IMPLEMENTATION OF A RISK ASSESSMENT PROGRAM TO FORECAST GREYBACK CANEGRUB DAMAGE IN MULGRAVE SUGARCANE FIELDS

By

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Abstract

RISK ASSESSMENT OF damage caused by the greyback canegrub, *Dermolepida albohirtum*, was implemented in the Mulgrave sugarcane growing region of Far North Queensland. Twenty growers participated in a 'GrubPlan' Integrated Pest Management (IPM) program where the risk of potential greyback infestation on selected fields on their farms was assessed. This was based on monitoring grub numbers and damage levels in 2008 to predict grub densities in 2009 using previously developed prediction models. Growers were advised whether or not to treat these fields according to the predicted level of risk, and the majority of growers accepted our recommendations. The same fields were sampled again in 2009 to validate predictions. Data showed a significant reduction in grub numbers where growers applied a chemical treatment following our recommendations. Grub numbers did increase in fields that were not treated; however, where growers were advised to refrain from treatment, grub numbers were still well below economic levels. We also validated two types of prediction models that are currently available: 1) a discriminant model, which predicts the likelihood of grub densities being either low, medium or high, and 2) a regression model, which predicts actual grub number/plant in the following year. Results showed that the discrimination model was more reliable, while more work is needed to improve the regression model. This study demonstrates the feasibility of implementing a risk assessment program to enable strategic application of insecticides and to encourage growers to embrace a proactive approach towards grub management. The success of this project confirms the value of BSES extension programs and demonstrates the importance of research-based extension in pest management.

Introduction

The greyback canegrub, *Dermolepida albohirtum* (Waterhouse) (Coleoptera: Scarabaeidae), is the principal pest of sugarcane crops in the area stretching from Mossman in Far North Queensland to Sarina in the Central District (Allsopp *et al.*, 1993). This pest exhibits a one-year lifecycle where adult beetles emerge following the onset of rainfall around October–December, and lay eggs in the soil in December–January. The larval stages feed extensively on the root mass, causing reduced growth, stool tipping and ultimately plant death.

By the time damage symptoms are apparent in the field in May–June, it is too late (and also unfeasible) to conduct chemical treatment. The sugarcane crop usually becomes too large to treat by about December, and machinery use at that stage will be destructive to the crop. Hence, sugarcane growers need to make a decision on chemical treatment well before the commencement of beetle flight, and, because it is not easy to predict where adult beetles will lay their eggs, this needs to be based on a risk assessment to ensure vulnerable crops are protected and to avoid treatment where fields are unlikely to attract infestation.

A number of parameters are available to assist in making a reasonable assessment of risk; for example, canegrub damage is a function of the extent of damage sustained in the same field or fields nearby in previous years (Samson, 2008). Other factors include the rate of pesticide application, level of regional grub damage and infection levels by beneficial pathogens, in particular the protozoan *Adelina* sp. which infects the larval stage (Robertson *et al.*, 1998; Sallam *et al.*, 2008; Samson, 2008). Until recently, no reliable risk assessment methodology by which a sound prediction could be made has been available, and growers' attitude towards grub infestation has always been reactionary, where levels of pesticide application decrease following the decline of grub populations and vice versa (Sallam *et al.*, 2008). However, a recent Integrated Pest Management approach was initiated and delivered to the sugarcane industry in 2001 under the training program 'GrubPlan' (Hunt *et al.*, 2002, 2003, Samson *et al.*, 2005).

That program aimed at monitoring grub populations and provided advice to growers not only on chemical treatment but also on farming practices that ultimately reduce reliance on insecticides. Furthermore, grub monitoring data that were generated through that program were used to build prediction models to forecast future population dynamics (Samson, 2008). These initiatives were designed mainly to ensure strategic application of insecticide so that chemical treatment is practiced only when needed. Adoption of this strategy means money can be saved by refraining from treatment in years of low grub pressure or by treating proactively to prevent emerging infestations from escalation.

In this paper, we report on a GrubPlan initiative that was implemented in the Mulgrave region of Far North Queensland. The initiative relied on implementing a regional grub monitoring system and deploying the available prediction models to predict future risk. Participating growers were provided with advice on potential grub dynamics and possible future damage levels. This study was the first to practically implement and test the risk assessment program developed by BSES Limited.

Material and methods

Grub monitoring and damage assessment

We selected 42 sugarcane fields or parts of fields belonging to 20 Mulgrave growers each measuring about 1 ha for grub monitoring and damage assessment in 2008. Selection of the fields was principally based on their known history of grub damage. Grub monitoring was conducted by digging 20 holes per field. The holes were in the four corners and the middle of the field. Each sample was taken by removing a 30 cm cube of soil that contained the root mass using a shovel. The soil was inspected for canegrubs and all grubs found were collected and reared in the laboratory in 30 mL plastic containers until they either produced an adult beetle or died in their larval or pupal stage. Cause of death was determined and mortality rates recorded.

A surveillance flight was conducted in June 2008 to assess regional grub damage. This was further 'ground-truthed' by examining all damaged patches recorded during the flight to ensure that damage was due to greyback canegrubs. Information on the history of insecticide use in the sampled plots was sourced from growers.

Grub density and mean grubs/plant prediction

We used three prediction models that were developed by BSES Limited in collaboration with University of Maine to forecast grub densities in the following year based on information gathered this year (Samson, 2008). Model inputs included information on history of chemical treatment, severity of damage in the sampled plot and adjacent plots, regional average of grub numbers and regional average of infection by the *Adelina* pathogen in year 0. Data collected were entered into the two discriminant models (Model 1 and Model 2) to calculate a likelihood of low, moderate and high greyback grub damage in the following season (Tables 1a). If one or both models showed a ≥ 50% probability that a particular plot would sustain moderate or high grub numbers in 2009, then the grower was advised to treat that plot if it was to be ratooned. If the probability of sustaining moderate or high densities was less than 50%, then the grower was advised to refrain from treatment in that particular plot in 2008. This was done for all sampled plots and growers were advised accordingly. A regression model (Model 3) was used to predict grub numbers/stool in the following year (Tables 1b). This model required information on the status of the plot (whether it was a fallow-plant or replant) and crop age (plant cane or ratoon).

Table 1—Extract from the model spreadsheet. (a) parameter entries of Yr 0 and probability of damage outputs for Yr 1 for a selected grub monitoring plot using two discriminant models. (b) parameter entries of Yr 0 and predicted grub numbers for Yr 1 using a regression model.

(a)

Predictor variables	Model 1	Model 2
Protected (suSCon 3 yrs, Confidor 1 yr) = 1, Unprotected = 0	0	0
Grubs/stool Yr0	0.45	
Grub presence Yr0 (present = 1, absent = 0)		1
Severity of damage (0–3) Yr0	1	1
Max severity within 400 m (0–3) Yr0	1	1
Grubs/stool regional average Yr0	0.17	0.17
% *Adelina* regional average Yr0	17.74	17.74
Probability (low)= %	20	34
Probability (moderate)= %	75	62
Probability (high)= %	5	4

(b)

Predictor variables	Model 3
Fallow = 1, Replant = 0	0
Ratoon=1, Plant crop = 0	1
Protected (suSCon 3 yrs, Confidor 1 yr) = 1, Unprotected = 0	
Grubs/stool Yr0	0.45
Severity of damage (0-3) Yr0	1
Max severity within 400 m (0–3) Yr0	1
Grubs/stool regional average Yr0	
% *Adelina* regional average Yr0	17.74
Predicted grubs/stool Yr1	0.37

Validating predictions made in 2008

Numbers of greyback canegrubs were sampled again in the same plots in the following year (March 2009). Six plots were discontinued due to either replanting or fallowing in 2008. Grub numbers were compared between the two years in treated and untreated fields using a paired two-sample t-test. The take up of the recommendations by growers was assessed.

Growers survey

At the conclusion of the monitoring program, growers were requested to fill in a survey form in which they were asked, among other questions, to place a value on their savings in fuel, pesticide and labour costs as well as to estimate any significant yield increase that they believed they had achieved by implementing BSES's recommendations.

Results and discussion

Grub density and mean grub/plant prediction

Discriminant models (Models 1 and 2)

Table 2 shows model predictions for each sampled plot, recommendations given to growers after 2008 monitoring and the growers' actions. According to the two discriminant models, 27 plots had less than 50% chance of sustaining moderate or high grub numbers in 2009, and hence the owners were advised to refrain from treating these particular plots. For the remaining 15 plots, one or both prediction models estimated a higher than 50% chance of sustaining moderate or high grub numbers in 2009, and hence growers were advised to apply insecticide in those plots. Most growers agreed to follow our recommendations if they were to ratoon the plot under study. In three cases (sites 26, 27 and 31), growers did not follow our recommendation to protect their plots and grub numbers escalated by 3–4 fold in 2009 in those plots. However, the owners of those three plots cited reasons beyond their control as to why they were unable to follow recommendations.

On the other hand, there were two cases where growers were advised not to treat but opted to treat (sites 24 and 39). One of these two plots (site 39) had to be protected against a different canegrub species, *Lepidiota frenchi*, which is the major pest species in that particular area. Since the model we used is designed to only predict greyback grub dynamics, it was logical to predict no greyback infestation in 2009 (hence the advice not to treat). However, a rational decision was taken by the grower to protect that plot and curb a possible escalation of *L. frenchi,* which was widespread in that area in 2008. Nevertheless, the majority of growers did follow our recommendation in 31 cases and only neglected our advice in four cases (three of which were due to reasons beyond the growers' control). This reflects a reasonable degree of confidence in the monitoring program and is likely to encourage other growers to implement risk assessment on their farms to combat the canegrub problem.

Figure 1 compares grub numbers in 2008 and in 2009 in plots that received chemical treatment in 2008, while Figure 2 compares 2009 results only in plots that were not treated in 2008. Where fields were treated, a significant decline in grub numbers was obvious (t=2.17; df=12; P=0.0097), while the opposite was true in most cases for fields that were not treated (t=2.07; df= 22; P=0.0013).

Despite an increase in grub numbers in plots where growers were advised to refrain from treatment, numbers were still below economic levels (which are usually between 1.5—2.0 grubs/plant). On the other hand, where growers neglected to treat despite the advice to treat (i.e. in sites 26, 27 and 31), grub numbers almost reached economic injury levels. These results confirm the soundness of the damage prediction models, and emphasise the significance of practical implementation of risk assessment in a field situation.

Regression model (Model 3)

Figure 3 shows the correlation between predicted grub numbers based on the regression model (prediction model 3) and the observed grub numbers (based on actual field monitoring). Only fields that received no chemical treatment in 2008 were used to validate the model. There was a moderate correlation between the two sets of values (R^2=0.425; P=0.0005), indicating a degree of 'soundness' to the model. However, the slope was greater than 1, indicating that grub numbers tended to be greater than predicted, and the maximum number of grubs/stool predicted by the model was less than 0.5 grubs/stool when the actual observed numbers were up to 2.0 grubs/stool. Hence, more work is required to enhance the model's accuracy.

Table 2—Model predictions, BSES's recommendations and growers' actual actions.

Site	Farm no.	Blk no.	Prediction1			Prediction2			Recommendation	Grower's action
			%Low	%Mod.	%High	%Low	%Mod.	%High		
1	106	7-1	55	39	7	46	47	7	Don't treat	Did not treat
2	106	8-1	77	20	4	71	24	5	Don't treat	Replanted
3	856	5-1	33	66	1	52	48	0	Treat	Treated
4	231	3-1	68	31	0	52	48	0	Don't treat	Did not treat
5	231	1-1	60	40	0	52	48	0	Don't treat	Did not treat
6	73	17-2	64	31	5	46	47	7	Don't treat	Did not treat
7	33	4-1	80	19	0	76	23	0	Don't treat	Did not treat
8	78	8-1	43	53	4	34	62	4	Treat	Treated
9	94	17-1	20	75	5	34	62	4	Treat	Treated
10	94	17-2	53	44	3	34	62	4	Treat	Treated
11	82	1-2	28	71	1	46	47	7	Treat	Treated
12	67	4-3	68	30	2	60	36	4	Don't treat	Did not treat
13	270	5-5	77	20	4	71	24	5	Don't treat	Did not treat
14	313	19-5	53	46	0	52	48	0	Don't treat	Did not treat
15	313	10-1	80	19	0	76	23	0	Don't treat	Did not treat
16	58	3-2	55	39	7	46	47	7	Don't treat	Fallowed
17	17	12-2	55	39	7	46	47	7	Don't treat	Fallowed
18	17	14-5	17	78	5	34	62	4	Treat	Treated
19	434	22-1	53	46	0	52	48	0	Don't treat	Did not treat
20	64	6-1	68	31	0	52	48	0	Don't treat	Did not treat
21	413	8-1A	15	22	63	20	22	58	Treat	Treated
22	413	8-1B	7	25	68	20	22	58	Treat	Treated
23	413	8-2	14	22	64	20	22	58	Treat	Treated
24	779	19-1	68	31	0	52	48	0	Don't treat	Treated
25	220	6-1	32	66	2	23	75	2	Treat	Treated
26	18	1-1	16	79	5	34	62	4	Treat	Did not treat
27	18	2-1	20	75	5	34	62	4	Treat	Did not treat
28	827	8-3	92	8	0	90	10	0	Don't treat	Did not treat
29	827	5-1	60	40	0	52	48	0	Don't treat	Did not treat
30	853	22-2	71	29	0	52	48	0	Don't treat	Did not treat
31	94	6-1	24	71	5	34	62	4	Treat	Did not treat
32	78	11-1	77	20	4	71	24	5	Don't treat	Did not treat
33	78	13-7	36	55	9	46	47	7	Treat	Treated
34	82	1-3	44	55	0	52	48	0	Treat	Replanted
35	82	8-5	53	46	0	52	48	0	Don't treat	Did not treat
36	82	8-6	53	46	0	52	48	0	Don't treat	Did not treat
37	67	8-1a	77	20	4	71	24	5	Don't treat	Fallowed
38	67	8-2b	55	39	7	46	47	7	Don't treat	Fallowed
39	67	4-1	64	31	5	46	47	7	Don't treat	Treated
40	270	4-4	71	29	0	64	35	0	Don't treat	Did not treat
41	270	4-5	64	31	5	46	47	7	Don't treat	Did not treat
42	270	4-7	77	20	4	71	24	5	Don't treat	Did not treat

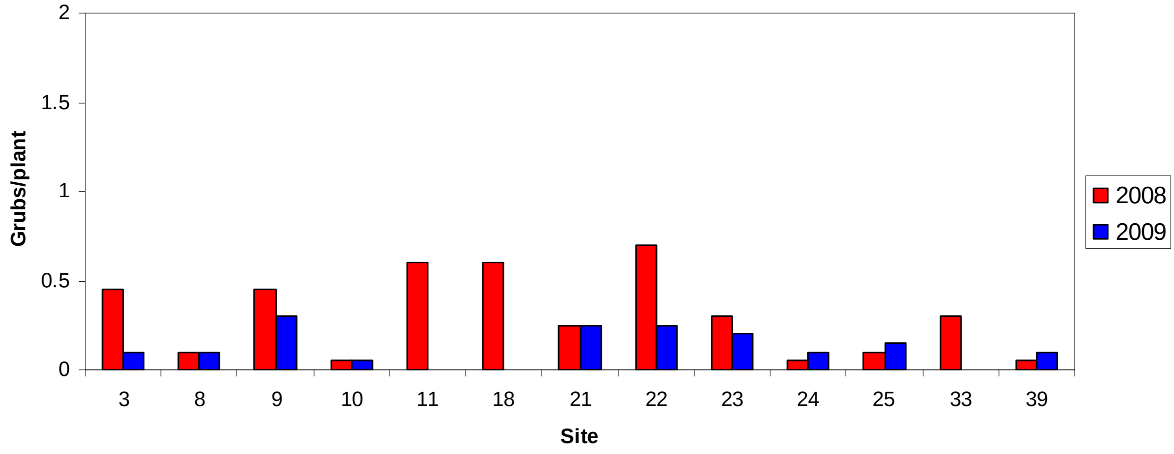

Fig. 1—Comparison of grub numbers in 2008 and 2009 in monitoring plots that received insecticides in 2008.

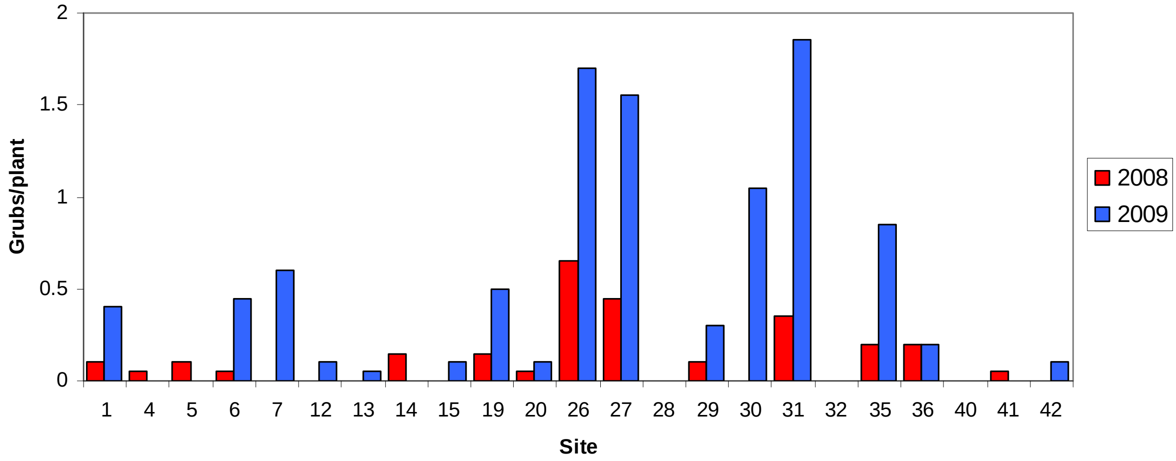

Fig. 2—Comparison of grub numbers in 2008 and 2009 in monitoring plots that did not receive insecticides in 2008.

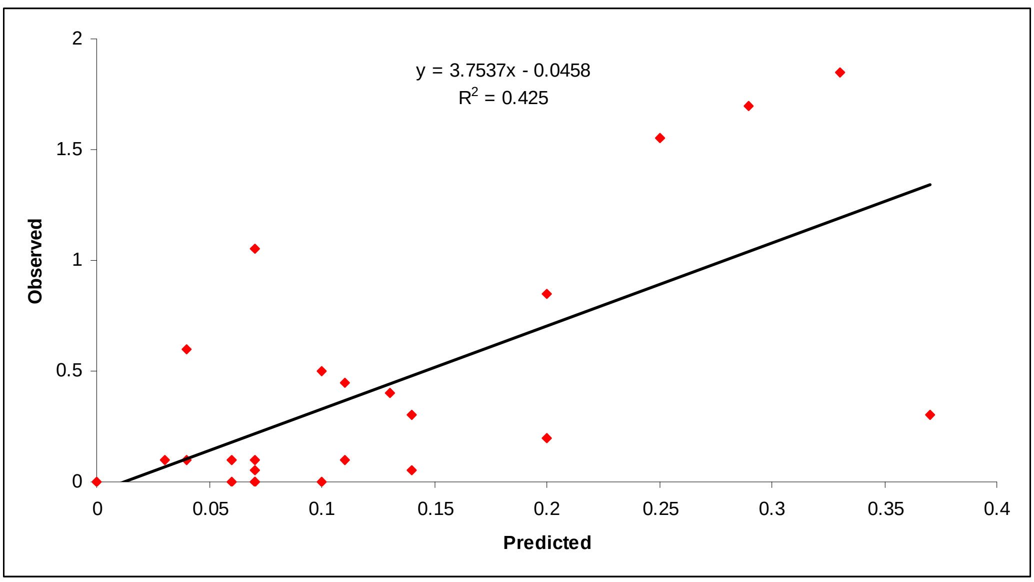

Fig. 3—2008-predicted versus 2009-observed grub numbers (grubs/stool) in untreated monitoring fields in Mulgrave.

Growers survey

Answers to the survey questions were provided by 15 participating and 9 non-participating growers. Tables 3 (a and b) show amounts that growers estimated as savings in fuel, pesticide application or labour, as well as estimated gain in increased yield as a result of following (or possible future implementing of) the BSES risk-assessment program. Not all surveyed growers replied to all aspects of the questions. However, estimations of annual savings ranged from a few hundred dollars to thousands of dollars, being either reduced input costs (for example due to strategic application of insecticides) or savings achieved via avoiding significant damage. These are encouraging results and demonstrate the benefits as well as the feasibility of establishing a regional forecast system in Queensland sugarcane fields.

Tables 3—Estimated savings (or potential savings) resulting from this project by (a) 15 growers participating in the grub monitoring program and (b) 9 non-participating growers.

(a)

No. of growers providing answers	Activity	Estimated savings ($)	No. growers
5	Insecticide	1500–2000	4
		3000–5000	1
5	Fuel	100–300	2
		500–600	2
		1000–2000	1
4	Labour	300–1000	2
		2000–3000	2
2	Increased yield	Y	1
		8000	1

(b)

No. of growers providing answers	Activity	Estimated savings ($)	No. growers
5	Pesticide	1500–2000	3
		10000–20000	2
4	Fuel	300–500	2
		1000–2000	2
3	Labour	400–1000	2
		6000	1
1	Increased yield	Y	1

Extension entomology and IPM

Extension entomology is a concept that emerged in the early 1900s in the United States and has since evolved to become a specific branch of agricultural extension. During that time, research to improve cotton production in Texas led to the recognition of the importance of improved pest control (Brogdon, 1967; Lincoln and Blair, 1977). It was realised then that large-scale insect management programs were most effective when research and extension departments collaborated together (Annand, 1937; Allen and Rajotte, 1990).

The role of extension entomologists changed greatly in the 1970s after the introduction of Integrated Pest Management strategies (IPM). Before then, pest management relied heavily on synthetic insecticides. With the introduction of IPM principles, extension methodologies evolved rapidly to incorporate pest monitoring and risk assessment strategies, where pesticide applications were only advised when deemed cost-effective (Allen and Bath, 1980; Allen and Rajotte, 1990). In our case, BSES Limited is the major provider of sugarcane research and extension for the Australian sugar industry, with extension a major work objective. BSES scientists work closely with growers, either directly or through extension officers, to ensure an effective flow of research-generated information. BSES Limited can be credited with the introduction of IPM concepts into the sugar industry through the GrubPlan program and other similar extension projects (Hunt *et al.*, 2002, 2003; Samson *et al.*, 2005; Allsopp, 2010).

The current study demonstrates the feasibility of establishing a hands-on risk assessment program, and provides an example on how research and extension could work together to benefit growers. The GrubPlan program proved successful in North and Central Queensland (Sallam *et al.*, 2008; Peter Samson, personal communication).

It is envisaged that this program can be adopted by the industry as an effective tool of canegrub management in canefields. Data generated through these programs could still be used to improve the forecast models for better prediction of damage levels and potential grub populations.

Conclusions

A risk assessment program is paramount if the aim is to achieve cost-effective greyback canegrub management in sugarcane fields. Greyback canegrub is a particularly difficult pest to manage due to the high cost of insecticide, difficulty of predicting future grub dynamics and the need to make a decision on treatment prior to actual beetle flight.

Historically, sugarcane growers had no practical method of judging future risk, and grub management was largely practiced based on the grower's own observations or general assessment. Using a regional monitoring program, we were able to provide advice to growers whether or not to invest in chemical application for specific fields., and this was further validated in the following year and shown to be largely successful.

It needs to be emphasised that the decision 'not to treat' can still be a correct decision, for example when grub numbers in the following year are predicted to be too low to justify investing in treatment. Provided that a grub monitoring/extension program is in place, it is envisaged that any rise in grub numbers is likely to be recognised and promptly contained.

The GrubPlan program can consequently be adopted by the industry as a service provided by BSES, and this will ensure consistent grub management is achieved at the farm level as well as the regional level.

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