Department of Primary Industries

Assessing the potential of a new monitoring tool (Zappa trap) for managing sucking pests on cotton **FINAL REPORT: DAN1902**

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More information

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Contents

CRDC

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Part 1 - Summary Details

CRDC Project Number: DAN1902

Project Title: Assessing the potential of a new monitoring tool (Zappa trap) for managing sucking pests on cotton

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Part 3 – Final Report

1 Background

The ability to accurately assess pest and beneficial populations and their impact on crop physiology is pivotal to making informed crop management decisions within an Integrated Pest Management (IPM) framework. The use of transgenic cotton provides a strong platform for IPM in the management of *Helicoverpa* spp. However, sucking pests such as *Creontiades dilutus* (green mirid) and *Nezara viridula* (green vegetable bug) are not controlled by the Bt toxin produced by transgenic cotton and traditional sampling techniques may not provide enough detailed information to determine timing and abundance of pest populations in cropping areas.

These pests are highly mobile and their flight phenology and pattern of dispersal is not well understood. They are also difficult to sample because distribution is often not uniform and insects are easily dispersed which can lead to an underestimation of abundance. Therefore, there is an urgent need to develop an effective monitoring tool to measure peak activity of these pests throughout the growing season and to provide a predictive tool for identifying quantitative shifts in population abundance that would optimise the timing of control measures.

The Zappa trap has demonstrated potential as a sentinel tool for surveillance of insects and has previously been shown to be a reliable biological indicator of abundance of insect pests in cotton and other crops. This light trapping system comprises a device that emits UV wavelengths specific for attracting various pest species and therefore offers the potential for in-field monitoring of a range of cotton pests, particularly green mirid which are difficult to quantify under field conditions.

In addition to a capability as a sentinel device for monitoring presence of insect pests, the Zappa trap may also have a more direct pest management application as an “attract and kill” strategy. Although this might not be a viable option in a high insect pressure scenario, deployment of a network of Zappa traps may be a feasible alternative to the current practice of early season prophylactic use of fipronil applied with glyphosate to reduce mirids.

Not only does the use of this insecticide have a detrimental impact on establishment of beneficial populations in seedling cotton, it is also potentially damaging to bee populations present in spring-flowering native vegetation. Farmers may not always be aware of the location of bee populations in their immediate area. Access to another tool which could reduce potential pest numbers could mitigate risk to bees and enhance the IPM potential in cotton.

Importantly, the Zappa Trap shows promise as a means of providing growers with an early warning of below-threshold pest populations. This in turn provides the opportunity to manage populations in a timely manner and minimise the damage to fruiting structures of plants, optimising the cost of effectively and sustainably managing green mirids and green vegetable bugs.

This project seeks to build on previous research aimed at enhancing surveillance and management of green mirid and green vegetable bugs which continue to be problematic insect pests in cotton. Such fundamental research can also improve our understanding of ecology and damage thresholds of these pests and thereby improve industry response to pest outbreaks.

2 Objectives

Objective 1. What can we learn about the management, ecology and damage thresholds of green mirids and green vegetable bug by using the Zappa trap?

Milestone 1.1 Project field monitoring - Collect the following data from at least 6 sites:
- Green mirids and green vegetable bugs and beneficial insects attracted to the Zappa trap
- Field crop growth stages, damage and fruit retention
- Field check data for mirids, green vegetable bugs and beneficials
- Field spray records and local climate information

ACHIEVED

Milestone 1.2 Work with collaborating consultants

Coordinate with collaborating consultants to provide the following data:
- Green mirid, green vegetable bugs and beneficial insects (presence/absence) attracted to the Zappa trap
- Intensive field crop growth stages, damage and fruit retention
- Intensive field check data for mirids, green vegetable and beneficials (presence/ absence)
- Field spray records and local climate information
- Field check data for mirids and green vegetable for fields at different distances from trap (including distant not effected by trap)

ACHIEVED

Milestone 1.3 Analysis of 18/19 season data as well as previous data to:

- Improve understanding of green mirid, green vegetable bug and beneficials including impact of management, climate, etc.
- Conduct comparison of traditional checking methods, crop damage and crop management with Zappa trap
- Analysis of impact of distance on Zappa trap catch region

PENDING

Objective 2. Does the project have freedom to operate and how do we manage grower expectations?

Milestone 2.1 Agreement with Zappa trap supplier (Biomass-fuel Tech & Equip) about project expectations and in-kind contribution

ACHIEVED

Milestone 2.2 Agreement with project collaborators about expectations and in-kind contributions

ACHIEVED

Milestone 2.3 Potential collaboration/sharing protocols with other CRDC projects (eg. Richard Sequeira, QDAF) investigated

ACHIEVED

3 Methods

3.1 Trap maintenance and deployment

All the light traps were cleaned and tested. New light globes and fuses were fitted and batteries were fully charged before delivery. Any repair work was undertaken prior to deployment to ensure that the Zappa traps were fully functional.

3.2 Liaison with collaborators

During September and October 2018 face-to-face meetings were held with each collaborator in the Emerald, Namoi, Gwydir, St George and Hillston/Hay regions to provide protocols for collecting samples from traps and in-field sampling. They were also provided with information on trap operation and how to troubleshoot potential problems.

Each collaborator was also briefed on the requirement to enter into an agreement regarding expectations and in-kind contributions (*Milestone 2.2*). An agreement with the Zappa trap supplier (Biomass-fuel Tech & Equip) regarding project expectations and in-kind contribution was signed prior to the commencement of project (*Milestone 2.1*).

There were several pathways investigated for linking this project with related projects (Milestone 2.3) as outlined below:

- During a meeting with CRDC on October 3rd 2018, a possible collaboration in the Moree district with CSIRO researchers conducting mirid and fruit retention field experiments was discussed. However this work was not pursued due to time and budget constraints within the CSIRO project.
- Communications with Dr Richard Sequeira (QDAF Emerald) were planned to investigate pathways for data sharing and collaboration with a related project focused on assessment of relative fruit damage caused by adult and juvenile mirids in the field. Although the research at QDAF ultimately prioritised establishment of mirids in culture prior to starting damage assessment work, there was interest expressed in viewing the trapping system.
- The CottonInfo team also expressed interest in the trial work being conducted at the Moree site and suggested potential to liaise with QDAF on an experiment to simulate mirid damage. As a result, Ms Young was invited to attend the Area Wide Management (AWM) meetings in Moree to discuss the use of the Zapper trap.
- At an end-of-season AWM meeting at the Moree trial site growers and consultants had the opportunity to view the Zappa trap *in situ*. A verbal presentation was also given and CottonInfo disseminated the information from the meeting in its AWM newsletter (see *Appendix 1*).
- The new prototype Zappa traps were delivered to consultants at Emerald who provided suggestions regarding the quality and design of the trap and the stand. These suggestions were passed onto the suppliers of the trap by Dr Robert Mensah and were subsequently incorporated into the next design.
- A possible collaboration was explored with a researcher from University of Queensland (Dean Brooks) investigating temporal host preference in green mirid by analysing the gut contents of mirids. Mirids were collected and placed in cold storage at ACRI for future testing.

3.3 Methodology used by consultants

At each trial site the following activities were undertaken by the collaborating grower/consultant:

- The Zappa light trap was set up adjacent to the cotton field.
- Catches from the Zappa trap were collected twice a week.
- Insects counted from the trap catches included moths of *Helicoverpa* spp., green mirids, green vegetable bugs any other pest and beneficial insects.
- Beat sheet sampling was done within 50 metres the trap on the same day that trap collections were made and at a distance of greater than 200 metres away from the trap.
- Beat sheet checks were done in a separate field without a light trap to compare with counts recorded from fields with the light trap.
- Fruit retention in both fields with and without light trap was according to the normal checking schedule.
- Spray data from field with and without light trap were recorded and compared.

3.4 Methodology used by staff at the Australian Cotton Research Institute (ACRI)

The trials were undertaken and managed by Technical Officer Ms Alison Young from November 2018 until 30 April 2019.

Field Location 1 (Field C1)

- Light traps were set up adjacent to the cotton field.
- Catches from the Zappa traps were collected twice a week.
- Insects counted included moths of *Helicoverpa* spp., green mirids, green vegetable bugs any other pest and beneficial insects.
- Beat sheet sampling was done at 5, 25, 45, 65, 85, 105, 125, 145, 165, 185 and 205 metres away from the trap on the same day as trap collections.
- Beat sheet checks were done in a separate control field without a light trap.
- Plant mapping was done fortnightly at each check area at the commencement of squaring started.
- Mirid density at incremental distances from the Zappa trap was measured. This involved placing the trap ten metres outside the field and then sampling at five metre intervals in from edge field of the field trial site (i.e. the first assessment of mirid density in cotton was performed 15 metres from trap with each successive assessment performed in the crop at 20 metre intervals).
- Spray data for fields with and without light traps were recorded and compared.
- Field weather data included temperature, wind direction and speed, and rainfall as environmental factors may impact on insect movement.

Field Location 2 (Field C4)

In a second field location, a similar methodology was used, except that beat sheet samples were collected at 5, 25, 45, 65, 85, 105, 125, 145, 165 and 185 metres away from the traps. Combining data collected in Field Locations 1 and 2 will help to strengthen the analysis for determining the zone of influence of the Zappa trap for attracting insects.

Control Field Location

Field 7 at ACRI served as a control field (i.e. nil treatment) and was located several kilometres away from Fields C1 and C4 in order to minimise the influence of these other Zappa trap trial sites at ACRI.

3.5 Plant mapping

Plant mapping was done by taking the following measurements: position of fruit on each fruiting branch and numbers of fruit on vegetative branches to give the total number of bolls per metre; percentages of position of fruit on the plant and the 1st position retention. The method for calculating boll retention is shown in Table 1. First position retention was calculated using the number of fruiting branches with 1st position fruit. For example, if there a total of 15 fruiting branches and nine have a 1st position fruit then the retention is 60%. First position retention is used in the decision making process to determine whether a spray application is warranted. First position retention is affected by many factors including physiological stress and, importantly insect damage particularly green mirids and vegetable bugs.

Table 1. Method of calculation for cotton boll retention

Boll retention	Bolls/m	Vegetative Bolls	Fruiting branch bolls	Fruiting branches	1st Position	2nd Position	3rd Position
	151	22	129	124	88	39	3
% total bolls		14%	86%		58%	26%	2%
1st position retention					71%		

4 Results

4.1 Crop and insect monitoring

Monitoring for green mirids and green vegetable bug was conducted in fields at various distances from the trap. Specifically this included other crops/areas such as pigeon pea and native vegetation outside the zone of influence of the light trap. A total of nine traps were delivered by the supplier and installed at six sites across the industry at Emerald, St George, ACRI, Moree, Hillston and Hay.

Data from light traps was collected from all six trial sites. However some locations experienced unforeseen difficulties throughout the trial period, as outlined below:

- On December 20th 2018 ACRI experienced a major hail storm in conjunction with winds of over 150km. This resulted in major damage to the location of field trials. The subsequent delay in cotton plant development resulted in a protracted season in 2018-19. The two traps located at ACRI required repairs due to major damage suffered as a result of the storm and were not operational until mid-January 2019.
- The Moree trial site ran out of water mid-season. As a result, the field closest to the light trap location only received two irrigations, with no useful in-season rainfall which consequently impacted on the capacity of the crop for attracting insects.
- The Hillston trial site also had very high winds during November 2018 ranging from 20 – 60km. Although the trap was damaged and needed repairs, the fact that this weather event occurred early in the season meant there was no impact on data collection at this site.
- The trial site at St George was impacted because the collaborating consultant was diagnosed with a medical condition during the season and as a consequence field checks were sporadic. Due to the incomplete nature of the trapping data from St George it has not been included in this report.

4.1.1 Field monitoring at ACRI

The relative abundance of green mirid adult and nymphs at all fields sampled at ACRI are shown in Figure 1. Field C4 had consistently lower mirid activity across the season with Fields C1 and 7 experiencing prolonged mirid pressure during 2018-19. These data demonstrate the increase in population with crop maturity and a decline in population abundance with crop senescence.

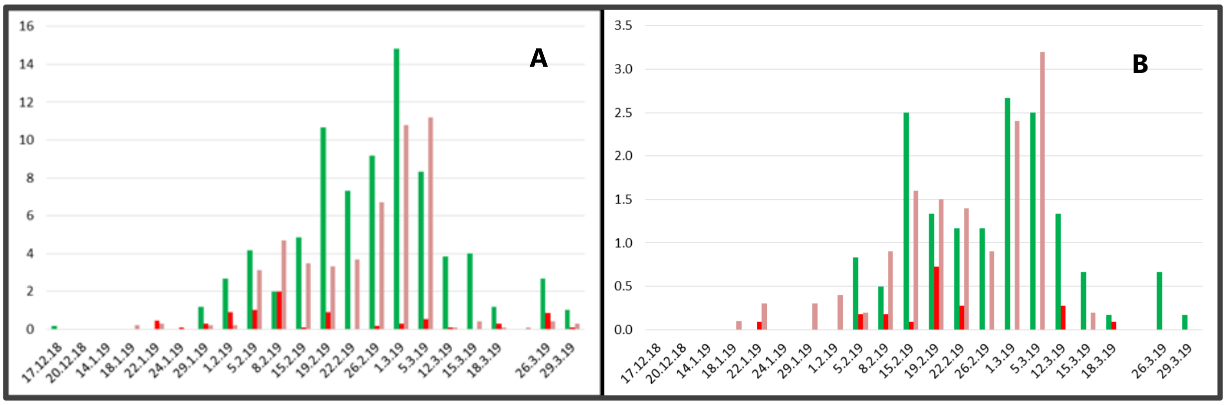

Figure 1. Comparative abundance of green mirids by life stage at ACRI: Field 7 ■ Field C4 ■ Field C1 ■ A) nymphs B) adults

The numbers of adult green mirids captured in the light trap ranged between 40 on the first sampling date of December 3rd 2018 and reached a peak of 355 on February 1st 2019 (Figure 2). The period of intensive sampling between January 12th 2019 and February 1st 2019 suggests a gradual build-up of the green mirid population at this location.

The average number of mirids per metre of beat sheet checks (i.e. one metre sampled every 20 metres from the tail drain to the head ditch) was recorded and the results shown in Figure 2. Nymphal instars accounted for the largest proportion of green mirids in the beat sheet samples throughout February to mid-March.

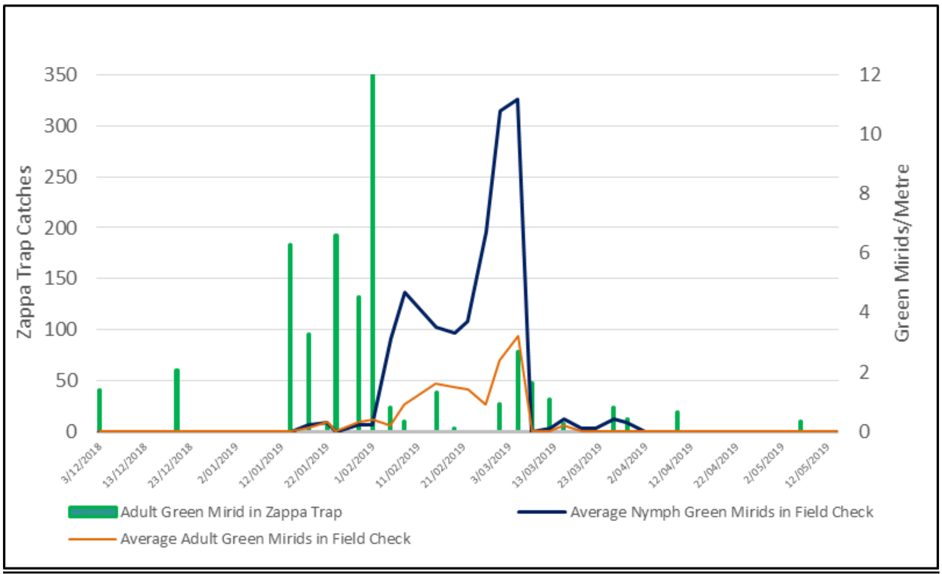

Figure 2. Adult green mirid from Zappa trap catches and field checks in Field C1

The first peak of adult abundance occurred on January 14th 2019 and the first peak of nymph abundance occurred on February 8th 2019. Peak abundance of nymphs followed peak abundance of the adult cohort by approximately one mirid generation (three weeks) suggesting that data accumulated from the Zappa trap could be used as a predictive tool for forecasting temporal peaks in mirid populations.

The rapid decline of the mirid population was due to a spray application (Transform® 100g/ha) on March 8th 2019 which was based on a high threshold because the distribution of mirids was uneven throughout the field. In addition, the spray was applied by ground rig and therefore the application had to fit with the irrigation schedule.

The results of Zappa trap catches and beat sheet checks in Field C4 are shown in Figure 3. Peak activity for green mirid nymphs occurred on February 8th 2019. The field had a mirid spray application (Transform® 150g/ha) on the February 20th 2019. The decision to spray was based on a relatively low threshold. However uneven distribution of the mirid population meant that some areas of the field had higher levels of activity than others. In addition, this field was used for a nutrition and water deficit trial and there were constraints on management to limit interference with trial results.

The overlapping nature of the adult and nymphal cohorts suggests that the predictive capability of the Zappa trap can be confounded by coinciding generations of mirids. It is likely that local migration of mirid adults at this location had influenced the age structure of the population either through movement away from senescent hosts elsewhere in the landscape or seasonal dispersal on prevailing winds. Nevertheless these data highlight the need for a mirid sampling strategy that involves methods capable of detecting the presence of both nymphs and adults.

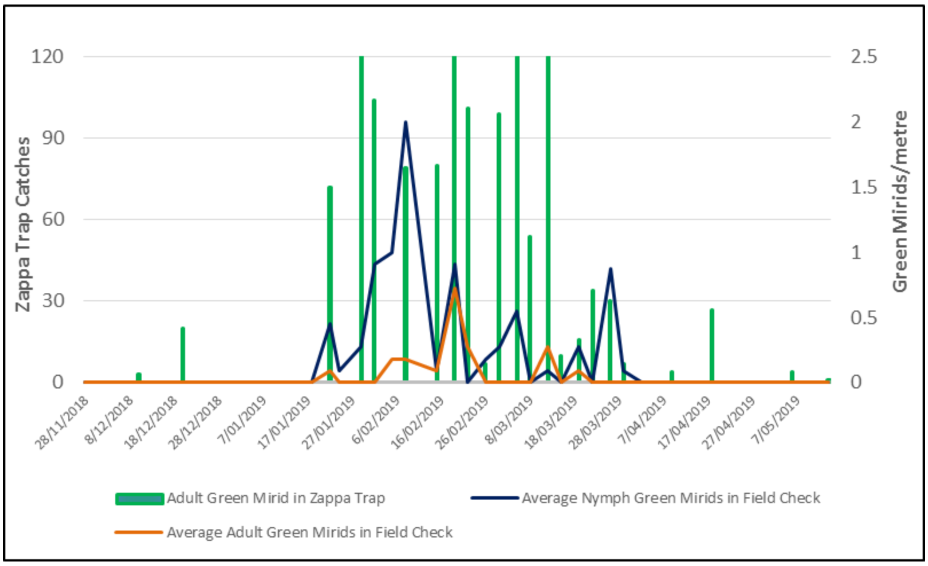

Figure 3. Adult green mirid from Zappa trap catches and field checks Field C4

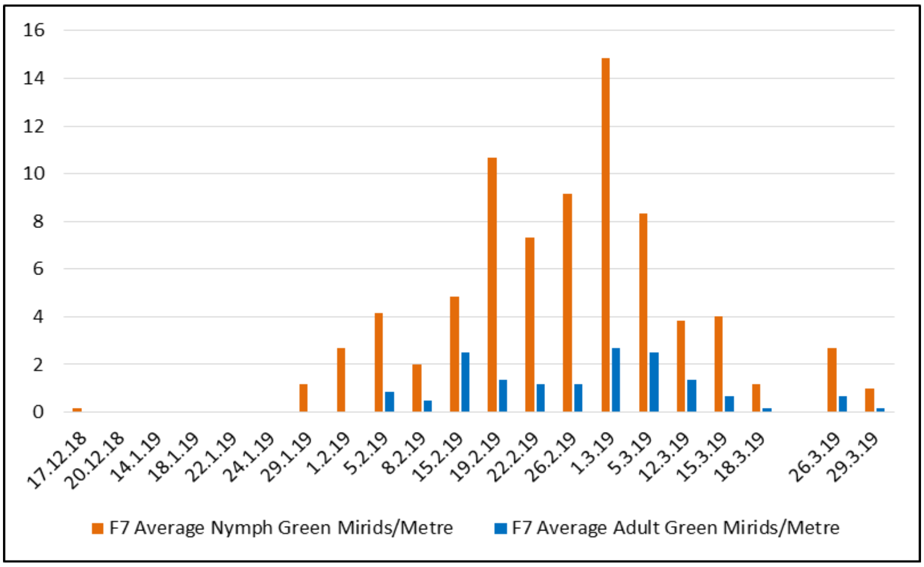

Figure 4. Abundance of mirid adults and nymphs per metre in Field 7

Field Location 2 (Field 7) was used as a control field site at ACRI and the mirid abundance in this field is shown in Figure 4. The adult population remained relatively consistent from early February onwards in Field 7 which was located approximately 2.5km from the nearest light trap and mirid activity at this site was unlikely to be influenced by other Zappa traps used in field trials at ACRI. In addition, Field 7 had no mirid spray applications and therefore accurately reflects survival of mirid nymphs as beneficial insect populations were not disrupted. There was a gradual increase of the nymph population followed by a decrease from mid-March onward.

Figures 5 to 8 show the activity of adult and nymph mirids in C1 and C4 at ACRI at various distances away from the trap. The traps were set up approximately ten metres from the edge of the field so the distance from the trap was an additional ten metres from the location of field checks. Results indicate a general trend of increased mirid activity with increasing distance away from the trap. Although sampling was conducted at 20 metre intervals, a representative number of measurements are presented in the figures below.

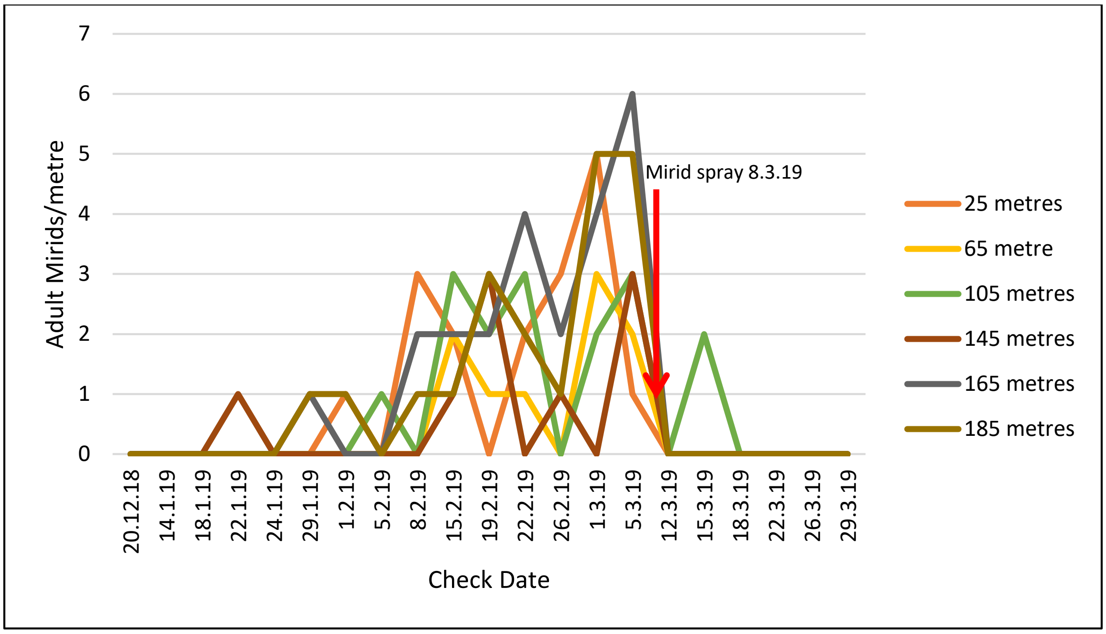

Figure 5. Mirid adults by distance in Field C1

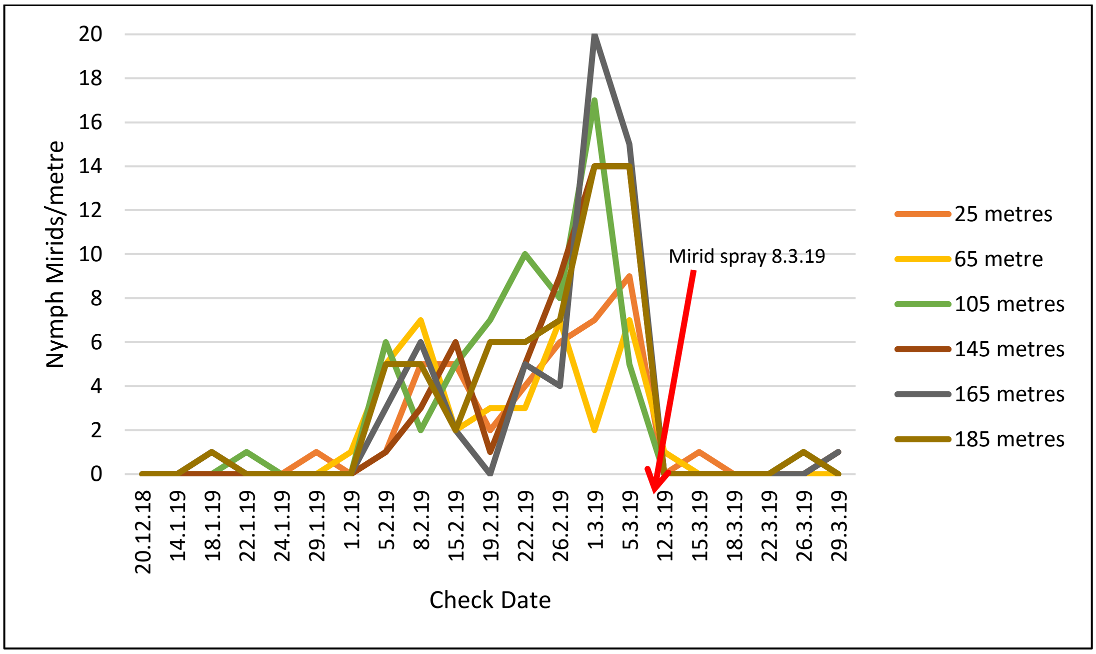

Figure 6. Mirid nymphs by distance in Field C1

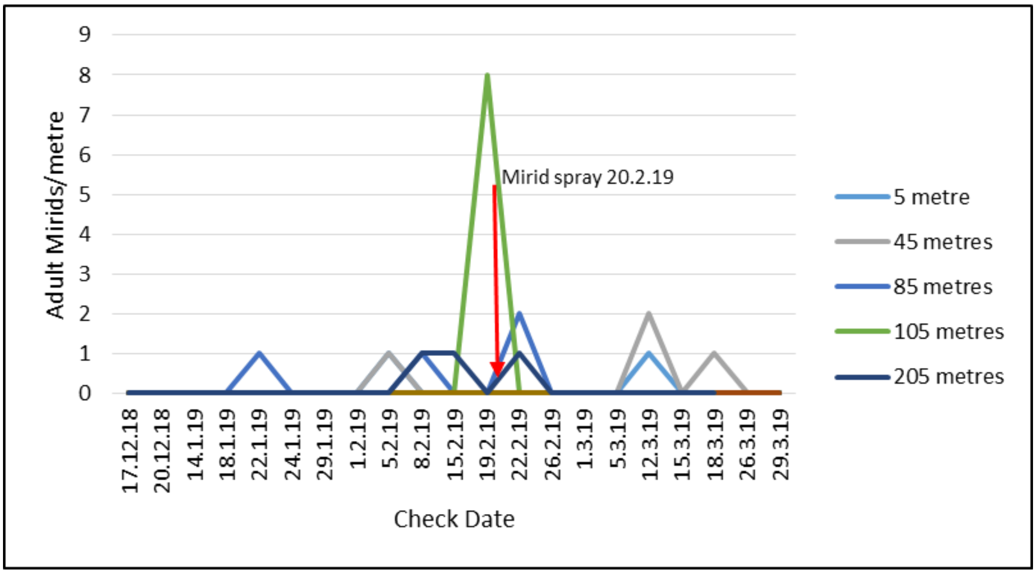

Figure 7. Mirid adults by distance in Field C4

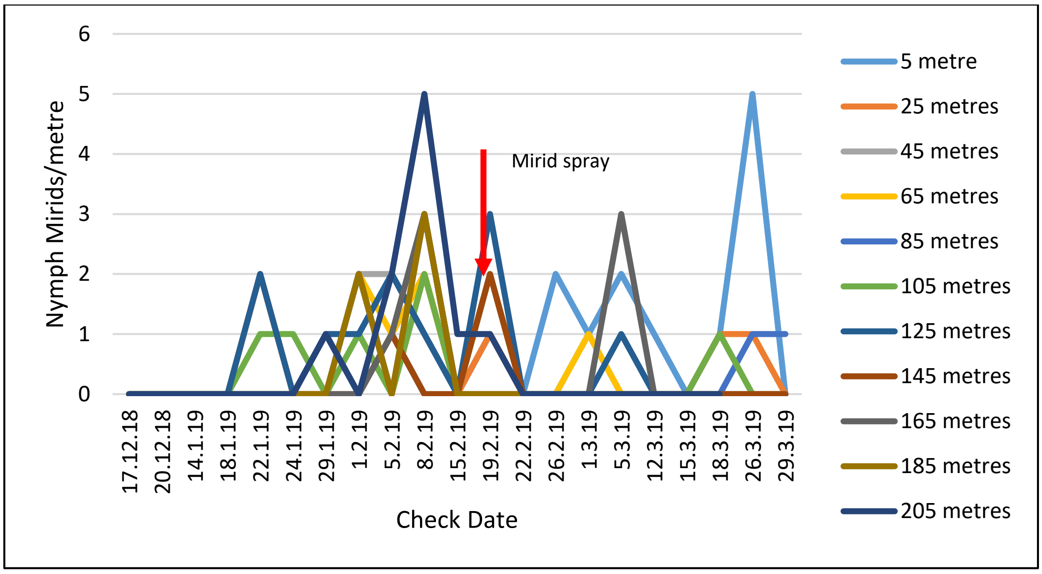

Figure 8. Nymph mirids by distance in Field C4

4.1.2 Field monitoring at Emerald

Adult green mirid abundance from Zappa trap catches and total in-field mirid abundance was determined at a trial site near Emerald and the results shown in Figure 9. A high catch of mirids in the Zappa trap was recorded on November 6th 2018 and the population was also evident in the in-field checking records. This triggered a spray application which appeared to achieve satisfactory control of the mirid population as none were recorded in the crop until two weeks later on November 28th 2019. There were no further mirids sprays were applied to this field.

Two additional traps were used on a commercial field (Field J2) at Emerald, with one trap located at the head ditch and one located at the tail drain. Figure 10 shows the difference in the catches of adult mirids between the two trap locations in Field J2. The higher insect activity in the trap on the tail drain might be attributable to the proximity of trees and native vegetation which may have been the source of resident population of green mirids

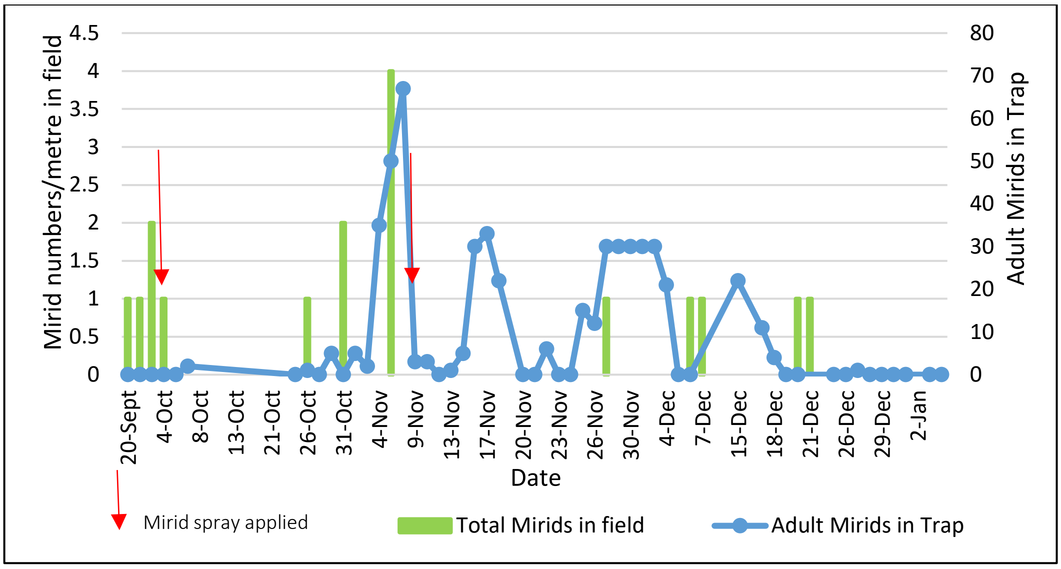

Figure 9. Adult green mirids from Zappa trap catches and mirid numbers per metre at Emerald

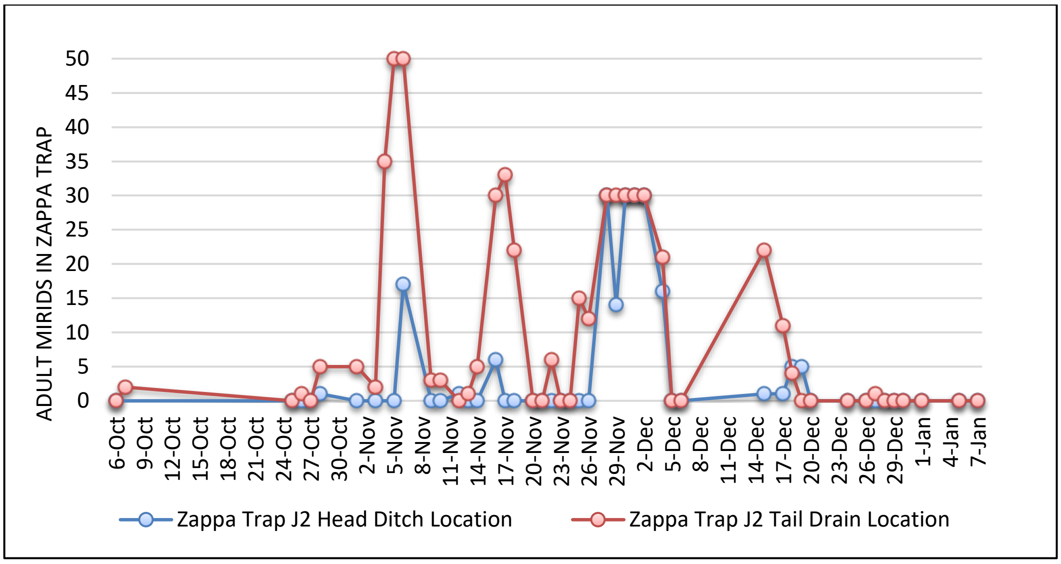

Figure 10. Zappa trap catches at head ditch and tail drain of Field J2 Emerald

Figure 11 shows the total mirid and green vegetable bug catches in both traps at Emerald. Although green vegetable bugs were captured in Zappa traps the presence of this species was not noted in the field checks. This could be attributable to a migratory cohort of green vegetable bugs that did not establish in the field that was sampled. Nevertheless, these data indicate that sucking pest damage in field may not necessarily be attributable to mirids and detection of green vegetable bugs in Zappa traps warrants closer inspection of the crop as it is often difficult to attain accurate sampling data for this species.

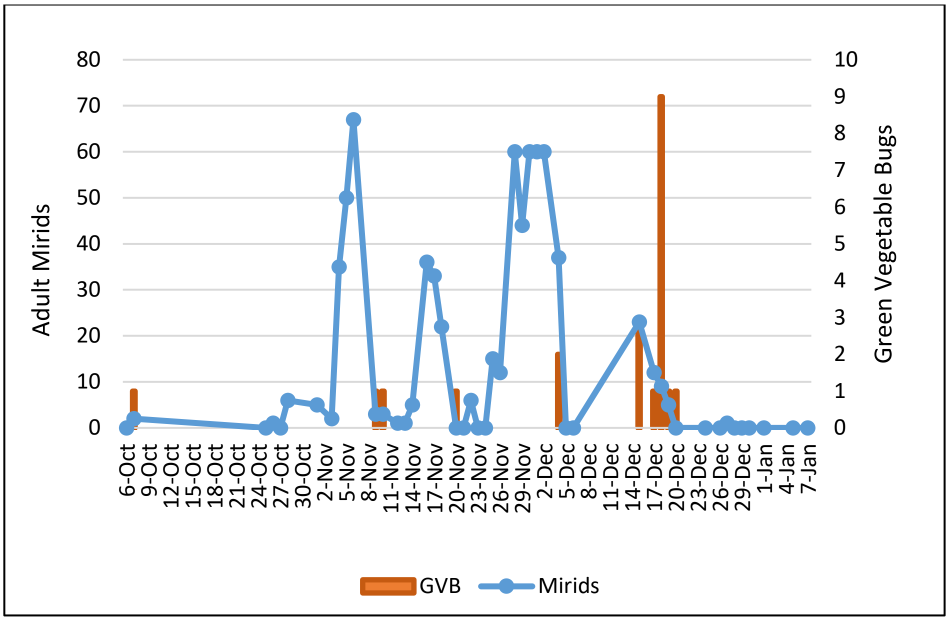

Figure 11. Total adult mirids and green vegetable bugs in Zappa trap catches at Emerald

4.1.3 Field monitoring at Hillston and Hay

Adult green mirid abundance from Zappa trap catches and mirid nymph abundance was determined at a trial site at Hillston with results presented in Figure 12. At this location the numbers of adult mirids caught in Zappa traps was relatively low compared with other locations. However, predictive capability of the Zappa trap may be evident from these data with peak abundance of adults on December 19th 2018 followed by mirid nymph activity in the field seven to ten days later.

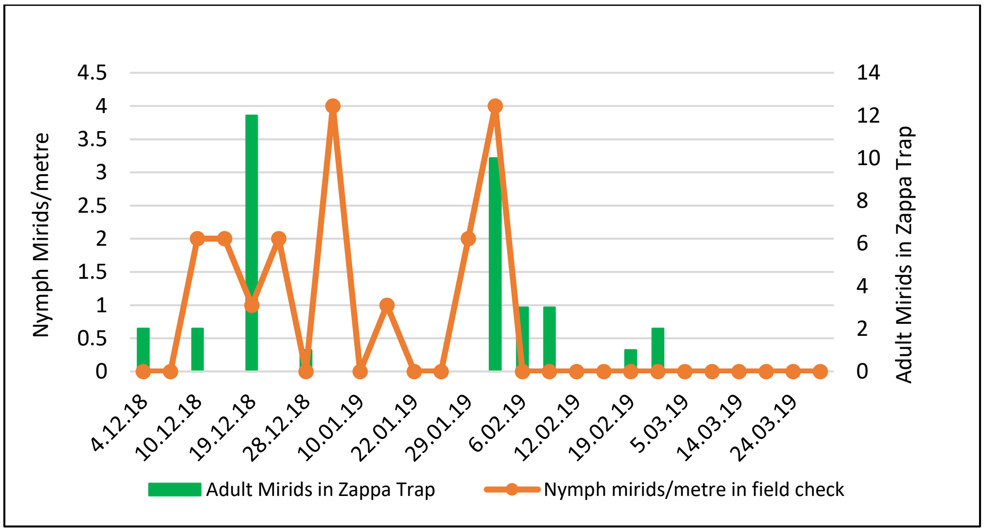

Figure 12. Adult green mirid from Zappa trap catches and field checks at the Hillston trial site

Figure 13 shows the total numbers of *Helicoverpa* spp. moths and green mirids caught in Zappa traps on-farm at Hay. After trialling the Zappa trap in the previous season the grower purchased additional traps resulting in a total of six traps spread across all management units. Mirid abundance was variable throughout the season with peak activity during early January and mid-February.

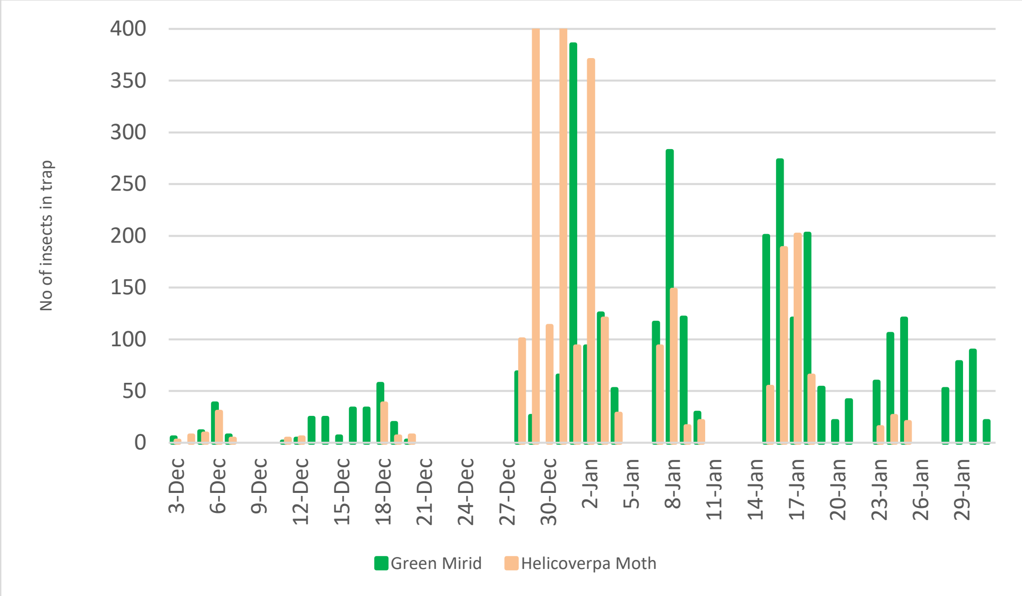

Figure 13. Adult mirid and Helicoverpa moth Zappa trap catches at the Hay trial site

4.1.4 Field monitoring at Moree

Mirid activity at the Moree trial site was generally low throughout the season. In-field checks were performed at the trap location and at distances of 800 metres and 1200 metres away from the trap. Due to the low level of activity it is difficult to suggest an association with distance at this location. The field suffered from water stress as no irrigation water was available from January 2019 onward resulting in the crop only receiving a total of two irrigations. Figure 14 shows numbers of adult green mirid catches in Zappa traps and adult and nymph mirid abundance per metre in field check conducted at incremental distance from the traps. Monitoring continued even though the crop by the trap was no longer attractive.

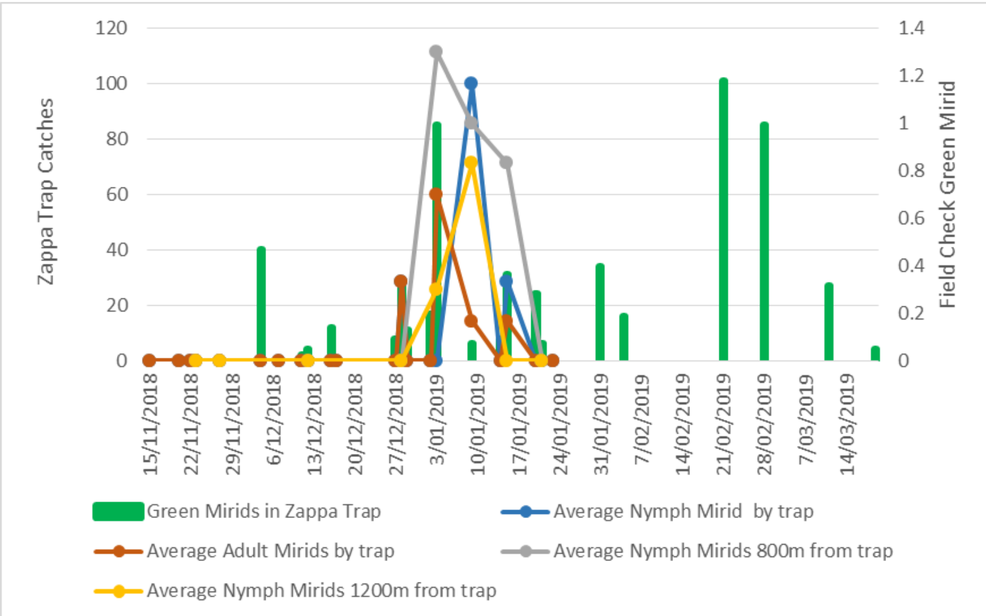

Figure 14. Green mirid adult and nymph abundance by distance from Zappa trap at Moree trial site

4.2 Beneficial insect abundance

Beneficial insect abundance was recorded in field checks and in samples caught by the Zappa trap at ACRI. The full data set for Field C1 is shown in Appendix 2 and summarised in Figure 15. On the March 12th and 26th there were peaks in predatory bug abundance recorded in the Zappa trap catches which are attributable to large numbers of damsel bugs caught on those two trapping occasions. In-field beneficial abundance ranged between six and 22 insects per metre from January 18th and March 30th 2019. However, more research is needed to determine whether in-field abundance of beneficial insects is negatively impacted by the Zappa trap.

Beneficial abundance was also recorded at all other trial sites. However, numbers were very low and were not included in this report

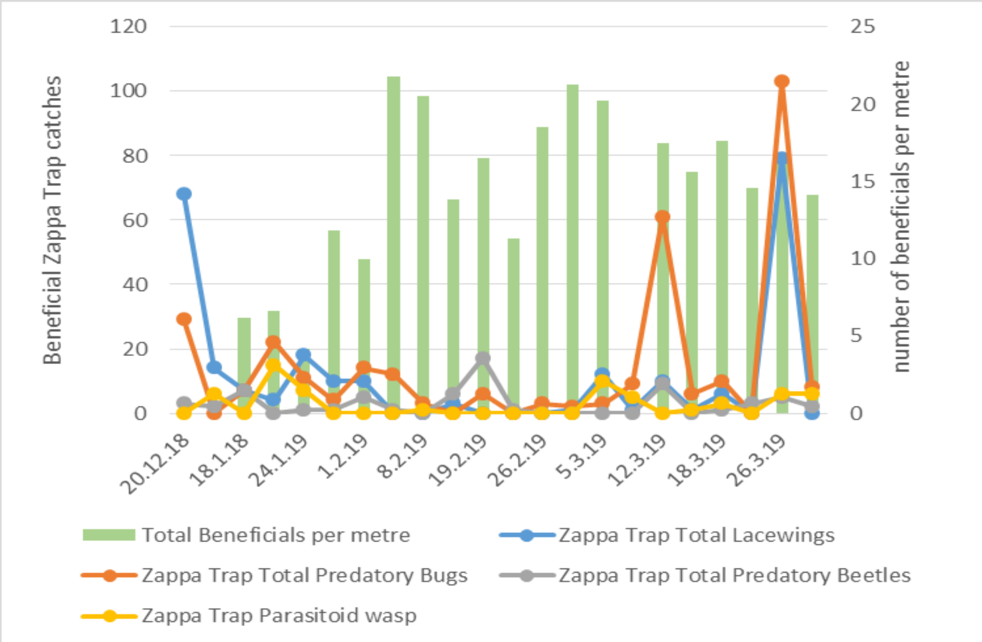

Figure 15. Beneficial insect by type caught in the Zappa trap compared to the average number of beneficial insects recorded per metre in field checks in Field C1 ACRI

4.3 Plant physiology - number of bolls per metre, damaged bolls and 1st position retention

Australian Cotton Research Institute results.

A comparison of boll numbers per metre, damaged bolls and 1st position retention at the ACRI trial sites is shown in Figure 16. The results indicate that in Fields C1 and C4 there was a higher average total number of bolls per metre at locations closest to the light trap compared with those 350 and 400m away from the traps, in each field, respectively.

The boll counts were conducted at each check location at all the distances in the field from the light trap i.e. at every 20 metres from the tail drain to head ditch. The 1st position retention was also slightly higher closest to the light trap locations. Field C4 had a lower average number of bolls per metre than Field 7. This was potentially due to the nature of the other trials being conducted in the field which was for nutrition and irrigation deficits. This meant that areas of C4 may have suffered from some physiological stresses which affected the boll load.

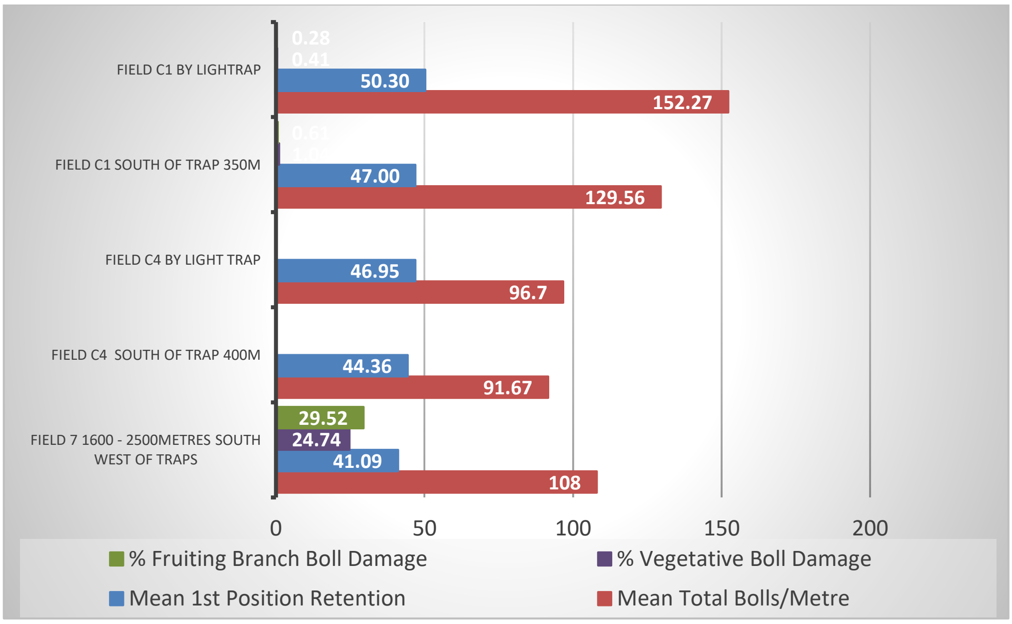

Figure 16. Comparison of boll numbers per metre, damaged bolls and 1st position retention at ACRI

The main point of interest in this graph is the damage to the bolls by sucking pests. Field C4 experienced extremely low levels of sucking pest damage. Even though the spray (applied on February 19th 2019) was at a low threshold it was enough to prevent damage through the season in the area away from the light trap. Field C1 also had very low levels of sucking pest damage in the area away from the light trap. Whilst the threshold for the spray (applied February 8th 2019) was high, mirid nymph activity in the field did not appear to negatively impact on yield and quality of the crop. In contrast, in Field 7 received no mirid spray applications and had relatively high numbers of mirids continually through the season (Figure 4). Consequently, this field had the highest level of sucking pest damage compared with the other fields at ACRI where Zappa traps were located (Figure 17).

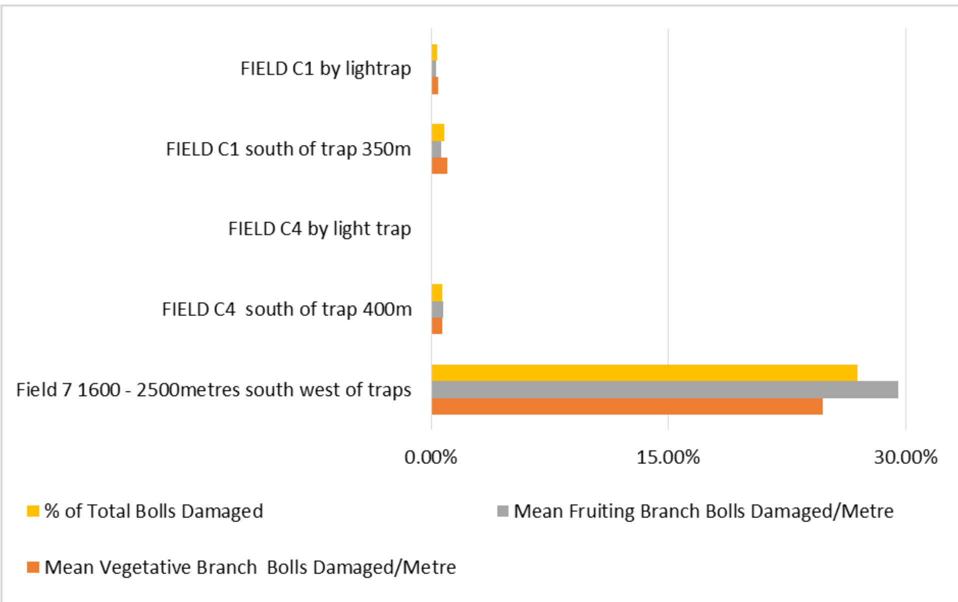

Figure 17. Comparison of damaged vegetative bolls, fruiting branch bolls and total bolls damaged per metre by sucking pests over all sites at ACRI

Emerald results.

Figure 18 shows the comparison of mean boll numbers per metre and 1st position retention across two different fields at Emerald with distance from Zappa traps. Farm 1 field 1A was approximately 3Km from the light traps and Farm 2 field 1 tail drain counts were approximately 900 metres from the light trap. The boll counts and 1st position retention were highest on Farm 2 field 2 where there was a light trap on both the head ditch and tail drain.

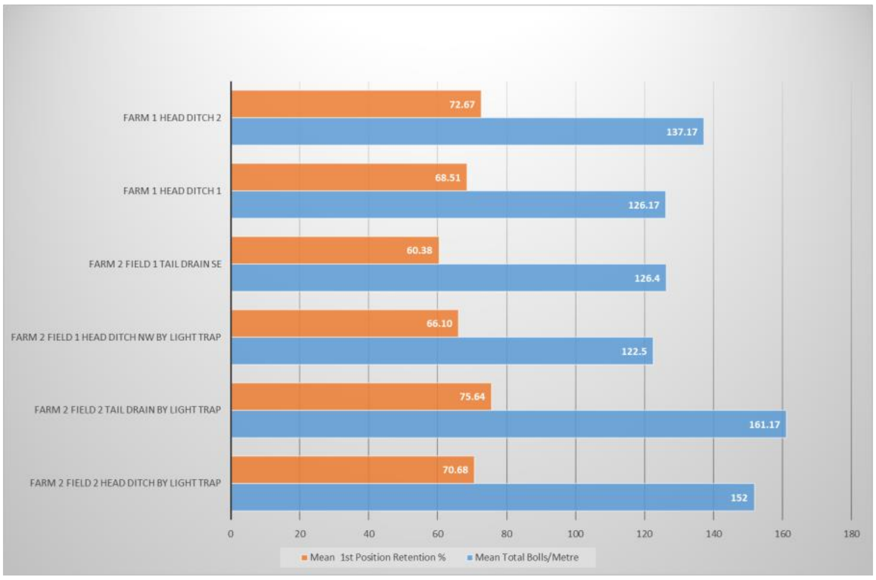

Figure 18. Comparison of boll numbers per metre and 1st position retention at Emerald

Ginned yield results are presented in Table 2 and demonstrate that yield in Farm 2 Field 2 (12.94 bales/ha) was higher compared with Farm 1 Field 1A (11.41 bales/ha). This supports the boll count data which also suggests that Farm 2 Field 2 had the highest yield potential (Figure 18). The comparison field was chosen as it had a very similar soil and irrigation schedule and was managed in the same way as the field with the light traps.

Table 2. Yield results from ginned cotton at Emerald

Field	Variety	Planted	Defoliated	Picked	Ginned yield	Turnout %	Quality Average Grade	
							Colour	Leaf
Field 1A Farm 1	Sicot 714 BG3	1-Aug-18	31-Dec-18	13-Jan-19	11.91	41.5	11	1.3
Field 2, Farm 2	Sicot 714 BG3	1-Aug-18	31-Dec-18	14-Jan-19	12.94	42.3	11	1.0

Hay and Hillston results.

Comparison of boll numbers per metre and 1st position retention at two fields at the Hay trial site are shown in Figure 19. Results indicate that in both Field 52 and Field 6 the average boll numbers per metre was higher closer to the trap compared with those 900m away from the trap. In Field 6 there was a difference between the 1st position retention at the two locations. There was lower retention in the assessment area away from the trap in Field 6. In contrast, retention was marginally higher at the location furthest from the light trap. However, damage assessments indicated there were extremely low levels of sucking pest damage to the bolls in this field location.

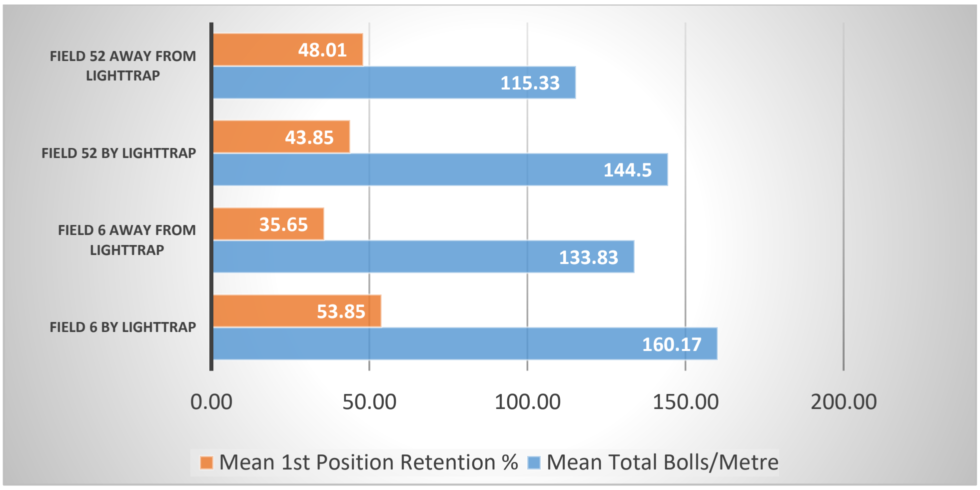

Figure 19. Comparison of boll numbers per metre and 1st position retention at Hay

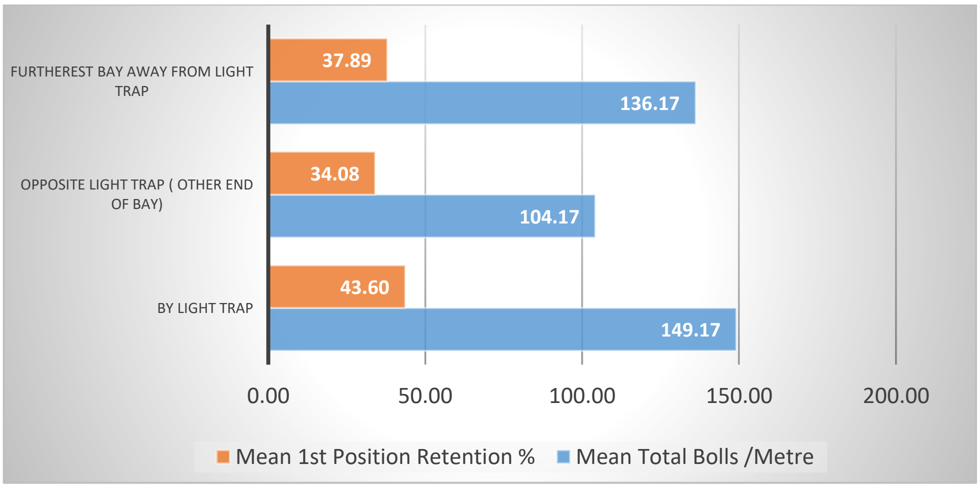

Figure 20. Comparison of boll numbers per metre and 1st position retention at Hillston

Comparison of boll numbers per metre and 1st position retention at Hillston are presented in Figure 20. Here two plant mapping assessments were made; counts conducted "opposite the light trap" were approximately 800 metres away from the trap, and the "furthest bay away from the light trap at a distance of approximately 2Km. Results show that boll counts were highest at the closest points to the light trap compared with areas of field furthest from the trap. However, due to the lack of mirid activity at this site physiological factors may have contributed to reducing the retention percentage.

Moree results.

A comparison of boll numbers per metre, damaged bolls and 1st position retention in the trial site at Moree is shown in Figure 21 and demonstrates that in a drought affected field, boll numbers and 1st position retention were similar. It is likely that the crop suffered major physiological stress and aborted a significant amount of fruit. A notable feature observed whilst performing plant mapping in the field was the relatively high degree of insect damage at trial site compared with other trial sites. There was also a notable difference in the number of bolls which had been damaged by sucking pests at different proximities to the Zappa trap. Results show there was a 43% reduction in damage of fruiting branch bolls in locations nearest the light trap compared with locations approximately 950 metres away from the trap.

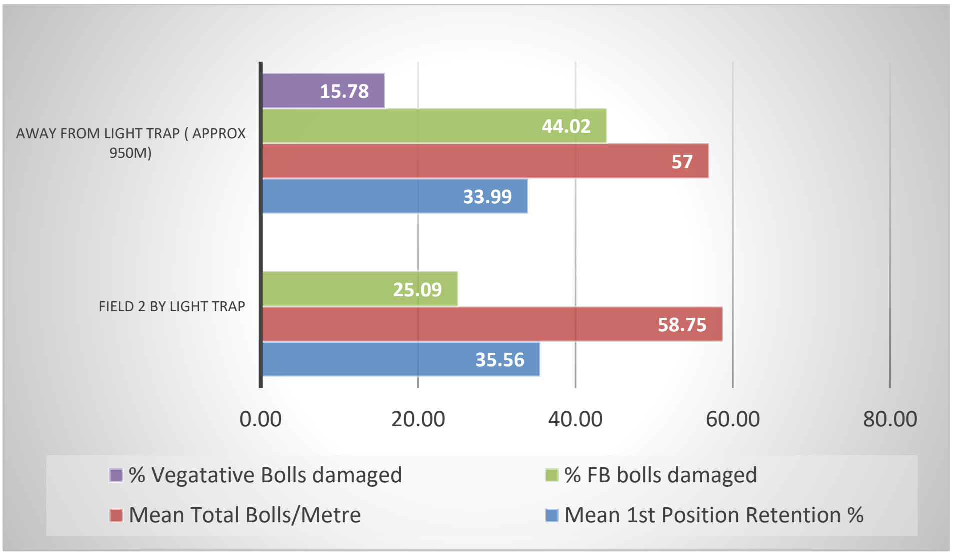

Figure 21. Comparison of boll numbers per metre, damaged bolls and 1st position retention Moree (FB = fruiting branch)

4.4 Data analysis

In consultation, with CRDC it was decided that at this stage no statistical analysis would be undertaken.

5 Summary of activities

- The data presented in this report quantifies green mirid, green vegetable bugs and beneficial insects caught in the Zappa trap at all sites.
- In-field checks at ACRI and Moree quantified all pest and beneficial insects. Field records from the other sites consisted of mainly pest species.
- An in-field assessment documented presence of insects at increasing distance away from the Zappa trap at ACRI with checks conducted in two fields (Field C1 and Field C4) at 20 metre intervals.
- Field checks were conducted on an unsprayed field away from the influence of the traps.
- Plant mapping was done at all sites to determine the location of bolls on plants, total number of bolls per metre and 1st position retention. This showed potential yield expectations of all sites for comparing light trap location and at locations away from the expected influence of the Zappa trap.
- The expected outcome was to establish a data set to inform future research questions.

6 Conclusions and opportunities for future research

- The data presented herein suggest that Zappa trap sampling could be a useful biological indicator for predicting the timing of mirid nymph activity in cotton. In general there was temporal synchrony between adult mirids recorded from Zappa trap and total mirid numbers samples recorded during in-field insect checks. In some cases, such at ACRI Field C1 and Hillston, mirid populations recorded in field checks had been preceded by high numbers of adult mirids caught in Zappa traps suggesting that the Zappa trap could have a predicative capability in crop management.

- Although it is possible that the relative abundance of mirids detected by Zappa trap sampling could be confounded by environmental factors such as prevailing wind speed and direction, information from this method of sampling could nevertheless provide an early warning for the presence of populations in the vicinity of cotton fields and heighten grower awareness to the need for vigilant assessment of pest abundance and assist in optimising the timing of spray applications.

- Importantly, the data presented supports the use of a strategy that involves sampling of both adult and immature mirid life stages to optimise the cost of managing green mirids in cotton. However, more research is needed to validate these results and determine the effectiveness of the Zappa trap in seasons with varying insect pressure.

- The impact of trap placement on the distribution of mirids within cotton at ACRI indicates that mirid nymph abundance increased with increasing distance from the trap location. More research is needed to validate these results and determine the potential zone of influence that the Zappa trap exerts on mirid population distribution in the field as well as the critical number of traps that would optimise crop protection.

- Results from the crop damage assessment study generally support the insect abundance and distribution data. This was particularly evident at in Field C1 at ACRI where increasing incremental distances away from the trap were correlated with higher levels of insect damage to bolls. Similarly, at the Moree trial site there was a 43% reduction in damage of fruiting branch bolls in locations nearest to the Zappa trap compared with locations approximately 950 metres away from the trap.

- The trials in Field C1 and C4 at ACRI had different thresholds for mirid management. Results suggest that applying a spray based on a higher than normal threshold may not have impacted on yield potential or quality.

- At all sites the boll numbers per metre and 1st position retention was generally higher at locations close to the trap compared with locations at distance from the trap which suggests that the placement of traps in strategic locations around cotton fields could have a positive influence on yield outcome. This finding is supported by yield data from a commercial field at Emerald which suggests that a field where Zappa traps were deployed yielded approximately one bale to the hectare higher compared with a field with no Zappa trap under the same conditions. Future replication of field experiments in different cotton growing regions is necessary to validate this observed impact on yield outcome.

Part 4 – Final Report Executive Summary

A capacity to accurately assess economically important insects and their impact on crop physiology is pivotal to making informed and cost-effective decisions within an Integrated Pest Management (IPM) framework. The use of transgenic cotton provides a strong platform for IPM in the management of *Helicoverpa* spp. However, sucking pests such as *Creontiades dilutus* (green mirid) and *Nezara viridula* (green vegetable bug) are not controlled by the Bt toxin produced by transgenic cotton. Traditional sampling techniques can underestimate abundance of green mirid and green vegetable bug populations in cropping areas because these pests are easily dispersed and their distribution is often not uniform in cotton fields. Therefore, there is an urgent need to develop an effective surveillance system to measure peak activity of these pests throughout the growing season and to provide a predictive tool for identifying quantitative shifts in population abundance that would optimise the timing of control measures.

The Zappa trap was previously tested in proof-of-concept trials over a three year period from 2015 to 2018. Results of these trials demonstrated the potential of the Zappa trap as a sentinel tool for providing growers with an early warning of pest presence, particularly green mirids and green vegetable bugs, which are otherwise difficult to quantify under field conditions. The Zappa trap could also have a direct pest management application as an "attract and kill" strategy, potentially offering growers an alternative method to reduce pest numbers while mitigating risk to non-target species and enhancing the IPM potential in cotton.

The aim of this one year project was to further test the potential of the Zappa trap in field trials located in different cotton growing regions and under intensive sampling regimes. The results provided additional evidence that Zappa trap sampling could be a useful biological indicator for predicting the timing of mirid nymph activity in cotton because temporal synchrony was consistently observed between adult mirids recorded from Zappa trap and total mirid numbers samples recorded during in-field insect checks. Notwithstanding the possibility that Zappa trap sampling could be confounded by environmental factors such as the speed and direction of prevailing winds, the information could nevertheless provide an early warning for the presence of populations in the vicinity of cotton fields and heighten grower awareness to the need for vigilant assessment of pest abundance to optimise the timing of spray applications.

The study of trap placement on the distribution of mirids within cotton indicated that mirid nymph abundance may be influenced by distance from the trap location. Results from the assessment of crop damage generally support the insect abundance and distribution data and there was a trend toward higher levels of insect damage to bolls and lower yield potential at increasing distances away from traps, suggesting that the placement of traps in strategic locations around cotton fields could have a positive influence on yield outcome.

The predictive capability of the Zappa trap could provide the opportunity to manage populations in a timely manner and minimise the damage to fruiting structures of plants while optimising the cost of effectively and sustainably managing green mirids and green vegetable bugs on cotton. An additional benefit could be an increased understanding by growers of pest phenology and behaviour of these problematic species which could reduce reliance on chemical control measures and reduce the risk of flaring end-of season-pests in cotton such as silver leaf whitefly.

Appendix 1. Handout to Gwydir Valley Area Wide Management Group

THE ZAPPA TRAP

CRDC ID: DAN1902 Assessing the Potential of a new monitoring tool ("Zappa" trap) for managing sucking pests on cotton

Dr Robert Mensah Senior Principal Research Scientist, Biopesticide, IPM and Alison Young - Technical Officer, IPM. NSW DPI

The "Zappa" trap pictured below has been trialed on cotton farms over the last couple of seasons. The "Zappa" trap uses a specific wavelength which is highly to Green Mirids (*Creontiades dilutus*) and Green Vegetable Bugs(*Nezara viridula*) but not beneficial insects(predatory insects and parasatoids).

Green mirids and green vegetable bugs are not affected by the Bt toxin in Bollgard cotton.

These pests are highly mobile, and their flight phenology is difficult to understand. Current sampling techniques for these pests may not be providing us with enough information about when these pests arrive on the farm and the numbers infesting the crop. Therefore, there is the need for an effective monitoring tool to determine arrival time and their numbers, which will lead to being able to predict peak activity of these pests within the crop enabling effective control measures to be applied in a timely fashion.

The "Zappa" trap is a light trap which has been tested over the last 3 seasons using different UV wavelengths. The study has determined which wavelength is best for various pest species.

- **Pests monitored include Helicoverpa moths, green mirids and green vegetable bugs**
- **Beneficial insects are also monitored**
- **It has been found that the different wavelengths attract different species**
- **Insect catches have been compared to the check data from the field with the light trap**
- **Field data from fields without a light trap have been compared to the field with a light trap**
- **Light traps have been placed on commercial farms at Emerald, Moree, Narrabri and Rowena**

Growers and consultants have observed higher catches of green mirids and green vegetable bugs in the traps than seen in the field and believe that the use of the "Zappa" trap is a good indicator of when to expect seeing an egg hatch occur. Some results of the trials are shown in Figures 1-4 on Page 2.

The use of the "Zappa" trap could help gain a better understanding of pest behaviour which in turn could lead to optimal timing of control measures. This would help reduce the reliance on chemical control measures which might reduce the potential for end of season pests such as whitefly flaring.

CRDC

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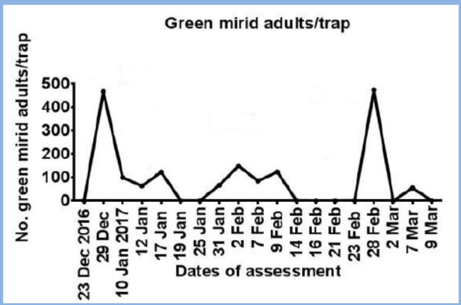

Figure 1: Green Mirid catches in the Zappa trap 2017 season

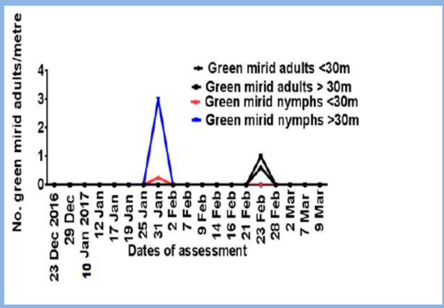

Figure 2 : Green Mirid adult and nymphs field counts close to the trap and >30m away.

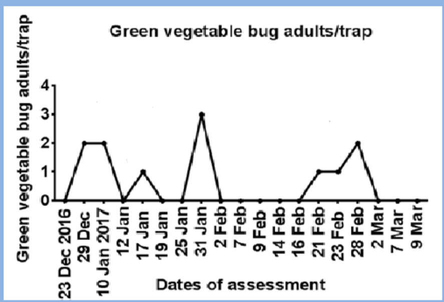

Figure 3: Green Vegetable Bug catches in the Zappa trap 2017 season

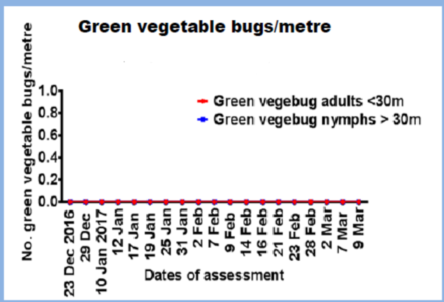

Figure 4 : Green Vegetable adult and nymphs field counts close to the trap and > 30m away

Appendix 2. Beneficial insect by type recorded per metre in field checks in Field C1 ACRI

DATE	Green Mirid							BENEFICIALS	Predatory Beetles						Predatory bugs							Other Beneficials				Total	Other pests							
	1st	2nd	3rd	4th	5th	Total Nymphs	Adult	Spider	Lady Beetle	2 Spot Lady Beetle	Red & Blue	Carabid beetle	Totl Predatory Beetles	brown smudge bug	Damsel Bug	Big Eyed Bug	PSB	Pirate Bug	brown shield bug	Total Predatory Bugs	Parasitic Wasp	Lacewing Larvae	Lacewing Adult	Total Other Beneficials		ADB	Jassid	Cotton Seed Bug	Flea Beetle	Weevil	Pollen Beetle	Rutherglen	Evans grey Cluster Bug
20.12.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0
14.1.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0
18.1.18	0	0.1	0	0.1	0	0.2	0.1	3.4	1	0	1.1	0	2.1	0	0	0.7	0	0	0	0.7	0	0	0	0	**6.2**	0	3.2	0.5	5.7	0.2	0	2.6	0
22.1.19	0.2	0	0.1	0	0	0.3	0.3	2.4	0.6	0	1.6	0	2.2	0	0.2	2	0	0	0	2	0	0	0	0	**6.6**	1.4	0.7	1.4	0	0.4	2.3	4.9	0
24.1.19	0	0	0	0	0	0	0	2.1	0.3	0.3	0.7	0	1.3	0	0	0.7	0	0	0	0.7	0	0.1	0	0.1	**4.2**	0.7	0.8	0	0.3	0	0	2.1	0
29.1.19	0	0.2	0	0	0	0.2	0.3	4.3	1.7	0	4.5	0	6.2	0	0.1	1.2	0	0	0	1.2	0	0.1	0	0.1	**11.8**	0.4	0.6	2.3	3.7	0	0	2.9	0
1.2.19	0	0.1	0.1	0	0	0.2	0.4	2.7	0.7	0.4	3.9	0	5	0	0.3	2.3	0	0	0	2.3	0	0	0	0	**10**	1.2	0.2	0.8	0	0.3	5	0.9	0
5.2.19	0.6	1.9	0.4	0.1	0.1	3.1	0.2	8.1	2.6	0.4	8.3	0	11	0.1	3.1	2.2	0	0	0.1	2.3	0	0	0.1	0.1	**21.8**	5.4	0.7	5.7	12	0	0	2.4	0
8.2.19	2.3	0.6	1.6	0.2	0	4.7	0.9	6.6	1.1	0.3	7.6	0.1	9.1	0	1	4.3	0	0.5	0	4.8	0	0	0	0	**20.5**	8.5	1.9	4.9	5.5	0	0.4	4.8	0
15.2.19	1.4	0	1.6	0.5	0	3.5	1.6	6.3	0.6	0.1	5	0	5.7	0	0	1.8	0	0	0	1.8	0	0	0	0	**13.8**	3.2	1.3	0.1	3.8	0.2	0.5	4.3	0
19.2.19	0.7	1.2	1	0.3	0.1	3.3	1.5	6.6	1.4	0.2	7.3	0	8.9	0	0.1	0.8	0	0.2	0	1	0	0	0	0	**16.5**	4.1	0.2	0.7	1.9	0.1	1	0.1	0
22.2.19	0.9	1.1	1	0.4	0.3	3.7	1.4	5.2	0.3	0.4	3.8	0	4.5	0	0.2	1.4	0	0.1	0	1.5	0	0	0.1	0.1	**11.3**	8	3	0	6	0.1	0.1	0.9	0
26.2.19	2.5	1.8	1.9	0.5	0	6.7	0.9	8.4	0.8	0.1	6.3	0	7.2	0	0.1	2.3	0	0.5	0	2.8	0	0.1	0	0.1	**18.5**	7.6	5.7	0.3	5.3	0	1.4	1.2	0
1.3.19	2.8	4.1	2.8	0.7	0.4	11	2.4	8.2	1.2	0.4	9	0	11	0	0.9	2	0	0.5	0	2.5	0	0	0	0	**21.3**	15	3.8	0.6	1.5	0	2	0.3	0.1
5.3.19	2.7	1.6	3.2	3.1	0.6	11	3.2	9.2	0.3	0	8.3	0	8.6	0	0.3	1.5	0	0.9	0	2.4	0	0	0	0	**20.2**	15	3.4	0.5	2.5	0	1.3	0	0.4
12.3.19	0.1	0	0	0	0	0.1	0	8.1	0.5	0	7.7	0	8.2	0	0.4	0.6	0	0.5	0	1.1	0	0	0.1	0.1	**17.5**	0	1	0.2	3.1	0	1.6	0	0
15.3.19	0.4	0	0	0	0	0.4	0.2	8	0.2	0	3.7	0	3.9	0	0.4	2.3	0	1.4	0	3.7	0	0	0	0	**15.6**	0.4	4.6	0.4	5.2	0	3.1	0.2	0.1
18.3.19	0.1	0	0	0	0	0.1	0	8.8	0.5	0	6.3	0	6.8	0	0.2	0.6	0.1	0.3	0	1	1	0	0	1	**17.6**	0	4.3	1.2	0.5	0	1.6	0	0.2
22.3.19	0.1	0	0	0	0	0.1	0	7.5	1.1	0	4.3	0	5.4	0	0.6	0.5	0	1	0	1.5	0.1	0	0.1	0.2	**14.6**	0.2	1.1	0	0.2	0	0.8	0	0
26.3.19	0	0.1	0.3	0	0	0.4	0	9.4	0.2	0	4.8	0	5	0	0.7	0.6	0.2	1.7	0	2.5	0	0	0	0	**16.9**	0	2.3	0.8	2.7	0	4.2	0	0.3
29.3.19	0	0.2	0.1	0	0	0.3	0	7.7	0.2	0.1	5.8	0	6.1	0	0.1	0.3	0	0	0	0.3	0	0	0	0	**14.1**	1.6	0	0.2	0	0	6.8	0	0.2

All counts are average per metre (over 11 metres) through the field

Appendix 3. Communications and feedback from industry collaborators

Emerald consultant

1. What was your general view of the light trap technology?

Revealing. It is very compelling to see what is around at night.

2. Did the light trap technology influence crop management decisions? If yes what was the outcome?

Yes. Increased scouting frequency (insects & plant damage) depending on trap catches.

3. Should there be further refinement of the technology? If yes what needs to be improved?

There are still a lot of mirid ecology questions. I feel the light trap is an extra piece but could be linked to other population drivers?

I had the feeling that wind (direction & speed) at night was a strong factor in trap catches but it could be just perception.

There may be concerns about the level of by-catch but it is also handy to know what else is around.

One idea I had was the light could be a mechanism to attract adults to distribute a biocontrol agent but this might be a long shot.

4. Do you intend to purchase a light trap/s from your commercial supplier? If so how many?

When this drought breaks we will probably put at least one per farm in our Capital Expense (CapEx) budget initially.

5. Would you recommend the technology to other growers?

A consultant in another area of Queensland purchased 2 traps last season after seeing photos of mirid catches.

Verbal communication with Moree collaborator

The collaborator indicated that he has been very happy with the use of the Zappa trap. He used the technology mainly as a warning sign that nymph mirids might be active in the crop. He found about 70 trapped mirids/night was the trigger to start looking for nymphs seven to ten days later.

The collaborator also found it especially useful for letting him know if there were any green vegetable bugs around as they are very elusive and difficult to detect using existing sampling. He felt it could help explain damage and loss of fruit when no pests are being seen in the field.

The collaborator has since left Moree and is now working on a strawberry farm in Stanthorpe and is considering purchasing a couple for use there as the pest complex of strawberries is similar to cotton.

Written communication with Hay collaborator

A representative from the Hay farm requested background information as they were interested in learning more about the potential field application of the Zappa trap.