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FINAL REPORT – SRDC PROJECT BSS205
CONTROL OF GREYBACK CANEGRUB
BY MANIPULATING ADULT BEHAVIOUR

by

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SD00015

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ABSTRACT

In the Burdekin, early-planted and early-cut cane is more frequently damaged by greyback canegrub than other classes of cane. Cane height is important in attracting egg-laying greyback beetles and early-planted and early-cut cane is generally the tallest cane on Burdekin farms during the period of beetle flight. In this project, the effect of trap crops (tallest sections of cane or other crops) on damage to surrounding cane was determined. These trap crops were created by planting cane ‘early’, harvesting sections of blocks in early harvest rounds, planting forage sorghum, applying high rates of N fertiliser, and selective irrigation. In the 1999- and 2000-harvest seasons, early-plant and early-harvest or ratoon trap crops reduced grub numbers in adjacent blocks by 70-100%. The single critical factor for successful trap crops was the height of the crop relative to adjacent blocks. Cane cultivar and fertiliser rate were not important in the success of trap crops. Beetle flight determined by light-trap catches in the summers of 1998-1999 and 1999-2000 generally had a single identifiable peak. Dispersal of greyback beetles was difficult to quantify.

SUMMARY

Greyback canegrub remains the major constraint to cane production in the Burdekin. Recent research on the means to reduce losses due to greyback canegrub has included testing of insecticides, study of greyback ecology and the effect of farm management practices. Confirmation of the association of damage due to greyback canegrub and height of crops during beetle flight has led to the experimental work with trap cropping in this project, BSS205. A trap crop for greyback canegrub is a section of cane that is taller than the surrounding cane. In the Burdekin, two general classes of cane are damaged more frequently than others and are potential trap crops: 'early-plant' cane, which is planted between February and June, and ratoon cane cut in the early rounds of the harvest period. In addition, selective irrigation and supplemental application of fertiliser may increase the attractiveness of trap crops relative to surrounding cane by increasing their vigour and size.

During 1999-harvest season, trap crops were established on nine farms in the Burdekin. A 1.7 ha trap crop of early plant cane was effective in reducing numbers of canegrubs in the adjacent 53 ha of cane by 70-100%. Trap crops of early-cut ratoons were effective in reducing numbers of canegrubs in immediately adjacent blocks by >80%. Trap crops of forage sorghum did not reduce damage because the adjacent taller block of plant cane was more attractive and consequently received significant damage. Withholding irrigation from sections of cane in order to create trap crops in the 1999-harvest season was ineffective due to record late-spring rainfall in the Burdekin.

Trap crops were established on 18 farms during the 2000-harvest season. Trap crops on 12 farms had sufficient infestation of canegrubs for comprehensive sampling. Cultivar-based plant trap crops were less effective. There was no difference in the number of canegrubs in Q127 trap strips and the Q117 non-trap strips in the plant block. However, the plant block as a whole attracted more grubs than the surrounding cane. Two of seven ratoon trap crops were effective in reducing grub numbers in adjacent blocks. Failure of five other ratoon traps was probably due to lack of difference in height and, in two cases, to canegrub infestation independent of crop height. Fertiliser-based trap crops were not effective. Crop height remains the only significant factor in the effectiveness of trap crops. Further work is warranted on cultivar-based trap crops to confirm results achieved in this project.

The peak beetle flight was about two weeks later in 1999-2000 than in 1998-1999. Dispersal of greyback beetles proved difficult to quantify with the mark-release-recapture technique, largely due to the inadequate scale of the experiments. Difficulties occurred with capturing adequate numbers of beetles for marking. We suggest that further attempts to quantify greyback beetle dispersal should be based on other methods.

1.0 BACKGROUND

Greyback canegrub, *Dermolepida albohirtum* (Waterhouse), has been in outbreak numbers in the Burdekin district since the early 1990s. The outbreak coincided with first reports of the failure of suSCon® Blue to prevent damage by greyback canegrub to plant and first-ratoon crops. Research work to improve understanding of the behaviour of greyback and to overcome the problems of canegrub control with suSCon Blue has been carried out since the early 1990s. Ward (1998) confirmed early suggestions that beetles prefer to lay eggs in the tallest crops (Illingworth 1918). Blocks planted relatively early in the year and those cut and ratooned in the early part of the harvest season tend to be the tallest cane during November-January when greyback beetles are laying eggs. These blocks subsequently sustain most damage (Ward and Cook 1997).

The tendency for greyback beetles to lay eggs in the tallest crops led Burdekin canegrowers to adopt 'late' planting to avoid damage. Crops planted relatively late (after June) were shorter during beetle flight than many adjacent ratoon crops and less likely to be damaged. This project, BSS205, extends the findings of Ward and Cook (1997) by examining whether the use of small sections of tall cane (trap crops), which attract egg-laying beetles, can minimise damage to cane in the surrounding area. By concentrating canegrubs in trap crops, production losses due to canegrub damage may be minimised in blocks adjacent to trap crops.

Trap crops can be created in a number of ways. Plant trap crops may be created by planting sections earlier than the remainder of the block or with selected cultivars such as Q127 (which may be more attractive than others). Sections of blocks may be harvested early to produce ratoon trap crops. Both plant and ratoon trap crops may be enhanced by selective irrigation and fertiliser application. Planting strips of forage sorghum and maize may create trap crops, although the latter remains untested.

2.0 OBJECTIVES

- Assess how the size and type of trap crop can reduce canegrub damage in the surrounding area.

- Quantify greyback beetle dispersal to provide a rational basis on which to improve the effectiveness of trap crops.

Significant progress was made in addressing the first objective. The second objective was less successfully addressed and requires further study with a different methodology than attempted in this project.

3.0 METHODOLOGY

3.1 1998-1999 trap crops

Potential trap crops were established by four methods:

(1) Growers on six farms were encouraged to set up a trap crop by preferential watering of a 10-20 row section of cane. Irrigation was withheld from the remainder of the block to create a water-stressed appearance. Beetles were expected to avoid laying eggs in stressed cane and concentrate in the well-watered cane.

(2) Ratoon trap crops were established by Paul Sgarbossa on his farm by harvesting parts of blocks earlier than adjacent cane.

(3) An early-plant block on Felesina's farm was selected as a site to test the effect of a plant trap-crop on infestation in surrounding blocks. The block was treated with BioCane™ at 33 kg/ha. Four rows were left untreated.

(4) Trap crops of forage sorghum (cultivar Betta Dan) were established on Becke's farm, Leichardt. In cage tests, beetles laid eggs equally in potted forage sorghum and cane (Logan and Kettle, unpubl.). Four rows of sorghum at 1.5 m row spacing were planted in three strips separated by 160-240 rows of cane.

Plant height was measured for each trap crop and for each adjoining block in December 1998. The height of 10 stalks of cane at both ends of trap crops and all adjoining blocks was measured from ground level to the last visible dewlap. Eight stools from each corner of trap crops including sorghum trap crops and from each corner of blocks adjacent to trap crops were sampled for greyback canegrubs in January and February 1999. Each stool and surrounding soil were removed by spade to a depth of 30 cm and the number of canegrubs present recorded.

3.2 1999-2000 trap crops

Plant trap crops were established on 10 farms. Planting date was used to establish a trap crop at one site. At other sites, the cultivar Q127 was planted in strips of 10-25 rows as trap crops; the remainder of the block was often planted to another cultivar, often Q117. The variety Q127 is thought to be attractive to egg-laying greyback beetles, because it frequently shows damage. Either suSCon Blue plus acidifiers or BioCane was applied to trap blocks.

Ratoon trap crops were established on six farms by harvesting sections of blocks earlier than the remainder. Two additional potential trap crops were identified where growers harvested plants for planting material.

Fertiliser trap crops were established on two farms. A high rate of fertiliser was applied to eight-row strips in three blocks (two on one farm) in an attempt to create ‘greener’ sections for gravid greyback beetles. It is possible that high soil N levels may increase crop attractiveness to egg-laying beetles by increasing the level of green leaf volatiles, which may play a role in attracting beetles. Leaf samples were taken three months after fertiliser application and analysed for N levels to detect any differences between treatments. No trap crops of forage sorghum were established in the 2000-harvest season.

The height of 10 stalks at both ends of trap crops and all adjoining blocks was measured from ground level to the last visible dewlap. Measurements were made in November-December during the period of beetle flight.

Trap crops and adjoining cane were sampled by counting the number of greyback canegrubs under 6-8 stools at each end of the block in March 2000. Some trap crops were not sampled comprehensively because of poor establishment relative to adjacent crops, absence of untreated sections in trap and/or adjacent non-trap crops and absence of infestation. Numbers of canegrubs were sampled for cultivar-based trap crops on three farms, for seven farms with ratoon trap crops and for three fertiliser trap crops in March 2000 (Table 3.1). Some sites had more than one trap crop in the same block (Mottin, Davenport) or had trap crops in adjacent blocks (Breene).

Table 3.1: Trap crops sampled for canegrubs in February-March 2000

Trap crop type	Grower	Number of trap crops	Size of trap crop (rows)
Cultivar/plant	Breene	2	6
	Mitchell	1	15
	Mottin	3	10-12
Ratoon	Blaik	1	20
	Hartwell	1	14-19
	Kelly	1	24
	Mau	1	15
	Michielin	1	7 (plant source)
	Pilchowski	1	21
	Shoyer	1	6 (plant source)
Fertiliser	Davenport	2	8
	Spence	1	8

3.3 Effect of trap crops on damage and yield at the farm level

Productivity data and canegrub damage data were obtained from CSR and the CPPBs respectively, and compared for farms with trap crops and without trap crops.

Three farms with and four farms without trap crops (Table 3.2) were compared for differences in the area damaged by canegrubs and the tonnes of cane lost to canegrubs for four or five consecutive years. The area of damage was compared for the 1997 and 1999 harvest season by Analysis of Covariance with area harvested as the covariate.

Table 3.2: Farms with and without trap crops compared for productivity and damage

With trap crops (mill district)	Without trap crops (mill district)
Sgarbossa 1 (Inkerman)	Poli (Inkerman)
Sgarbossa 2 (Inkerman)	Fowler (Inkerman)
Felesina-Romeo-Fabbro-Quagliata[1] (Ayr)	Lyons (Invicta)
	Peters (Invicta)

[1]Composite farm made of blocks surrounding a trap crop

3.4 Greyback beetle flight and dispersal

Light traps and intercept traps were used to study seasonal flight patterns and within-farm dispersal by greyback beetles. Dispersal by greyback beetles was assessed by capture-mark-release studies.

Greyback beetle flight was monitored with light traps at 11 sites during the summer of 1998-1999 and at five sites during 1999-2000 (approx distance between traps, 0.5 - 40 km). Three sites monitored in 1998-99 were included in the 1999-2000 monitoring. Light traps were placed on farms near trap crop sites to determine when peak flights occurred and, hence, estimate when most beetles may be laying eggs. Beetles were removed from light traps approximately twice weekly from 22-23 October until 24 December 1998 and three-times weekly from 15 October 1999 until 2 February 2000. Small trap catches (<100) were counted or estimated to the nearest 10 greyback beetles. The number of greyback beetles in large trap catches was estimated by the number of 10 L bucket loads (mean = 183 greyback beetles/L, n = 3) needed to empty the trap. A sample of 50-100 beetles was sexed at intervals of approximately two weeks during the beetle flight season of 1999-2000. Females were grouped according to ovarian status into the following categories:

- with no or little development;
- with some fully-grown oocytes present; and
- with most or all oocytes fully-grown (gravid).

Beetles at Sgarbossa's farm were also monitored with intercept traps for flying beetles (type 1 trap, Fig 3.1) and intercept traps for egg-laying females (type 2 trap, Fig 3.2) during the summer of 1999-2000. Type 1 intercept traps were placed on headlands next to cane in six locations 0-400 m from the riverbank. Type 2 traps were placed within an early-cut ratoon block. Traps were checked three times weekly and any beetles removed, sexed and females dissected to determine ovarian status (as above). In 1998, type 1 intercept traps were placed in a trap crop and in adjacent short cane. Traps were placed such that the intercept surface of traps was above or below the crop canopy in the trap crop and above the canopy in short cane.

Several mark-release-recapture experiments were undertaken to measure the level of dispersal of beetles. In December 1998, beetles were captured over several days from feeding trees and marked by removing a small section of elytron (wing cover). Marked beetles (n = 1800) were released at the centre of a 7 x 7 grid of type 1 intercept traps (n = 48, central trap omitted) placed in cane; traps were separated by 70 m. Beetles were released in the evening and remaining beetles counted and removed from the site the following morning. Traps were checked for marked beetles one and two weeks after their release.

In December 1999, beetles were collected from light traps and marked by immersion in a solution of diluted ethanol and paint powder. Twelve hundred marked beetles were released from a cane field 70 m from the riverbank in the late afternoon. Seven light traps along the riverbank, 170 m to 1.5 km from the release point, were emptied of previous beetle catches on the day of release and checked for marked beetles the following morning.

An experiment was conducted to estimate beetle persistence in the vicinity of light traps. Greyback beetles were collected from light traps in December 1998 and 1999. One light trap (trap A) was immediately adjacent to two feeding trees on the riverbank; the second (trap B) was in a residential area of Ayr. Beetles were marked (trap A: n = 880; trap B: n = 124) by removing a small section of the elytron and released in the late afternoon within 5 m of each light trap. Marked beetles in the light trap were counted daily until no marked beetles were captured for at least three days.

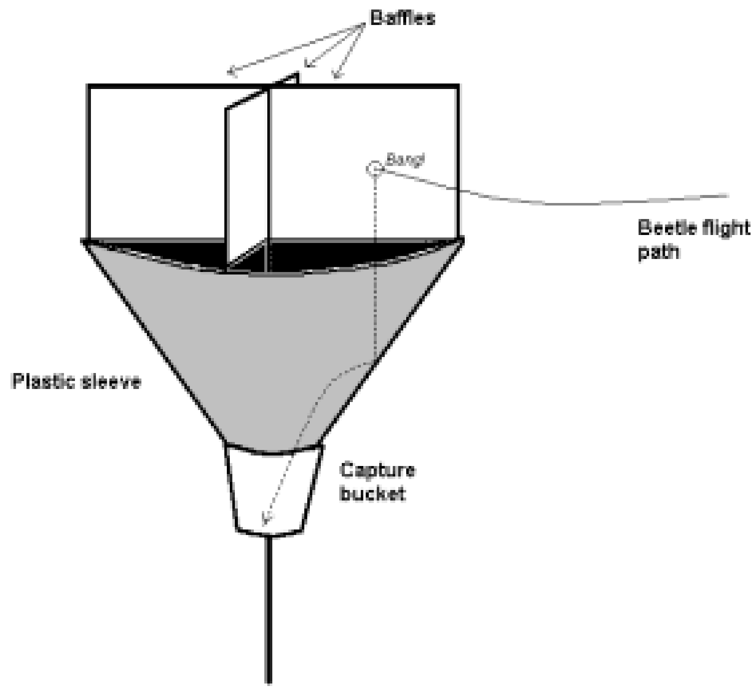

Figure 3.1: Diagram of intercept trap to capture greyback beetles in flight. Many traps were from Andrew Ward's project on greyback canegrub. The traps were modified to have a single sleeve and capture bucket instead of four sleeves with capture containers. The diameter of the top of the plastic sleeve is 1.2 m.

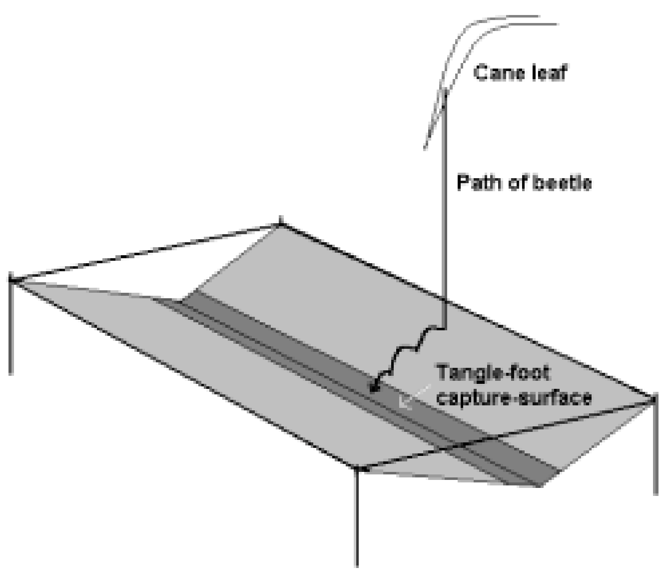

Figure 3.2: Diagram of intercept trap designed to capture egg-laying females as they fall from leaves to the soil. The trap measures 1.2 m wide, 1.5 m long and 0.4 m high.

4.0 RESULTS

4.1 1998-1999 trap crops

Withholding irrigation from sections of cane in order to create trap crops in the 1999-harvest season was ineffective at the six sites. Record late spring rainfall in the Burdekin reduced differences in appearance and height between trap and non-trap sections of cane.

Early-cut ratoons (trap-crops), and all other blocks, were sampled for canegrubs on Sgarbossa's farm in February. Cane height, measured in early December 1998, was significantly related to density of greyback larvae, with higher larval densities in blocks of taller cane (regression: $F = 13.8$, $P = 0.0005$, $n = 49$, $r^2 = 0.23$) (Fig 4.1). Blocks with cane greater than 900 mm tall had ten times more canegrubs/stool on average (2.5/stool) than blocks with shorter cane (0.26/stool) (two-sample t-test, $P = 0.003$, $T = 3.4$, $df = 17.6$).

The 1.73 ha trap crop of early plant Q165[A] on Felesina's farm was infested with 2.1 greyback larvae/stool in February. Infestation was heavy in one end of the trap crop (3.75 larvae/stool). Blocks of cane bordering the trap crop (53 ha in total) were infested with 0.2 greyback larvae/stool (0-1.125 larvae/stool); a 70-100% reduction relative to the trap crop. Cane in two blocks adjacent to the trap crop was as tall as the trap crop at the time of beetle flight (two sample t- test, $P = 0.50$, $T = 0.70$, $df = 8$), but had low numbers of greyback larvae (0.1 and 0.8/stool). Both blocks were ratoon crops with many sprawling and lodged stalks. Cane height in these blocks was more variable (Co-efficient of Variation (CV) =21 and 24%) than in the trap crop (CV = 9%).

There was no difference in the number of greyback larvae in BioCane™-treated and untreated sections of the trap crop in the following February (two-sample t-test, $P = 0.65$, $T = 0.46$, $df = 30$). Although the density of canegrubs was relatively high in one end of the trap crop, no obvious damage was observed during an inspection flight on April 21 1999.

Canegrub density was not related to distance from the riverbank (regression: $F = 1.4$, $P = 0.24$, $df = 37$, $r^2 = 0.04$) (maximum distance measured, 920 m). Differences in the number of canegrubs per stool in adjacent blocks in February were related to differences in the height of cane measured in December (regression: $F = 13.5$, $P < 0.001$, $df = 48$, $r^2 = 0.25$) (Fig. 4.2). For any block of cane on Sgarbossa's farm, every increase of 265 mm in cane height relative to adjacent blocks, was associated with an increase in canegrub density of one canegrub per stool.

Two trap crops of sorghum, and adjacent blocks of cane, were sampled on Becke's farm in January 1999 for greyback canegrubs. A 2.8 ha block of early plant cane, which was over 400 mm taller than the sorghum trap crops during beetle flight, had more canegrubs (3.75/stool) than adjacent blocks (Kruskal-Wallis Statistic = 40.9, $F = 23.7$, $P < 0.0001$). The sorghum trap crops had 0 and 0.375 greyback larvae per stool. Late planted cane (19 ha), which was about 400 mm shorter than sorghum trap crops during beetle flight, had 0.06 larvae per stool.

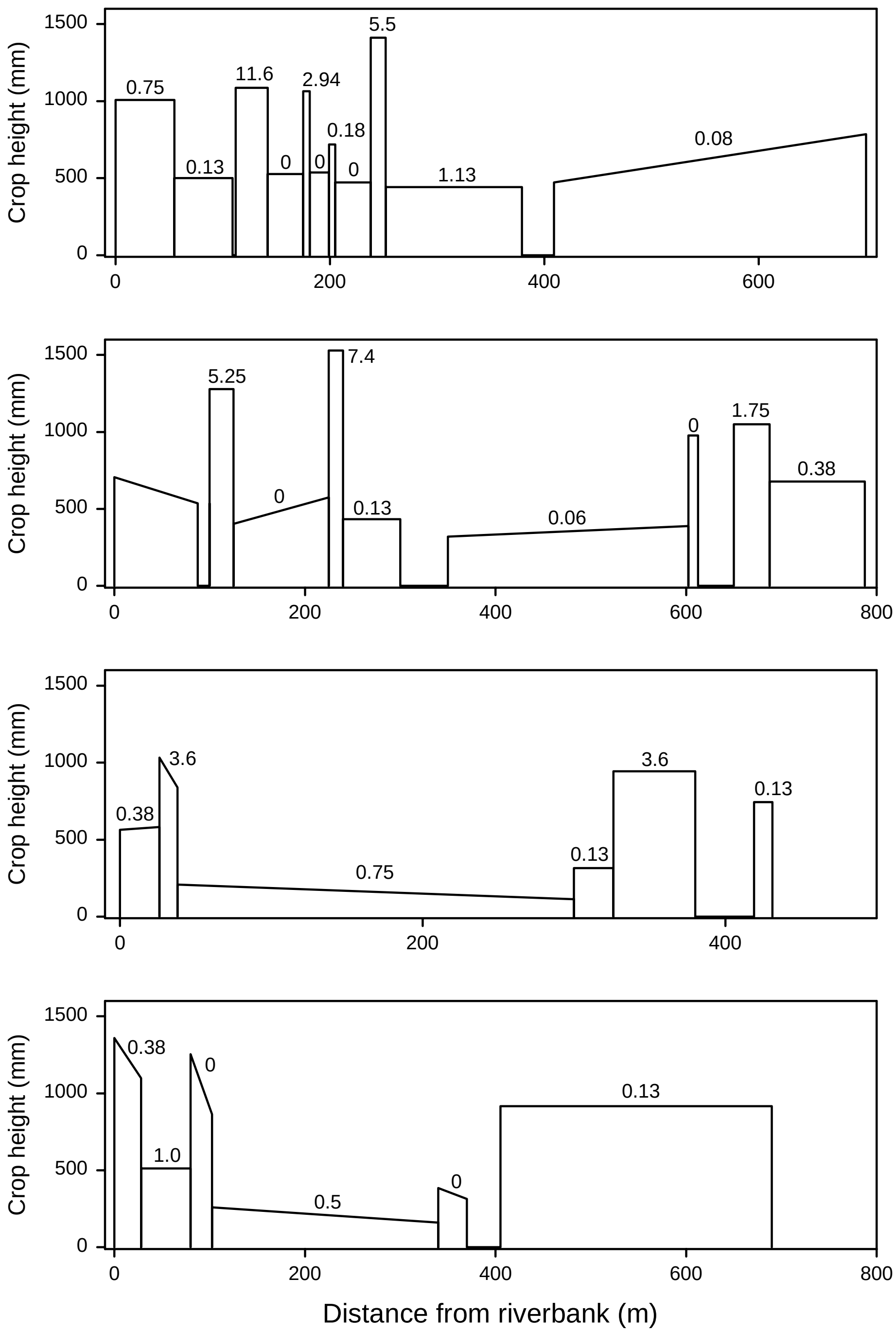

Figure 4.1: Crop height profiles for transects across Sgarbossa's farm. Crop height was measured in December 1998 at the time of oviposition; cane stools were sampled in February and March 1999 for canegrubs. Numbers above each block profile are the mean number of greyback canegrubs/stool.

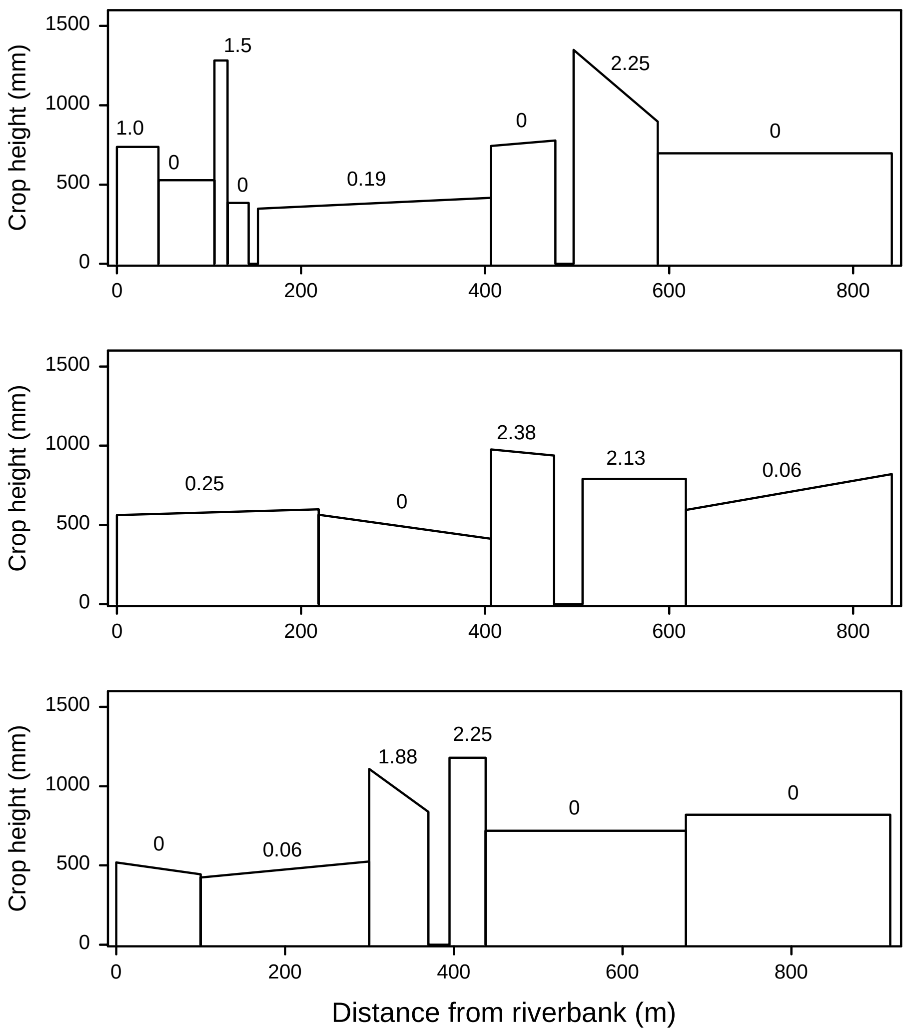

Figure 4.1 continued: Crop height profiles with numbers of greyback canegrubs for transects across Sgarbossa's farm. Crop height was measured in December 1998 at the time of oviposition; cane stools were sampled in February and March 1999 for canegrubs.

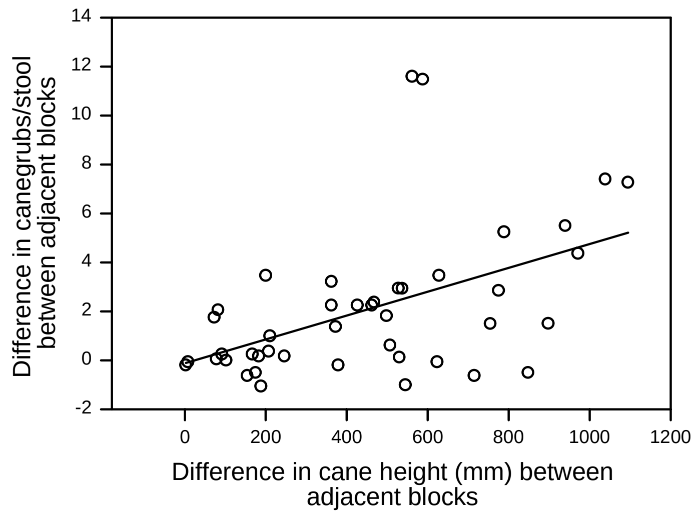

Figure 4.2: The relationship between difference in cane height and difference in canegrub density in adjacent blocks on Sgarbossa's farm in 1998/99. Regression equation: Difference in canegrubs per stool = 0.005 (ht diff. mm) – 0.124.

4.2 1999-2000 trap crops

Cultivar trap crops

At Breene's farm, there was a low-level infestation of trap and non-trap crops (Table 4.1). At Mitchell's and Mottin's farms, the plant crop attracted greater numbers of canegrubs than surrounding blocks of ratoon cane (two-sample t-test, Mitchell: $P < 0.0001$, $T = 5.78$, $df = 33.0$; Mottin: $P < 0.0001$, $T = 7.46$, $df = 121.1$) (Table 4.1). Within plant crops, Q127 trap crops were not successful in attracting more canegrubs than Q117 non-trap cane (two-sample t-tests: Mottin, $P = 0.78$, $T = 0.28$, $df = 54$ (Fig. 4.3); Mitchell, $P = 0.13$, $T = 1.56$, $df = 26$). At Mottin's and Mitchell's farm, Q127 trap crops were 400 mm and 200 mm taller than the Q117 non-trap planted at the same time, respectively (Table 4.1).

Table 4.1: Mean numbers of canegrubs/stool in March 2000 and mean stalk height in November-December 1999 for plant trap crops based on the cultivar Q127, the adjacent plant non-trap and surrounding blocks.

Grower	Plant Q127 trap		Plant Q117 non-trap		Surrounding blocks	
	Mean ht (mm)	Grubs/st.	Mean ht (mm)	Grubs/st.	Range of mean ht (mm)	Range of grubs/stool
Breene	1344.5	0.5	976.5	0	223-966	0-0.19
Mitchell	1338.0	1.5	1144	2.4	110-235	0-0.14
Mottin	1608.5	1.5				
Mottin	1542.0	1.9	1096	1.7	344.5-757.5	0-0.7
Mottin	1575.0	1.4				

Ratoon trap crops

Two ratoon trap crops (Hartwell, Kelly) were relatively successful in attracting greater numbers of canegrubs than adjacent cane (Table 4.2, Fig. 4.4). Three ratoon trap crops (Blaik, Mau, Shoyer) were shorter than one or more adjacent blocks, and were not effective as trap crops (Table 4.2). Pilchowski's trap crop was effective at one end (trap 1.7 grubs/stool; non-trap 0.2 grubs/stool) (two-sample t-test: P = 0.09, T = 1.95, df = 6.2). At the other end, similar numbers of canegrubs occurred in the trap and adjacent non-trap crops (two-sample t-test: P = 0.62, T = 0.5, df = 21). At Michielin's farm, the trap crop was a plant source at least 400 mm taller than adjacent cane. Similar numbers of canegrubs were found in the trap crop and in the adjacent cane at one end of the block (two-sample t-test: P = 0.72, T = 0.36, df = 22). No canegrubs were found in the other end of the block. Damage to the trap crops at Pilchowski's and Michielin's farms appeared uniform during an aerial inspection flight on 19 May 2000. No damage was observed in the adjacent blocks during aerial inspection and, hence, trap crops at Pilchowski's and Michielin's farms may have been successful.

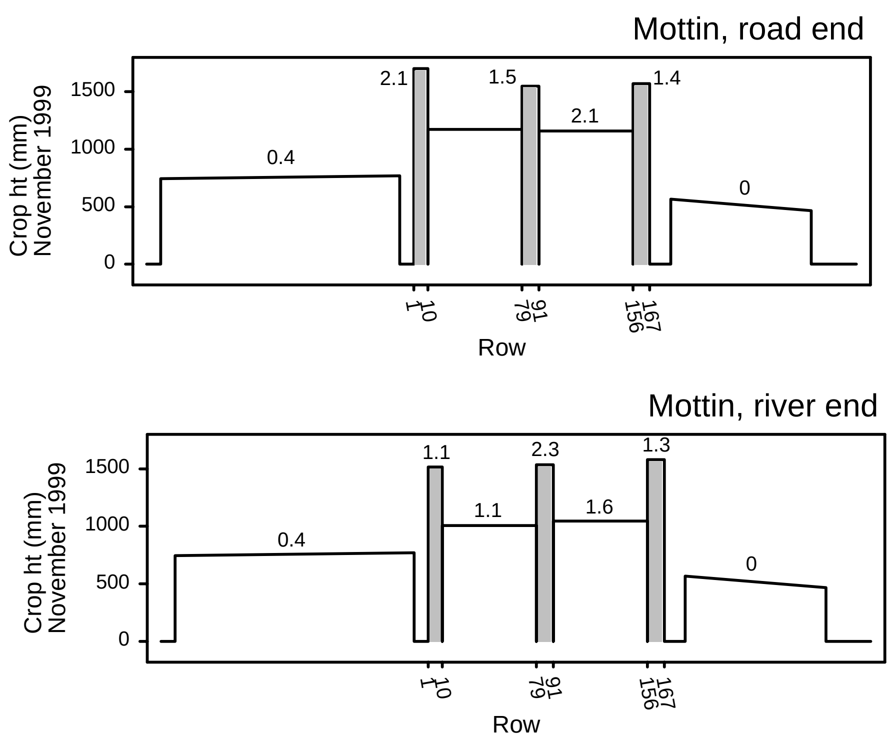

Figure 4.3: Crop profile for the top and bottom end of a plant block (centre block) with Q127 trap crops, and adjacent non-trap blocks at Mottin's farm. Shaded sections are the 10-12 row wide Q127 trap crops. Numbers above each block profile are the mean number of canegrubs/stool for 8-21 samples in March 2000.

Table 4.2: Mean numbers of canegrubs/stool in March 2000 and mean stalk height in November-December 1999 for ratoon trap crops and adjacent blocks.

Grower	Trap crop		Adjacent non-trap crops	
	Cane ht (mm)	Grubs/stool	Range of cane ht (mm)	Range of grubs/stool
Blaik	881.0	0.3	433-920	0-1.3
Hartwell	600.0	1.4	238.5-488	0.2-0.5
Kelly	830.0	2.3	270	0.1
Mau	1014.0	0.8	392-1223.5	0.1-1.3
Michielin	1066.6	0.8	642	0.6
Pilchowski	451.5	1.6	209-305	0.3-0.9
Shoyer	972.5	0.8	621.5-1176.5	0.12-2.6

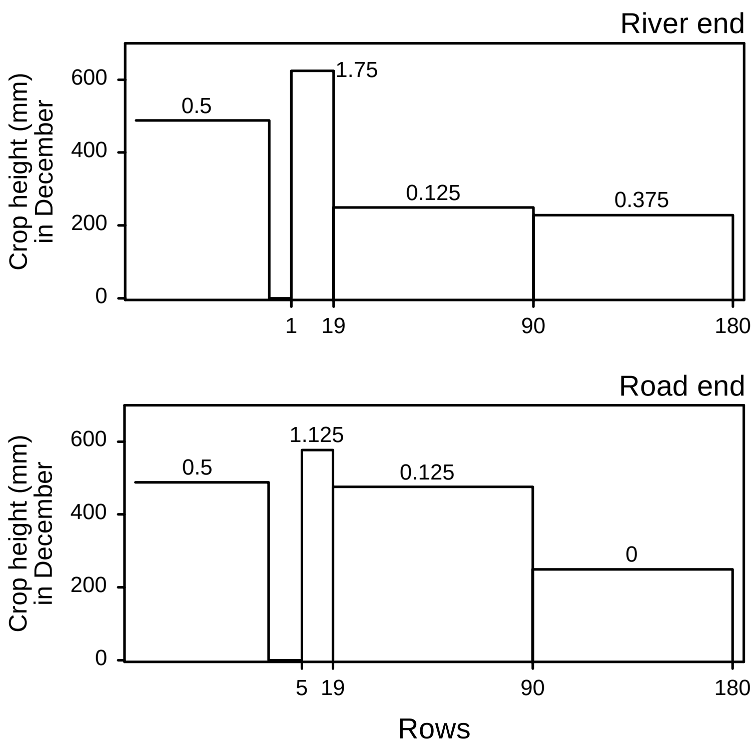

Figure 4.4: Crop profiles and grub numbers/stool (figures at the top of block profile) for trap crop (tallest block) and adjacent blocks for part of Hartwell's farm.

Data for trap crops in 1998 (Felesina, Sgarbossa, Becke) and 1999 (Kelly, Hartwell, Blaik) were combined to assess the effect of trap crop size on greyback infestation in adjacent blocks (Fig. 4.5). As planned trap crops at two sites (Becke, Blaik) were shorter than an adjacent block, the taller block was included in the analysis as the trap crop. Trap crop size was given as rows and regressed against the difference in grub numbers between traps and immediately adjacent blocks. The difference in height between the tallest block(s) for each site and the average height of the blocks either side was regressed with the difference in grub numbers between the same blocks (Fig. 4.5).

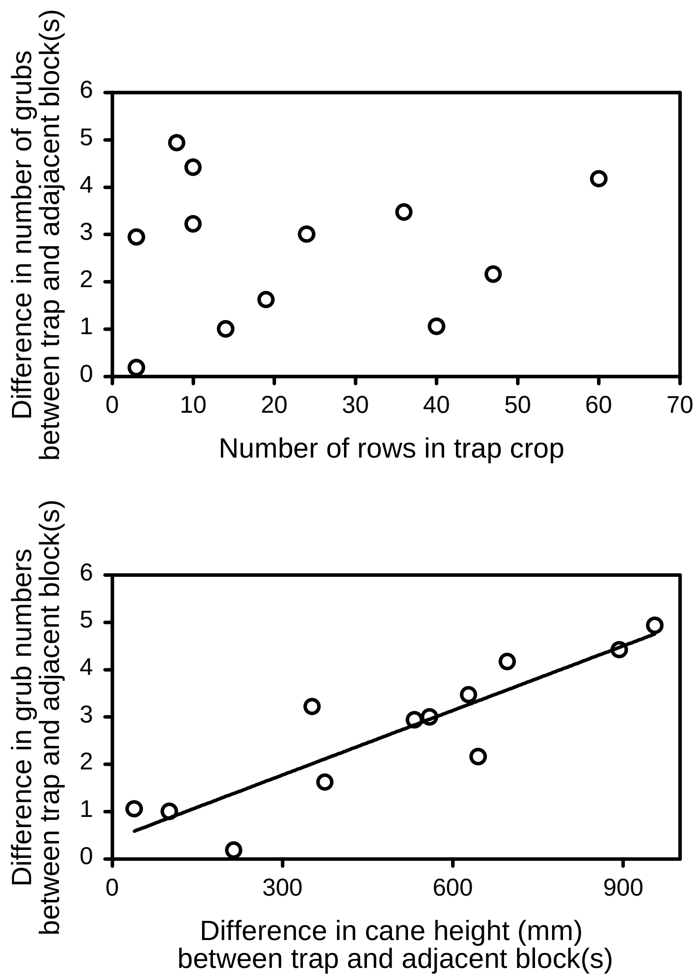

Figure 4.5: Comparison of trap crop size (number of rows) and difference in cane height between trap crops and adjacent blocks, and the difference in grub numbers between traps and adjacent blocks. A significant regression ($P < 0.05$) was fitted to data in the lower graph (difference in grub numbers = 0.41 + 0.0045 (difference in cane height), $r^2 = 0.79$), but not to the upper graph.

Numbers of rows in a trap crop did not affect the relative attractiveness of the trap crop (regression: P = 0.79, F = 0.07, df = 11) (Fig. 4.5). Difference in cane height between trap crops and immediately adjacent blocks significantly affected the relative attractiveness of the trap crop (regression: P < 0.0001, F = 36.9, df = 11) (Fig. 4.5).

Fertiliser trap crops

No canegrubs were found in the trap crops or adjacent cane at Davenport's farm (Table 4.3). A trap crop created with double rates of fertiliser at Spence's farm was shorter than adjacent cane (Table 4.3). There was no difference in the number of canegrubs/stool between the trap crop and the adjacent cane (P>0.05). Differences in the %N for leaf samples taken from the trap crop and adjacent cane in December were minor.

Table 4.3: Stalk height in December 1999, leaf nitrogen results and canegrub numbers/stool in March 2000 for fertiliser trap crops at Spence's and Davenport's farms.

Site	Treatment	Approx. kg N applied/ha	%N in leaf	Mean stalk ht (mm)	Mean grubs/stool
Spence	Non-trap	220	1.61	1180.5	1.4
	Trap	440	1.67	1034.0	0.9
Davenport 1	Non-trap	160	1.57	1042.3	0
	Trap	310	1.61	1023.0	0
Davenport 2	Non-trap	160	1.56	1290.0	nc*
	Trap	310	1.60	1430.0	0

* nc not counted

4.3 Effect of trap crops on damage and yield at the farm level

Farms were compared for the proportion of area damaged in to avoid distortions due to annual variations in area harvested and production. No differences are apparent for proportion of area damaged and production lost between farms with trap crops and those without trap crops (Fig. 4.6). The presence of one or more trap crops did not affect the area damaged due to greyback canegrub (ANCOVA, F = 3.5, df = 8, P = 0.10). Other unpublished reports (R. Schultz, R. Cocco pers. comm.) suggest that the productivity of farms in the Burdekin with and without damage by greyback canegrub does not differ.

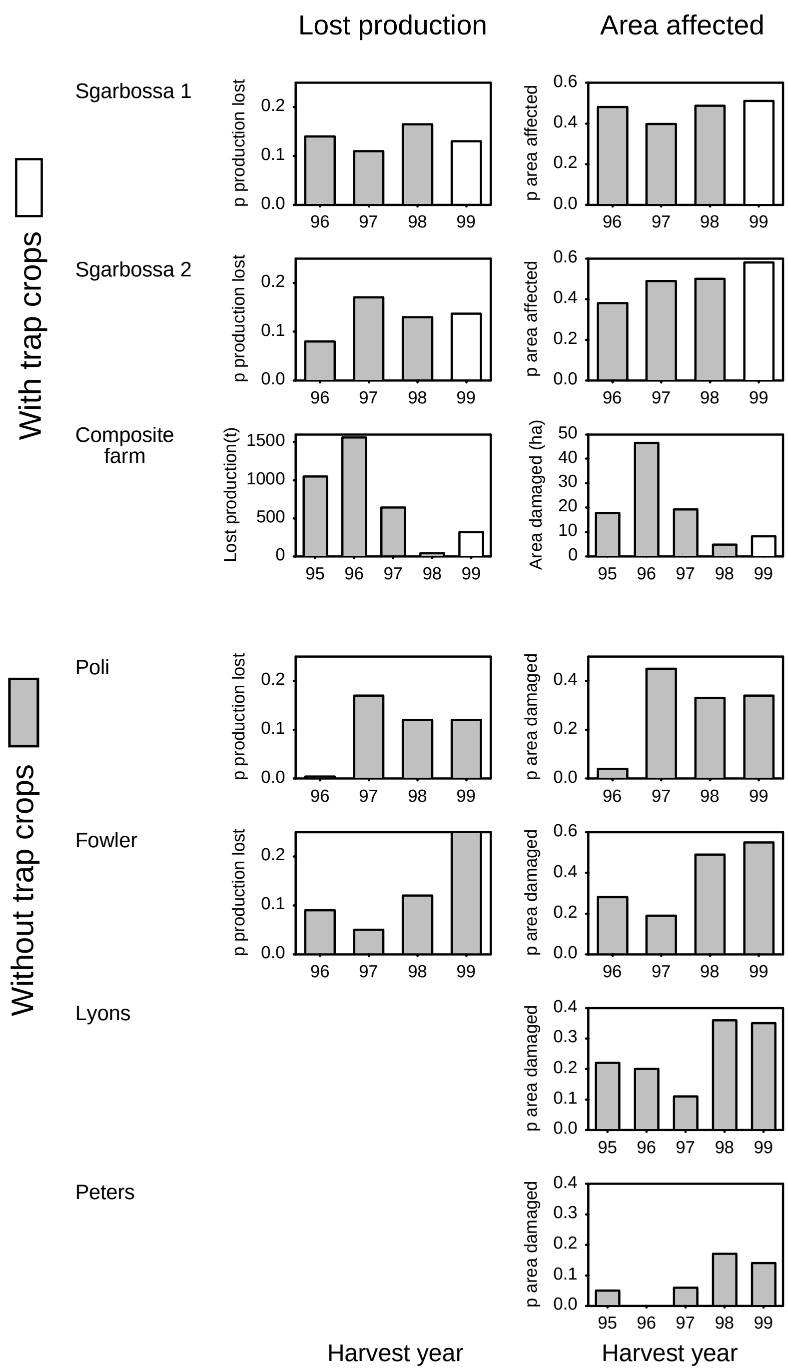

Figure 4.6: **Proportion of cane production lost due to greyback canegrubs and proportion of harvested area affected by grub damage for farms with and without trap crops. The composite farm is made up of a trap crop and adjoining blocks. Area harvested/year and production were not available for most years for these blocks. As a result, actual figures for production lost and area damaged are graphed.**

4.4 Greyback beetle flight and dispersal

There was a distinct single peak in the flight of greyback beetles at four of nine sites with light traps in 1998-99 (Fig. 4.7). Data at two sites were disregarded. At one site, trap catches were incomplete due to regular failure of the light trap. At the second site, data were probably unreliable because the grower moved the trap during the trap period. Most beetles in 1999-2000 were captured in the second and third week of December (Fig. 4.8), two weeks later than major beetle flights in the summer of 1998-1999.

In 1999-2000, Type 1 intercept trap catches of greyback beetles at Sgarbossa's farm were dissimilar in pattern to light trap catches (Kolmogorov-Smirnov test statistic = 0.29, $P < 0.0001$) (Fig. 4.8). Beetles were captured by light trap and intercept trap at a consistent 1:1 sex ratio throughout most of the flight period during 1999-2000 (Fig. 4.8). More females than males tended to be captured by light traps towards the end of the flight period (Fig. 4.8). Gravid females made up 12.7% of females captured by light traps (range 0-45%) (Fig. 4.9). Most (average 87%, range 55-100%) females captured by light traps had no or some fully grown oocytes and were not ready to lay eggs (Fig. 4.9). In 1999, type 2 intercept traps for egg-laying females captured too few beetles to provide useful data.

In 1998, there was a trend for type 1 intercept traps standing above short cane to capture more beetles than traps in or above tall cane (ANOVA, $F = 6.5$, $P = 0.055$) (Table 4.4). Most beetles captured were females (74%) ($\chi^2 = 8.2$, $P = 0.004$), and only females were captured in traps in tall cane. Most of these females were gravid (Table 4.4).

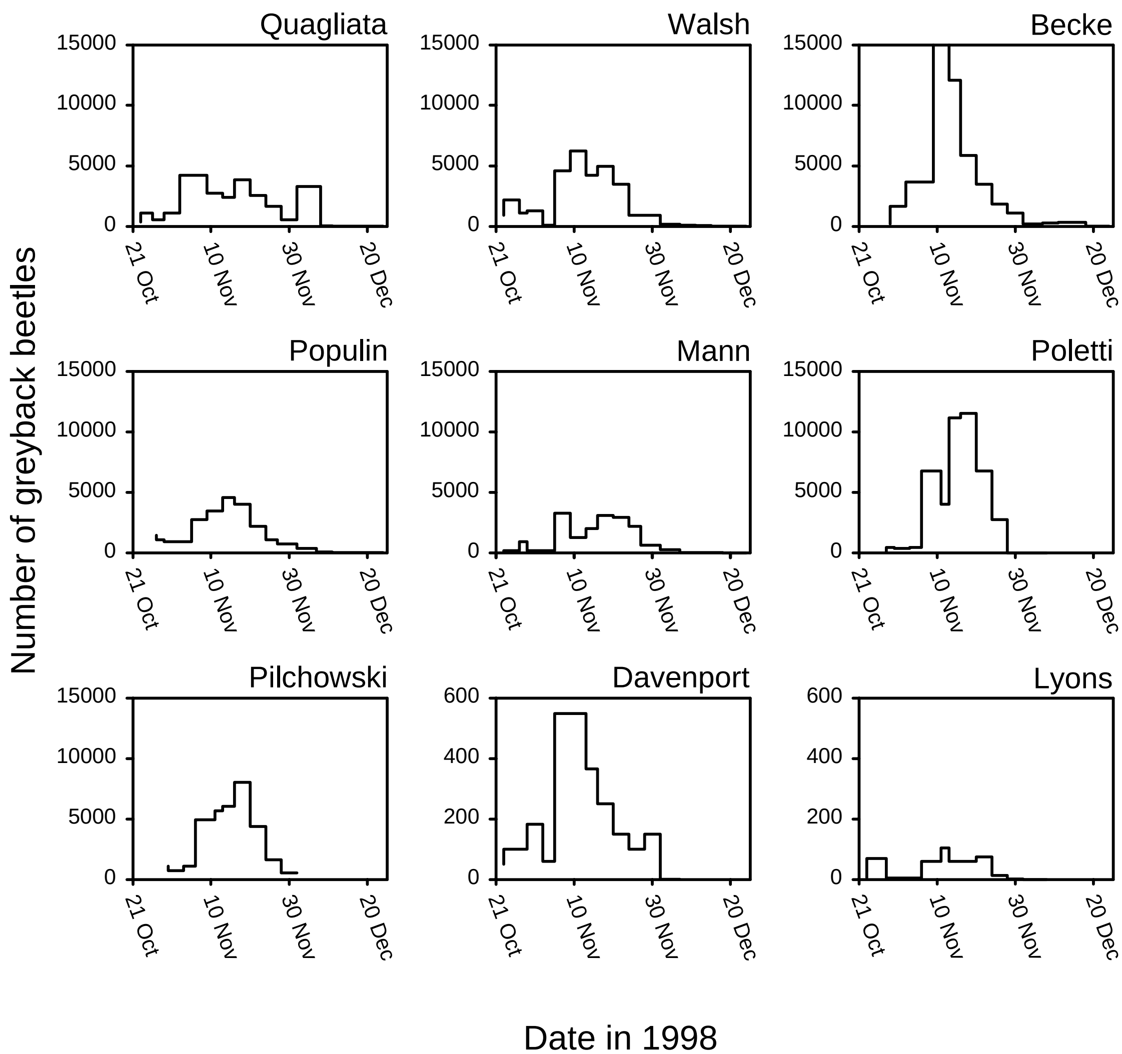

Figure 4.7: Light trap catches of greyback beetles in the Burdekin during 1998

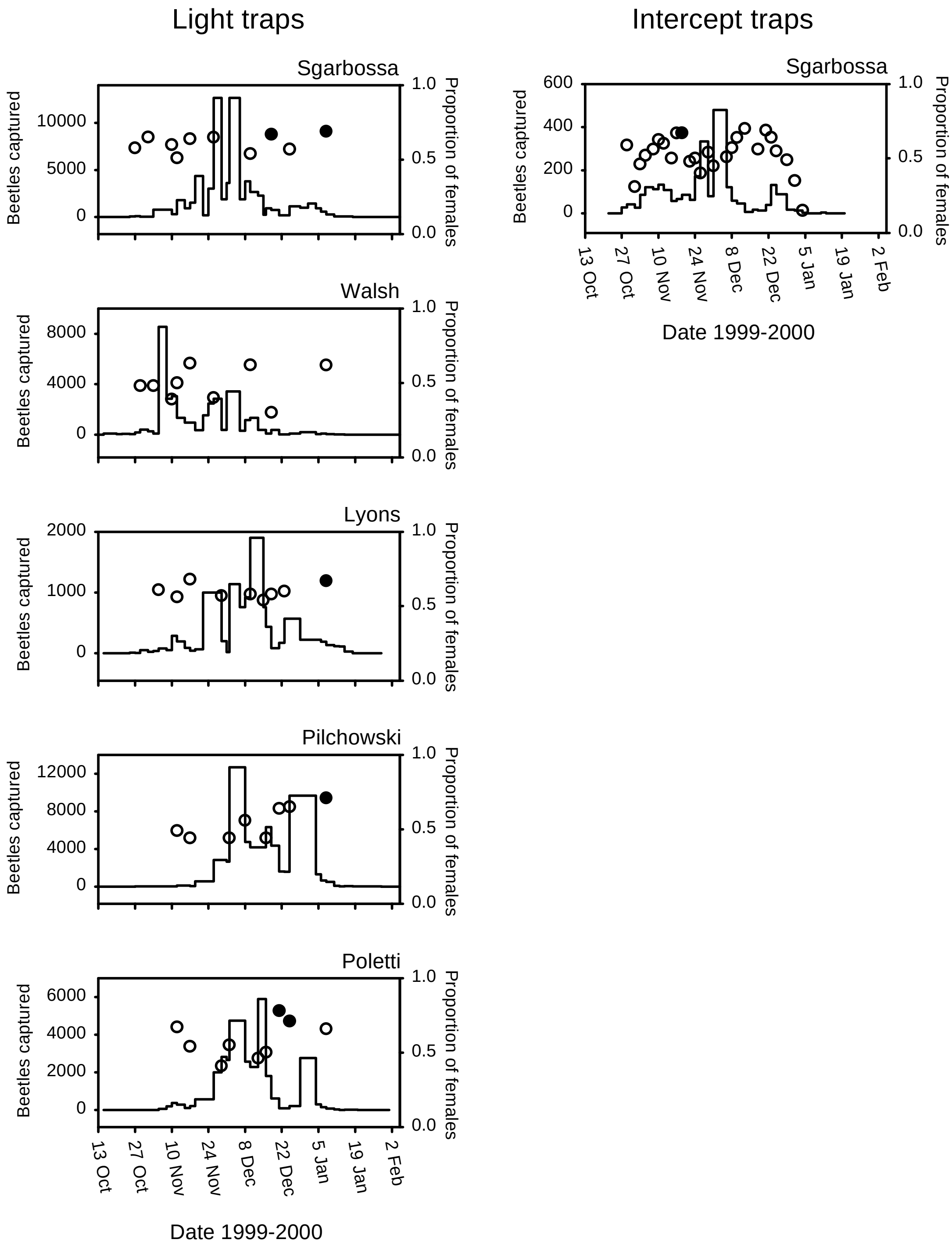

Figure 4.8: **Light trap and intercept trap catches of greyback canebeetles (solid lines) and the proportion of the catch that were females (open and closed circles) in the Burdekin during the summer of 1999-2000. Closed circles represent sex ratios different to unity at P < 0.05 (Chi-square analysis of 2 x 2 contingency tables).**

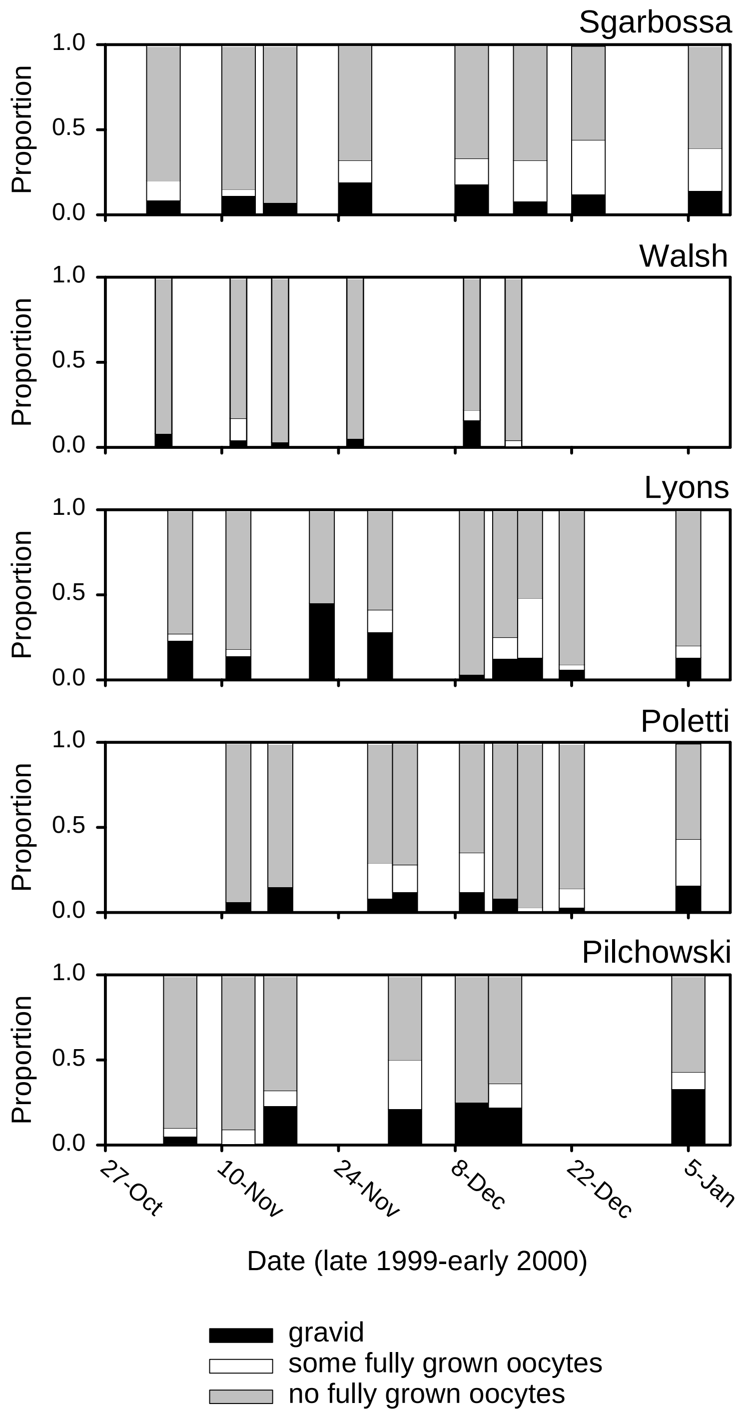

Figure 4.9: Proportion of females captured by light traps on five farms that were gravid (with most or all oocytes fully grown), or not ready to lay eggs (with some or no fully grown oocytes). Sample number varied from 19-72 females.

Table 4.4: Sex and ovarian status of greyback beetles captured in Type 1 intercept traps placed in a trap crop and in adjacent short cane (non-trap crop). Beetles were captured over a period of 11 days from 5 December 1998.

Crop type	Trap position	Sex and ovarian status of beetles		
		Males	Non-gravid females	Gravid females
Trap crop	Above canopy	0	3	6
	Below canopy	0	0	5
Non-trap crop	Above canopy	17	24	11

Capture-mark-release experiments

Capture-mark-release experiments failed to provide adequate data to estimate dispersion. In 1998, most of 1,800 marked beetles (60%) did not fly on the night of release. Many died or remained at the release point in the cane field. A single beetle was recaptured, 99 m from the release point. Of approximately 1,200 marked beetles released from a cane field 70 m from the riverbank in 1999, seven were recaptured. Six marked beetles were captured in the nearest light trap on the night of release and one beetle was captured on the following night in the same trap.

Marked beetles were recaptured in light traps on days 1-8 (Trap A) and days 1- 3 after release (Trap B) (Fig. 4.10). Relatively fewer marked beetles were captured in Trap A (0-4%) compared with trap B (0-19%).

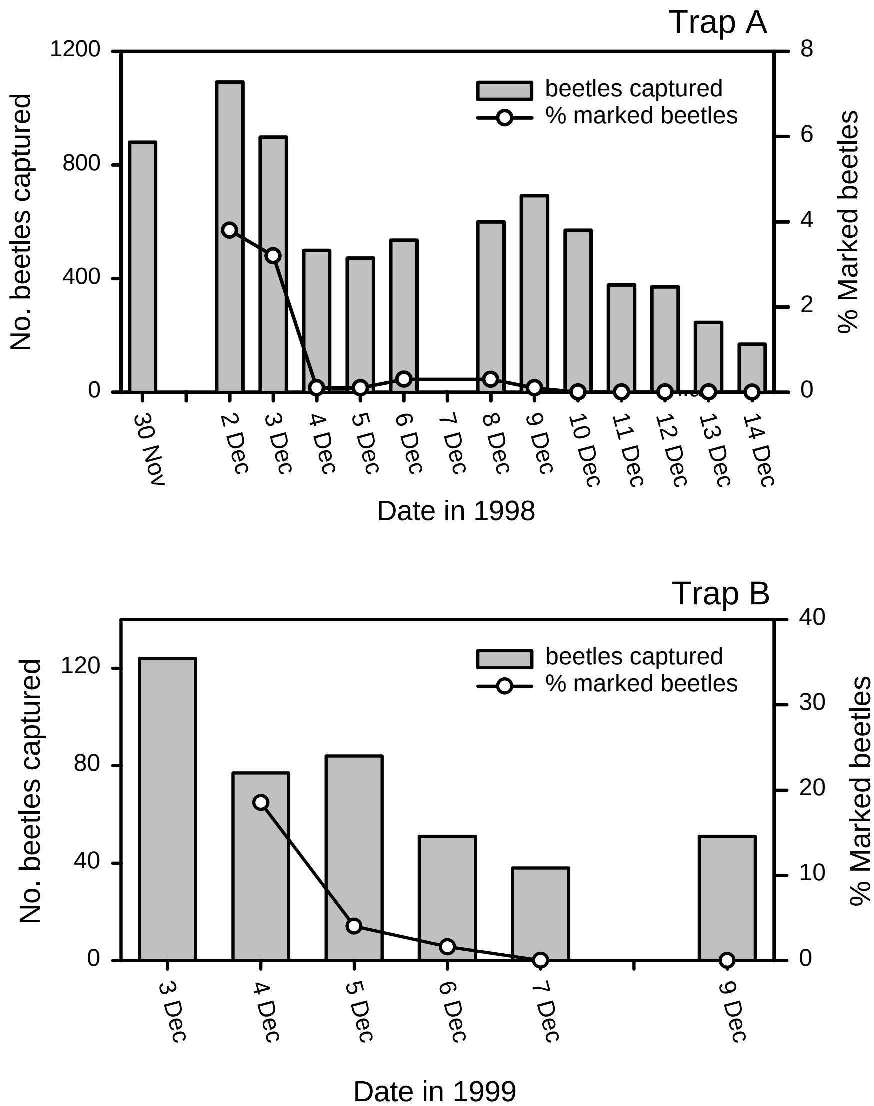

Figure 4.10: Daily capture of marked and unmarked beetles in two light traps

5.0 DISCUSSION

5.1 Interpretation of results

5.1.1 Trap crops

The level of infestation of trap crops and surrounding blocks was closely related to the differences in the height of cane between trap crops and other crops. Maximising the difference in cane height at the time of beetle flight is crucial for the success of trap crops.

The type of trap crop and the cane cultivar have no significant effect. Blocks of early plant cane act as trap crops, and should always be treated with an insecticide. The establishment of ratoon trap crops represents a new option for Burdekin growers to manage greyback canegrub damage. Other types of trap crops, such as forage sorghum, remain to be tested more thoroughly, and require a greater change to farm management practice than ratoon cane trap crops. Specialist planting equipment is required, appropriate seed beds need to be available, and planting needs to take place at the correct time to maximise the height of trap crops relative to adjacent cane.

The size of trap crops, measured in rows of cane for easy implementation, was not critical to maximising differences in canegrub density between trap crops and adjacent blocks. We were not able to establish an optimal size of trap crop. Ratoon trap crops established by growers in the Burdekin have been 10-30 rows wide, as advised by BSES staff based on initial experience with trap crops.

Irrigating trap crops more frequently than non-trap crops in August-December is desirable to maximise differences in height between non-trap and trap crops. Growers are reluctant to irrigate ratoon trap crops if the remainder of the block is being dried off for harvest. Trap crops of less than 30 rows cannot be irrigated in isolation; to reduce flow rates to acceptable levels, pumped water needs to be dispersed over larger areas.

The position of trap crops relative to feeding trees on the riverbank is not critical. Damage by greyback occurs in blocks with rows running parallel or perpendicular to the riverbank. The optimal number of trap crops on a farm and the optimal distance between them remains unknown. The effectiveness of individual trap crops and the likely absence of a suitable comparison complicate assessing the effect of several trap crops. Trap crops of different attractive power may give different results to the same number of trap crops with equal drawing power.

Production of cane from farms with and without trap crops did not differ. At least two factors reduce differences in production between farms with and without canegrub damage in the Burdekin. Firstly, farms adjacent to the rivers and in the Burdekin Delta tend to be among the most productive farms. These farms also tend to have the most damage due to greyback canegrubs. Secondly, farmers tend to minimise production losses due to canegrubs by changing farm management. Canegrub-damaged blocks are harvested in the first round to minimise production loss and generally replanted the same year (plough-out-replant cycle). In a 100% rotation system, plough-out replant tends to be more productive on a whole-farm basis than the practice of fallow-early plant. However, production costs are likely to be higher for grub-damaged farms than those without damage as a result of higher replanting costs, insecticide treatment costs and cost of lost production in affected plant and ratoon crops. Trap crops are likely to provide an economic advantage by restricting damage to smaller areas and reducing replanting and insecticide costs, and production losses. This may be evident when consultants, Macarthur Agribusiness, complete detailed economic analysis of canegrub-damaged and canegrub-free farms in the Burdekin and of various control methods, including trap cropping.

5.1.2 Greyback beetle flight and dispersal

Most greyback beetle flight in the Burdekin was restricted to a 3-4 week period in the summers of 1998-1999 and 1999-2000, as indicated by light trap catches. Egg-laying may occur in a similarly short period, although no data are available to confirm this. Most females captured in light traps were not ready to lay eggs. Intercept traps placed on headlands (1999-2000) captured males and female beetles in equal numbers consistent with light trap catches. Non-gravid females and male beetles may actively disperse over cane fields at distances of several hundred metres or more from riverbanks. Active dispersal is consistent with the rapid decline of marked beetles captured in light traps. The majority of beetles captured by intercept traps in a trap crop were gravid females. Further study with intercept traps in relatively tall cane may provide more information on the phenology of gravid females. Linking phenology data for gravid females with cane height measurements is likely to improve our understanding of trap cropping.

Studying dispersal of greyback canebeetles proved difficult with mark-release-recapture methods. Failure of mark-recapture methods was largely due to the failure to mark large enough numbers of beetles. Light traps capture inadequate numbers of beetles for marking and probably a very minor proportion of the available population. Identifying recaptured beetles marked with paint was also a problem. Large numbers of beetles in light traps removed scales and probably paint markings. Removing part of the elytron avoided this problem. But, this method is very time-consuming. Different methods are needed to quantify greyback dispersal. For example, the use of a GIS with historical records of canegrub damage to blocks at the subdistrict or district level may allow a better understanding of the pattern of greyback dispersal.

5.2 Commercial impact

The project has coincided with an increased interest in trap crops amongst Burdekin growers. In the 1999-harvest season, nine growers attempted to create trap crops to concentrate damage due to greyback canegrub. In the 2000-harvest season, approximately 20 growers attempted to create trap crops, many independently of BSES staff. Interest in trap crops remains high for the 2001 harvest season, due mainly to the promising results from ratoon treatment with Confidor® 200SC (200 g/L imidacloprid). By treating ratoon trap crops with an insecticide, growers hope to avoid heavy damage to trap crops by canegrubs and grow another ratoon crop.

6.0 FURTHER WORK

Interest in trap crops has increased recently following promising results from trials of Confidor applied to ratoon trap crops. Many growers are optimistic that the use of Confidor in trap crops will reduce problems with greyback canegrub. Trials with Confidor in trap crops in the 2001 crop will provide more data on the efficacy of trap crops in the Burdekin.

7.0 RECOMMENDATIONS

In the light of grower and planting-contractor reluctance to plant small areas as trap crops, the following recommendations are made for the Burdekin:

- Growers in grub-prone areas are encouraged to treat plant crops as trap crops and always apply insecticide (suSCon Blue® (chlorpyrifos 140 g/kg) with acidifiers, suSCon Plus when commercially available, or BioCane™ in the case of low-risk or late-planted blocks).

- Growers should consider creating ratoon trap crops in one or more blocks by harvesting sections of blocks in the first three rounds. Harvested sections in the order of 10-20 rows wide are effective. Ratoon trap crops should be treated with Confidor® 200SC when this chemical is registered.

- To maximise their effectiveness, ratoon trap crops must be 0.5 m or more taller than adjacent blocks. The greater the height difference, the more likely the trap crop is to attract beetles. This may be achieved by harvesting sections of cane in the first two or three rounds and adjacent cane in later rounds.

8.0 PUBLICATIONS

There are currently no publications arising from this work.

9.0 REFERENCES

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