plans. No more than one application per crop cycle unless monitoring indicates economic thresholds are likely to be exceeded. For liquid formulations, coulter slots are completely closed or covered in.
Moderate – low risk (Best practice)	
Moderate risk (minimum standard)	Control of canegrub is based on monitoring plant damage and risk assessments of likely pressure. No more than one application per crop cycle unless monitoring indicates economic thresholds are likely to be exceeded. For liquid formulations, coulter slots are completely closed or covered in.
High risk (superseded practices)	Insecticides are routinely applied to plant or ratoon crops. Often more than one application to a block over a crop cycle.

Analysis of water from creeks and rivers in some cane production areas has shown concentrations of imidacloprid commonly exceeding the freshwater guideline value. An example of freshwater concentrations is shown in *Figure 19*. In this example, samples were taken by SRA from two locations along the creek system; mid and lower sub-catchment.

Monitoring run-off from paddock-scale demonstrations shows losses of imidacloprid *(Figure 20)*, both from irrigation run-off and rainfall run-off

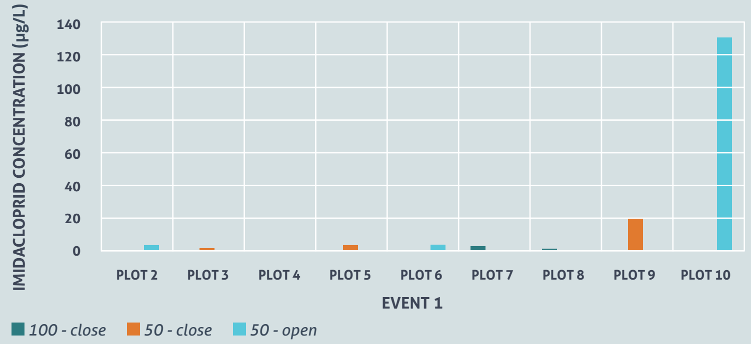
At the same time, recent and on-going research has shown that losses of imidacloprid in either rainfall or irrigation run-off, can be minimized by careful application and following label instructions, especially for application depth and slot closure. *Figure 21* shows less losses when liquid imidacloprid is applied at a consistent depth of 100 mm and with slot closure compared to higher losses at 50 mm application depth with either open or closed slots.

F.19



F.20

F.21



F.22

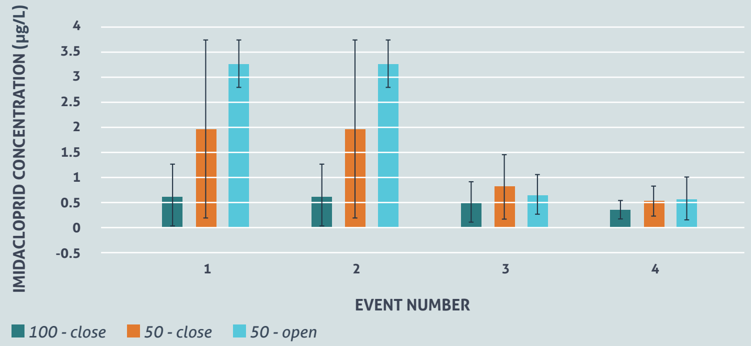


Figure 19 - *Imidacloprid concentrations in a sugar cane sub-catchment, over a 14-week period beginning 2 December 2019. The PC95 for imidacloprid is 0.11 ppb (µg/L)*

Figure 20 - *SRA paddock scale monitoring showing imidacloprid concentrations in furrow irrigation runoff (Events 1 and 2) and in the first four rainfall run-off events (Events 3 – 6). Liquid imidacloprid applied to third ratoon during October 2019 and run-off measured November 2019 to February 2020. The insecticide was also applied during the previous three seasons.*

Figure 21 - *SRA trial results showing potential extreme losses in run-off. Losses in Plot 10 are due to surface application in sections where the row profile sank below the depth setting of the applicator. Losses in Plot 9 are also attributed to some row sections being surface applied.*

Figure 22- *SRA trial results showing reduced losses to run-off when imidacloprid liquid is applied at a consistent 100 mm depth with slot closure versus 50 mm depth with or without slot closure. Data from Plots 9 and 10 are discarded in this figure to remove effect of surface application.*

Liquid application – critical to get it right

Surveys of imidacloprid applicators in ratoons during 2019 found that application depth varies considerably depending on applicator and operator.

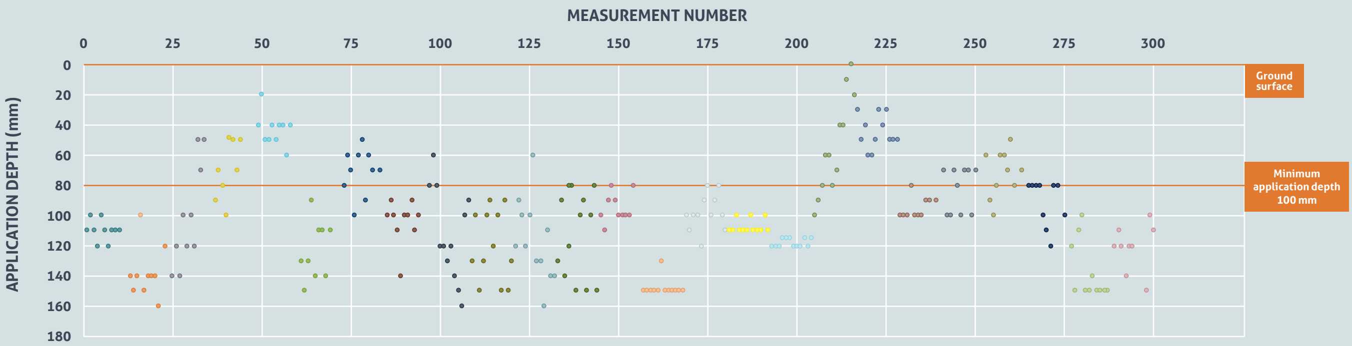
Figure 23 shows the measured application depths for 25 coulter/tyne units in the Herbert region. Each applicator depth was measured multiple times across the block. Thirty-three percent of measurements were less than 10 mm depth.

Figure 24 and 25 illustrate the range of application depths achieved for 10 double disc opener units in the central region and eight double disc opener units in the Herbert region. Twenty-two and fifty percent of measurements were less than 100 mm depth, for Central and Herbert, respectively.

The survey suggests that a combination of improved equipment design and operator care could greatly improve the application of liquid imidacloprid, with resultant water quality benefits. Many of these improvements will also increase the effectiveness of the insecticide against canegrubs.

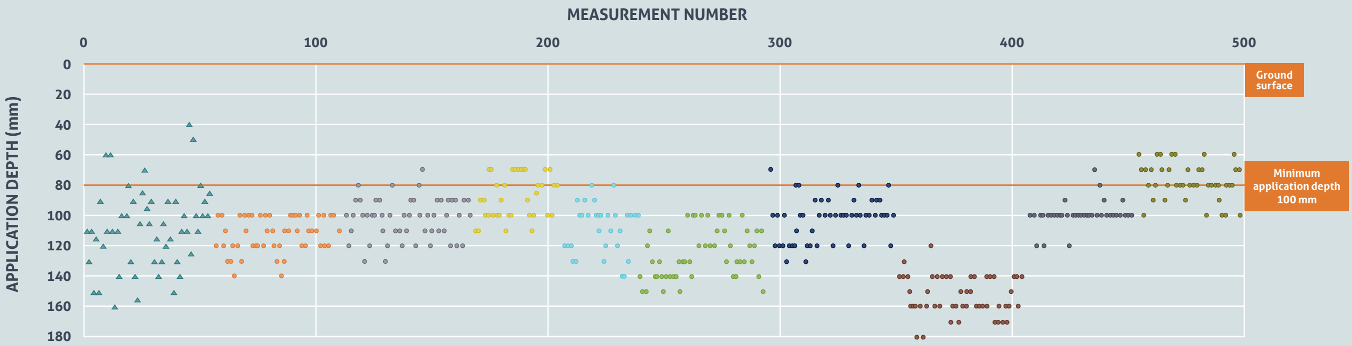
F.23

MEASURED APPLICATION DEPTHS FOR 25 COULTER/TYNE OPENER UNITS IN HERBERT REGION



F.24

MEASURED APPLICATION DEPTHS FOR 25 COULTER/TYNE OPENER UNITS IN HERBERT REGION



F.25

MEASURED APPLICATION DEPTHS FOR HERBERT STOOL SPLITTERS UNITS 1-8

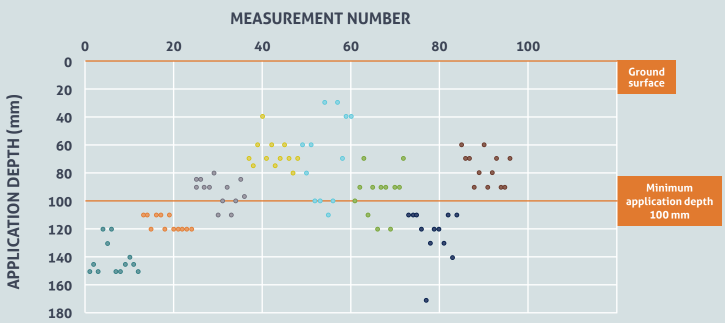


Figure 23- *Application depths achieved by 25 coulter/tyne units in the Herbert region. Each colour denotes a separate unit.* ***Figure 24-*** *Application depths achieved by 10 double disc opener units in the Central region. Each colour denotes a separate unit.* ***Figure 25-*** *Application depths achieved by 8 double disc opener units in the Herbert region. Each colour denotes a separate unit.*

Application issues

Liquid imidacloprid formulations

Compacted and dry soils can make application at 100 mm difficult, especially for applicators using coulters and double discs. Twin coulter side-dresser units and single side-dresser units have more trouble getting to the correct depth than stool splitters.

Compaction on the shoulders of beds may be a result of mis-matched row and wheel/track spacing.

Soil coverage

Coulter / double disc opener systems are generally more consistent in applying more soil cover over the insecticide band than coulter/tyne systems.

Depth wheels

Most applicators use a pair of depth wheels to set the coulter/tyne/double disc depth. Depth wheels run in the inter-row and if the relative height of the bed profile to inter-row changes, then this results in either too shallow (sometimes on the surface) or too deep application.

Operators should get out of the tractor to check that depth wheels are set correctly and that a minimum depth of 100 mm is maintained across the block. Some operators deliberately set a shallow application depth to avoid stool damage. Often this is a result of poorly designed equipment.

Slot closure mechanisms

Many applicators do not have any mechanism to close the application slot. In very sandy soils, the slot may close in on itself but for most others some sort of press wheel or slot closure mechanism is needed. Slot closure is more difficult on moist soils with higher clay content. Trash cover can hide an open slot. Closing the slot must be done in addition to applying imidacloprid at the minimum of 100 mm depth as per label requirements.

__Photo 32 -__ Depth wheels set the level of the double disc / tynes. __Photo 33 -__ Rake trash off to check slot depth and closure. This open slot is a result of not having any mechanism to close it. __Photo 34 -__ Except in loose soils, chains do a poor job of slot closure. Often this is hidden due to trash cover. __Photo 35 -__ StoolZippa™ is effective in most soils but care is needed in sticky soils as "flicking" may occur bringing treated soil to the surface. __Photo 36 -__ Single press wheels are effective in most situations; __Photo 37 -__ Double press wheels are effective in most situations.


P.32


P.33


P.34


P.35


P.36

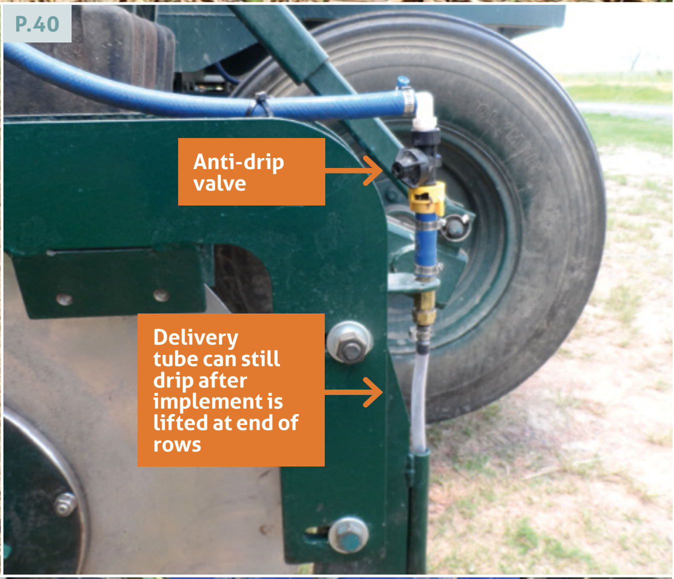

P.37

__Photo 38 -__ The nozzle on this applicator is angled too far back, resulting in shallow application and wetting of the press wheel. It is easily rectified by adjusting the angle forward. The solid arrow shows the existing nozzle angle and the dashed arrow shows the correct nozzle angle. __Photo 39 -__ Correct alignment of nozzle ensuring liquid reaches the base of the slot. However, this applicator could be improved by the addition of a slot closure mechanism. __Photo 40 -__ Coulter/tyne applicator showing the anti-drip valve, and the protective metal tubing to house the delivery tube. This applicator could also be improved with the addition of a slot closure mechanism. __Photo 41 -__ A twin coulter applicator - the horizontal distance between the coulters must be 500 mm maximum. __Photo 42 -__ Scraper fitted to double disc to minimize buildup of wet fertilizer granules on inner surfaces. This applicator also could be improved with the addition of a slot closure mechanism and by directing the imidacloprid stream away from the discs so that the liquid does not contact them.

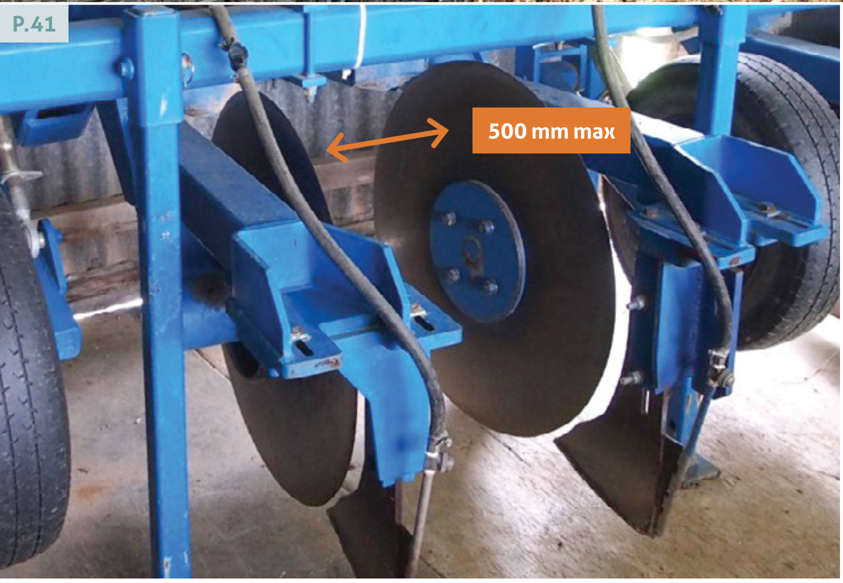
P.38

P.39

P.40



P.41



P.42

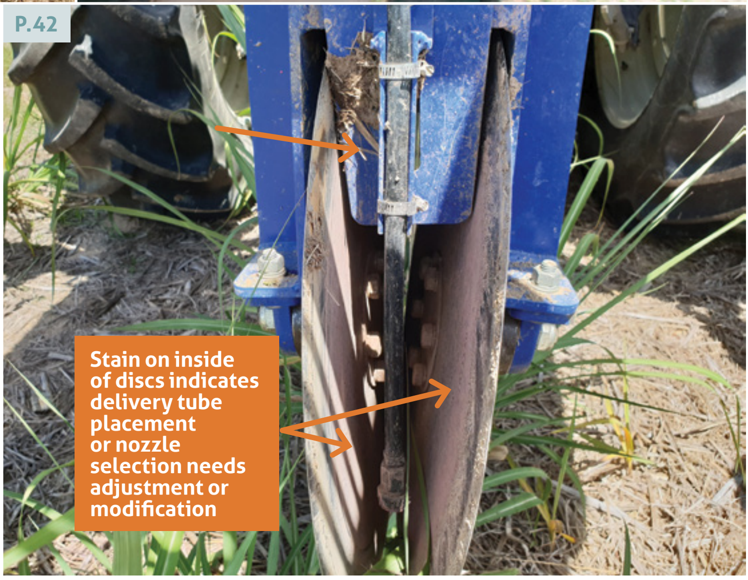


__Photo 43 -__ A Wilgar flow view™ ball flow indicator fitted to applicator. __Photo 44 -__ Location of ball flow indicator on applicator. It is visible from the cab. __Photo 45 -__ Dosatron units draw the imidacloprid concentrate straight from the original container and mix it with the water flow downstream from the pressure regulator. They must be maintained and calibrated.

P.43

P.44

P.45

Nozzle angle

Nozzles need to be angled and positioned so that liquid imidacloprid is applied to the bottom of the slot created by the double disc or tyne. Incorrect angle can result in the slot being partially filled before the liquid reaches the bottom, causing shallow application. The nozzle must be positioned so no liquid imidacloprid is sprayed or splatters onto the discs.

Preventing drip / surface application

Delivery tubing ideally should be fitted with anti-drip valves, to minimize the risk of drips after the flow is shut off. Even so, there is still a length of delivery tubing after the valve that will empty once the implement is lifted out of the soil.

Twin coulter side-dressers

It is important that the horizontal spacing between coulters is no more than 500 mm. This is to both ensure that the insecticide treats the whole root zone and to also minimize the risk of insecticide loss if too close to the bed shoulder. The coulters need to be an even distance from the cane row, e.g. 250 mm from the cane row on each side. An application depth of at least 100 mm is required.

In dry, compacted soil it may be difficult to apply to 100 mm depth using a twin coulter side-dresser.

Combined insecticide/fertilizer applicators

Sometimes the liquid insecticide will wet up the fertiliser granules, causing a buildup of wet fertiliser granules on the inner surface of the double discs. Fitting a scraper may help alleviate this issue.

Even flows

It is important to ensure even flow to each delivery tube. Uneven flows are commonly caused by plumbing issues and/or outlet pipe blockages. Fitting a ball flow indicator is an easy way to check, from the cab, that flows are uniform to each delivery tube. If the ball drops relative to the others, then the flow is blocked or restricted. If the ball rises relative to the others, the flow is too high.

Angled blocks

Angled blocks are a potential issue as to ensure application to the end of all rows, one or more of the double discs or tynes may cut into the headland, creating an additional risk of loss in run-off.

Disposal of excess solution

Excess insecticide solution must not be sprayed onto headland or to areas subject to runoff.

Installation of flow metering injection devices like Dosatron®, can alleviate most disposal issues, but they require regular maintenance and calibration.

Photo 46 - suSCon® granules still exposed after hill-up in a dual row system due to poor application.
Photo 47 - suSCon granule caught in leaf axil due to incorrect application.

P.46

P.47

EQUIPMENT CHECKLIST – CRITICAL DESIGN FEATURES FOR RATOON APPLICATION OF LIQUID IMIDACLOPRID

- Adequate slot opening mechanism
- Correct delivery tube placement
- Adequate slot closure mechanism

KEY POINTS – RATOON APPLICATION

- 100 – 150 mm slot depth
- Check depth when soil conditions change
- Remove trash to inspect slot
- Apply the liquid band to the base of the slot
- Cover treated band immediately with at least 100 mm soil
- Completely fill in slot with untreated soil
- No surface contamination (spills or drips) including disposal of unused solution
- No relocation of product from treatment slot to the soil surface with disc openers or slot closure equipment

(Bayer Crop Science Australia Confidor® Guard Sugarcane Stewardship Training Program 2020)

Application issues

suSCon maxi Intel

The main issues around suSCon maxi Intel seem to be ensuring correct depth of application and preventing leaf interference at application. These issues are most apparent when applying at first working/fill-in or hill-up. After applying into the furrow make sure the fill-in or hill-up provides the required level of soil coverage. Also ensure that granules are not being caught in the leaf axil.

REFERENCES AND FURTHER READING

Allsopp P G (2010) *Integrated management of sugarcane whitegrubs in Australia: an evolving success.* Annual Review of Entomology (2010) 55, 329 - 349

Fillols E, Davis E (2020) *Impact of application depth and slot closure on runoff losses of imidacloprid.* ASSCT Proceedings, V 42, 422 - 432

Sallam N (2011) *Review of current knowledge on the population dynamics of Dermolepida albohirtum (Waterhouse) (Coleoptera: Scarabaeidae).* Australian Journal of Entomology (2011) 50, 300 - 308

Samson P, Chandler K, Sallam N (2010) *Canegrub management and new farming systems,* BSES Limited 2010

SRA website material:

sugarresearch.com.au

Information Sheets and booklets

- Calibration of ground-driven granular insecticide applicators for canegrub management: when either the driving or the driven cog is changed to achieve the desired application rate
- Calibration of ground-driven granular insecticides applicators for canegrub management: when both driving and driven cogs are changed to achieve the desired application rate
- Calibration of liquid insecticide applicators for canegrub management
- Canegrub identification in the Northern region
- Canegrub identification in the Herbert region
- Canegrub identification in the Burdekin region
- Canegrub identification in the Central region
- Canegrub identification in the Southern region
- Canegrub identification in NSW
- Greyback canegrub

Bayer website material:

bayer.com.au

- Brochure: New Confidor® Guard keeps grubs out of cane

Nufarm website material

nufarm.com/au/products/sugar

- suSCon maxi Intel® Technical Guide – Always on guard to give grubs a caning
- suSCon maxi Intel® Technical Manual
- suSCon maxi Intel® Technote: Calibrate suSCon applicators annually (calibration worksheet)

Reef 2050 Water Quality Improvement Plan:

reefplan.qld.gov.au

Dread ravager of waving seas of cane,
Strange scaly creature, lowly yet supreme;
Cursed, but triumphant, fast attaining fame,
Haunting our growers like some evil dream.

What carest thou, grey spectre of the night,
For man's distress; or though his hard-won gold
Be lavished in prolonged unequal fight
Against thy feeble grub? Ages untold

Have watched thy countless hosts awake each Spring,
Crawl from the steaming earth and take to wing:
Thenceforth 'mong fragrant gums to freely roam,
And tast the glories of their native home.

Edmund Jarvis, 1923
(BSES entomologist 1914-1935)

Sugar Research Australia Limited
ABN 16 163 670 068

Brisbane Office 50 Meiers Road, Indooroopilly QLD 4068 Australia
Postal Address PO Box 86 Indooroopilly QLD 4068 Australia

T 07 3331 3333
E sra@sugarresearch.com.au
sugarresearch.com.au