SPA 1101

Spackman Iker Ag Consulting Pty Ltd
Independent Farm Management Consultants

Case Studies of Flooded Cotton Recovery In Central Queensland 2011

APPROVED 13/12/11

By Jamie Iker, Director
Spackman Iker Ag Consulting, Emerald

85 Egerton Street, P.O. Box 1029, Emerald, Queensland, 4720. ACN: 151 472 507 ABN: 73 151 472 507
Phone: (07) 4982 0958 **Fax:** (07) 4982 1348 **Email:** jiker@siac.com.au

Case Studies of Flooded Cotton Recovery In Central Queensland 2011

Table of Contents

Introduction

On New Year's Day 2011, the peak of the Comet River flood in Central Queensland broke long standing record levels. The alluvial lower floodplain of the Comet River is arguably some of the more fertile and productive soil in the region, with a significant percentage of this land being developed for irrigated farming and cotton production. Once the flooding had occurred, the region found itself in a position of having to try and find a way forward from this natural disaster. With cotton prices being at record levels and most farm businesses having forward-sold commitments, the most likely profitable avenue was to attempt to continue with the current cotton crop through to the end of the season. With no information on how cotton would recover from such an event available, any management decision came with the end result being uncertain.

Case studies were developed in consultation with growers, researchers and advisors to study a range of post-flood management options. The treatments were developed based on the state of the crop after the flood and the crop recovery immediately after the event. The case studies monitored were as follows:

1. **Crop retained most leaf matter however all fruit was lost, crop left untreated**
2. **Crop retained no fruit or leaf material, slashing was the first point of recovery**
3. **Crop was uneven in survival, uniformity was induced by "tipping" the crop**
4. **Crop retained no fruit or leaf matter and was left untreated**
5. **Crop totally destroyed and paddock was re-planted to conventional cotton**

Case Study 1 - Untreated, all leaf, no fruit (CS1)

Crop retained most leaf matter, all fruit was lost, crop left untreated

Case study 1 observed the ability of the cotton plant to recover from flooding which totally inundated the crop, caused the shedding of all fruit but retaining leaves. The crop was 17 nodes at the time of flooding and had high yield potential.

Figure 1: Flooded plant with no leaf, dowel indicates flood height

Figure 2: Close up of flooded plant

Post Flood

Immediately after the flood event, the crop was assessed for plant survival and the effect the flood had on the crop. Surprisingly the crop retained the majority of the leaf material, but it shed the entire fruit load. Due to the nature of the flood event and the minimal crop damage in this study, the decision was made to persist with the crop through to harvest. The flood had damaged most irrigation infrastructure on farm, which reduced the capacity for the crop to be irrigated until these structures were repaired.

The crop seemed to tolerate the transition from extreme water-logging to extreme drought reasonably well, with fruit production continuing throughout until the first irrigation was applied six weeks after the flood had receded. Flowers had reached the top of the plant prior to the irrigation being applied, however irrigation and nitrogen applications continued to promote new growth and fruit production.

Observations

Throughout the rest of the growing season, general crop growth was recorded photographically. The crop showed promising signs of recovery, at one point in the season it recorded 185 fruit/m^2 (including larger squares). At critical points in the season, field days were conducted with researchers Paul Grundy, Steve Yeates and Greg Kauter to discuss the progress of each treatment with regional growers and consultants. During these meetings this particular crop was observed and best described as the plant being "in competition with itself" (Paul Grundy) whereby leaves and squares were being set but were bunched and competing for nutrients. The crop had disproportional leaves and squares which seemed to be bunched on the top of the plant as can be seen in figures 3 and 4.

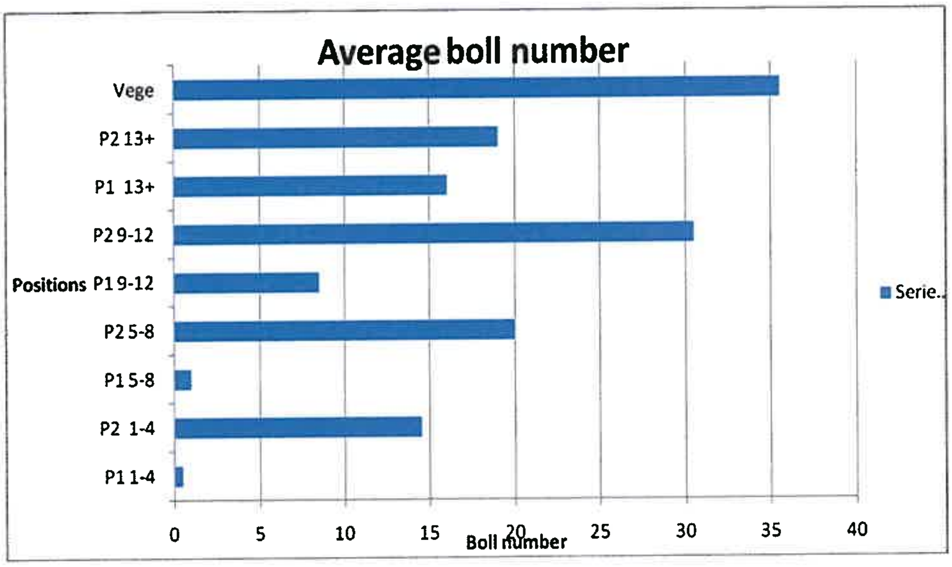
Figure 3: Bunched growth - leaf on

Figure 4: Bunched growth - leaf off

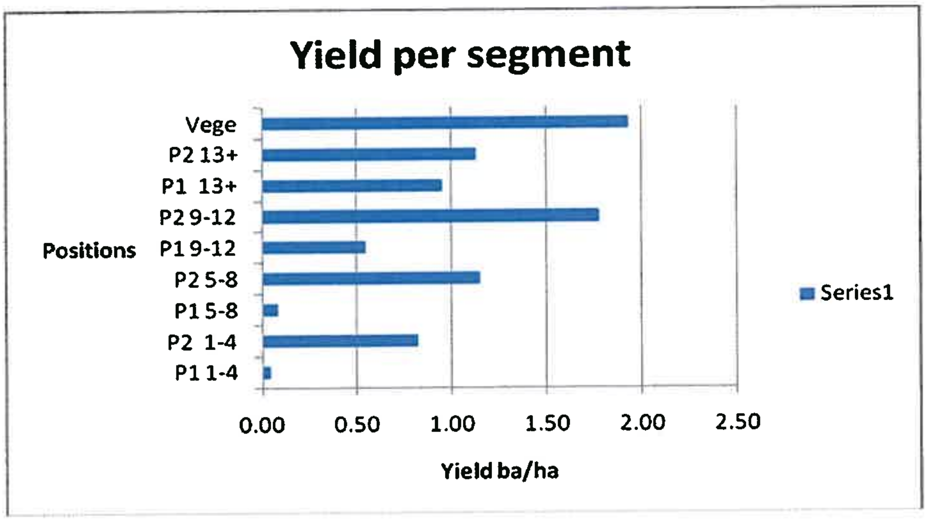
Despite the bunched growth, boll numbers remained reasonably high considering the abnormal growing season. Boll size was variable, with a large percentage of bolls being smaller than average. This was an ongoing concern due to this factor's likely impact on the overall yield of the crop.

Data

Segmented picking data was collected at the end of the growing season in this case study. This was to identify the compensation ability of the plant once significant fruit loss had occurred on lower fruiting branches, and to compare with the final commercial picking and quality data. The segmented pick was completed after the second defoliation was applied and just prior to picking. The following figures (5, 6, and 7) show the results of the processed data.



Figures 5: Segmented picking results showing the boll number of CS1



Figures 6: Segmented picking results showing the yield of CS1.

The graphs show that the plants compensated for yield loss on the fruiting nodes 9 and above and vegetative branches. This equated to 65% of the total hand-picked yield of 8.43 ba/ha.

The crop was limited by the shortened season as it needed to compensate for loss of fruit prior to the season cooling down in winter. This was always a concern as cold snaps were potentially just around the corner. Thankfully this didn't occur too often and the weather remained warm enough for the crop to fill and open bolls reasonably well. In figure 7 it shows the day degree accumulation of this crop through to harvest.

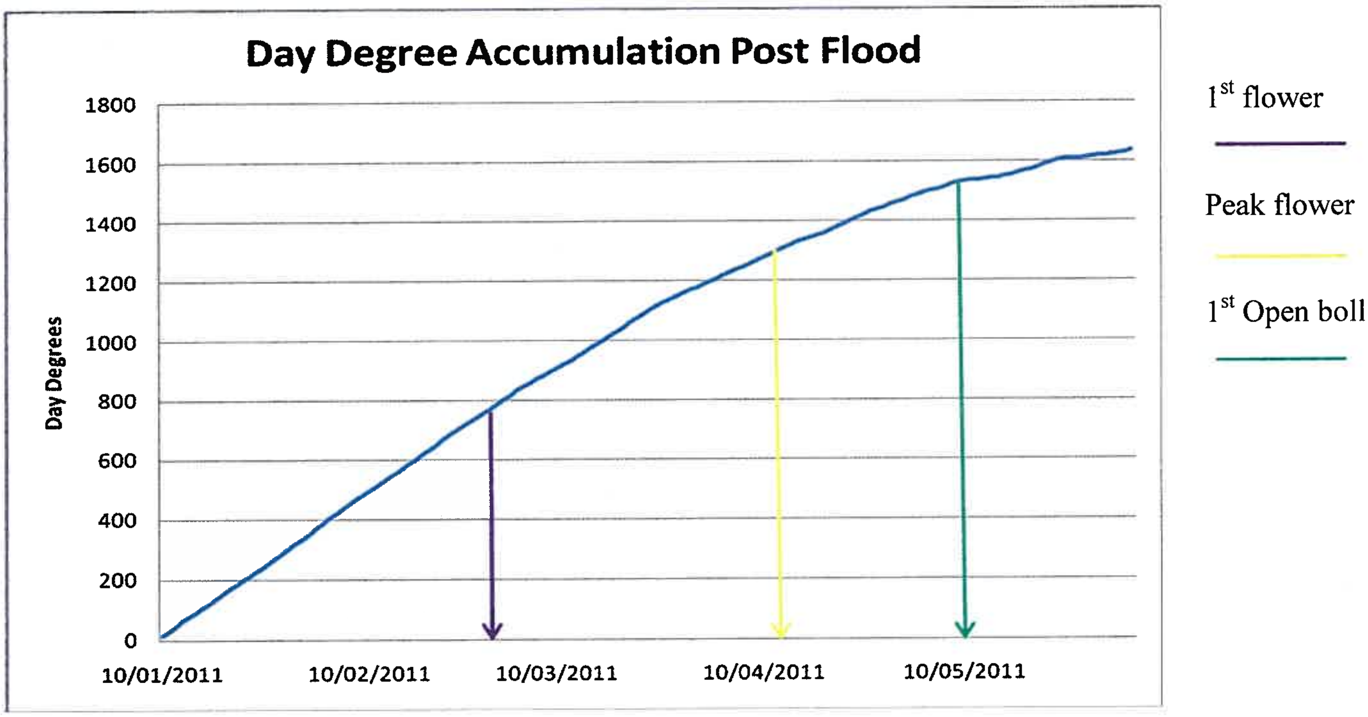


Figure 7: Day degree accumulation of CS1

Figure 7 shows that development did not rapidly decline at the end of the season, however day degrees after this crop was picked, were decreasing.

Classing Results – CS1

Case study one was the first of all treatments to be picked and the results from the pick are in the following table. This data is purely the classing data.

	Number of bales for each grade		
Length	**1 5/32**	**1 3/16**	**> 1 3/16**
	52	126	287
Strength	**28.0 - 30.0**	**30.0 - 32.0**	**32.0 - 34.0**
	25	367	73
Micronaire	**3.5 - 4.9**		
	465		
Colour	**21 SM White**	**31 MED White**	
	316	149	

Table 1: Classing data for CS1

The quality of the cotton was very good, with some bales reaching premium quality in length and strength.

Conclusions

This case study showed that the crop was resilient throughout the floods and recovered well. The critical time in the season was that the inability to irrigate this crop post flood for six weeks which forced it to cut-out. Despite the boll size seeming smaller than desired, the crop yielded well and was the stand out treatment of the case studies. In future floods, this option would be preferred in cases where plant survival was good.

Case Study 2 - Slashed (CS2)

Crop lost all fruit and all leaf material, crop slashed as first point of recovery.

Post Flood

As with the previous case study, the crop was assessed immediately after the flood had receded to assess the likely survival of the remaining plants. In this crop, sections of the field did not survive the flood and replanting of conventional cotton was to occur in these areas. To allow for ease of management with regard to irrigation, herbicide applications and fertilizer applications, the crop was slashed low to approximately six nodes to delay the growth and synchronise it with the conventional cotton in the same field.

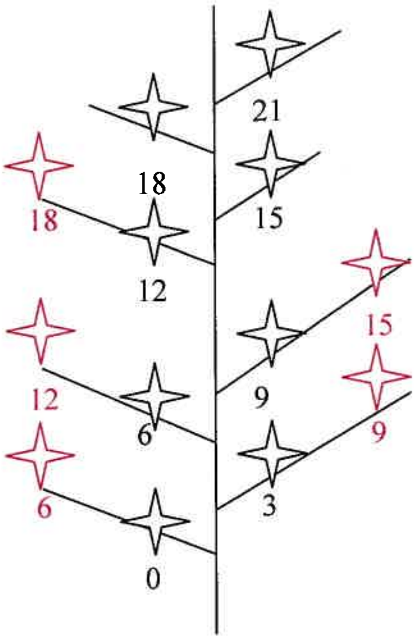
Observations

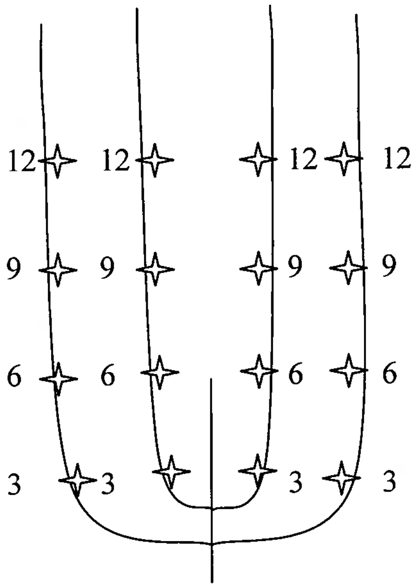
After slashing, this field began to initiate growth quickly with lateral growth being promoted by the slashing injury. Each of the laterals was a "mini plant" having similar structure to a normal un-tipped plant but was growing from a lateral position. In effect, the plant had three to four "mini plants" from one single primary stem. Figures 8 & 9 illustrate the growth of the crop at various points in the season.

Figure 8: Early recovery of slashed crop

Figure 9: Fruit production of slashed crop

The speed of the fruiting was the key here, as the plant reproduced rapidly once recovery had begun. This was both a disadvantage and an advantage, as explained below.





Figures 10 and 11: Schematic diagrams of the fruiting pattern on slashed and non-slashed plants. Numbers indicate the day each square is produced

The above diagrams represent un-tipped and tipped plants as observed in the field. The un-tipped plant has a staggered fruiting behavior. After the initial 1st position fruit has set, a 2nd position fruit on the same branch is set six days later. Each fruiting node produces a new 1st position fruit every three days, and so on. The slashed or tipped plant tended to set numerous fruit at the same time, every three days. This explained the rapid fruit development. However, if there was to be a shedding event, such as overcast weather or water-logging, a larger percentage of fruit was susceptible to this event and potentially shed. This rapid development was observed throughout the season and was most visible at boll opening.

Figure 12 and 13: Boll opening on slashed crop on two separate plants

Data

Due to the difference in plant architecture, segmented picking could not be completed in this crop as there were no defined or traditional fruiting branches. Instead, a maturity pick was conducted, where small plot areas of the treatment were picked once bolls began to open. These plots were picked each week, with boll number and weights measured. Generally, the boll weights for this treatment were high at the start of the pick and slowly tapered toward the end of the season. Weights ranged from 5.8 grams per boll to 3.75 grams per boll.

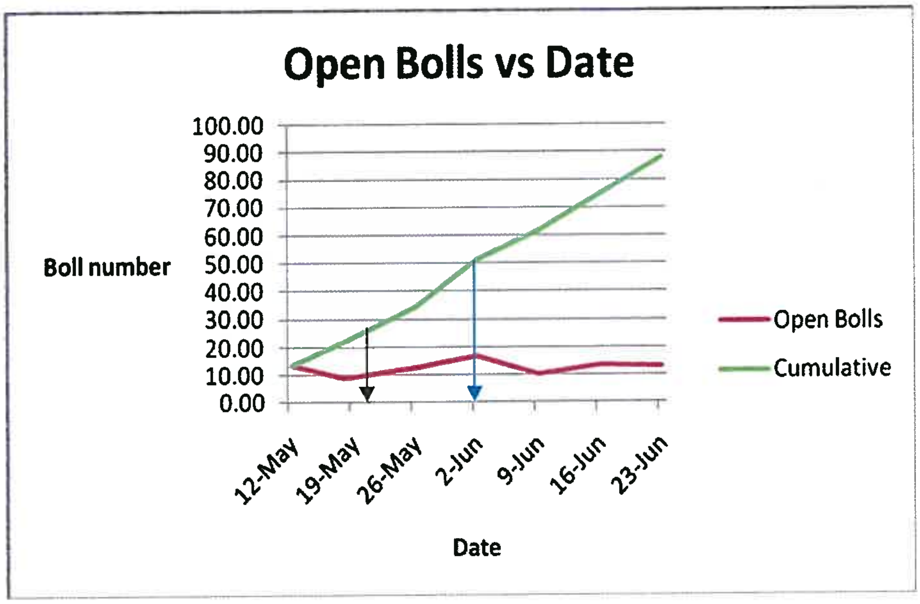


Figure 14: Black arrow indicates defoliation, where as the blue arrow indicates 60% open cotton

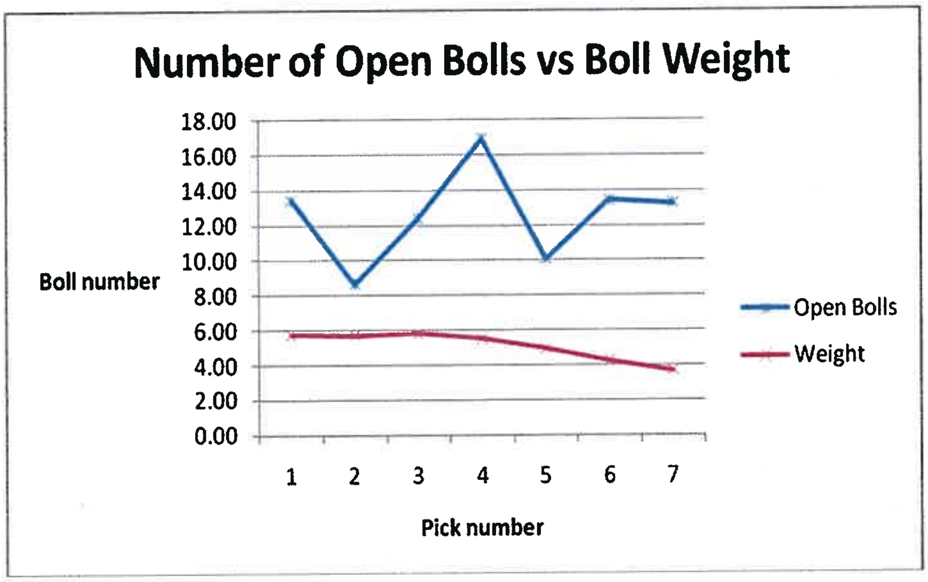


Figure 15: Variation in open bolls from week to week and average boll weights

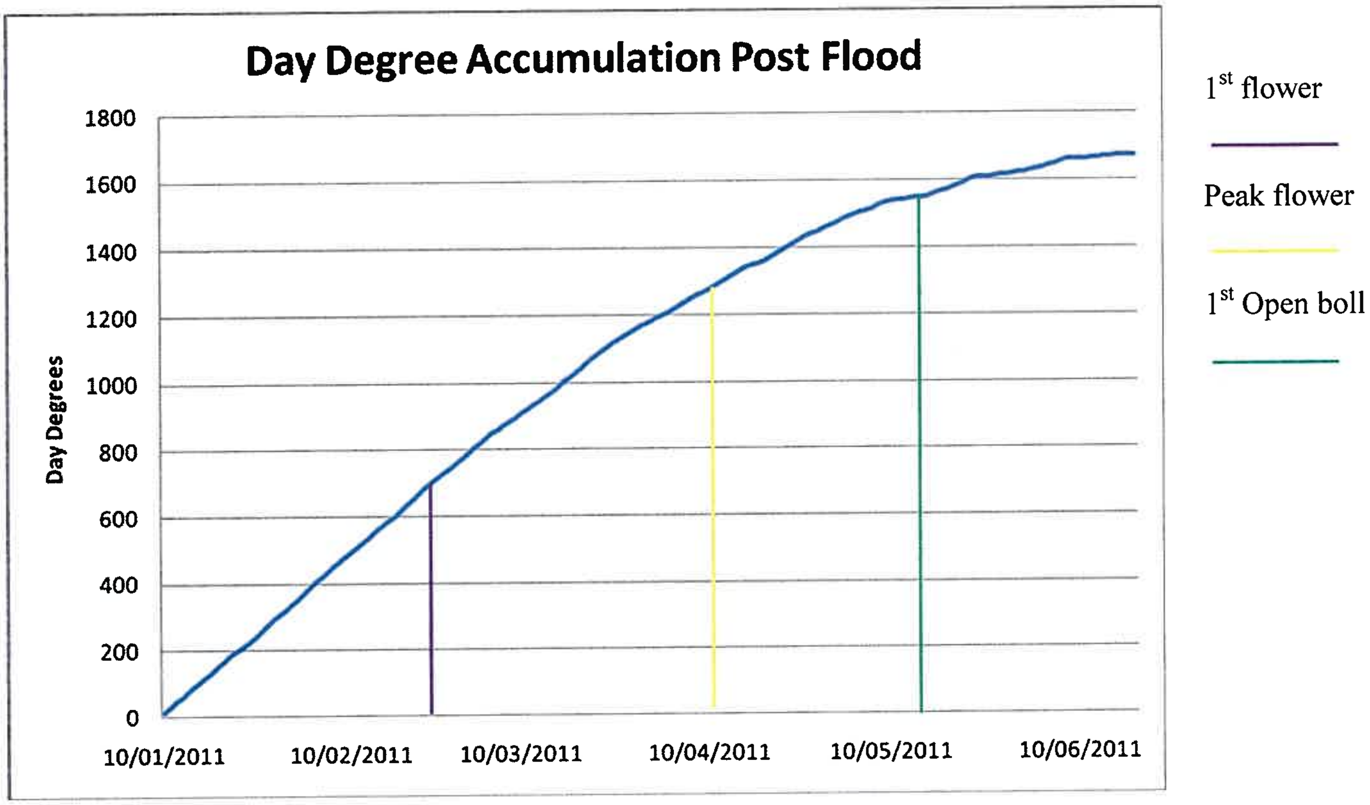


Figure 16: Day degree accumulation of slashed crop showing key times of development

This crop was defoliated earl (see figure 14) in attempt to complete the final management processes and harvest prior to a frost event, and return the field to next season's cotton. This is likely to have had an effect on the quality of the fibre, and may also have been a major factor in limiting yield.

Compared with the more advanced treatments, the day degree accumulation with this crop showed a tapering off towards the end of the season, which had an effect on the developing fruit. The bolls that were still developing were limited due to the lower micronaire, though this didn't occur in most of the crop. The small plot yield for this treatment was still a respectable 7.72 bales per hectare.

Classing Results – CS2

The classing results for CS2 are shown in the following table. In particular, the length, strength and micronaire grades for this crop had begun to slightly decrease due to the late timing of the crop. This crop matured later than CS1, with cooler weather during boll development.

	Number of bales for each grade				
Length	**1 1/8**	**1 5/32**	**1 3/16**		
	12	182	264		
Strength	**29.0 - 31.9**	**28.0 - 28.9**	**25.0 - 27.9**	**Below 24.9**	
	344	114	0	0	
Uniformity	**80 & below**	**Above 80**			
	1	457			
Shorts	**12 & below**	**Above 12**			
	458	0			
Micronaire	**3.8 - 4.5**	**3.5 - 3.7**	**3.3 - 3.4**	**3.0 - 3.2**	**2.7 - 2.9**
	68	165	146	3	76
Colour	**21 SM White**	**31 MID White**			
	439	19			

Table 2: Classing data for CS2

Conclusions

This crop achieved the budgeted results. The major limitations of this strategy were the susceptibility of a larger percentage of fruit to a potential shedding event, the uniformity of plant survival throughout the crop, and the shorter season length. Fibre quality issues with this crop were exacerbated by inducing boll opening with early defoliation decisions. Generally this crop performed well, given these limitations.

Case Study 3 - Induced uniformity by tipping (CS3)

Crop had uneven plant death and recovery through the field, and there was local opinion that "tipping out" would allow good crop recovery

Post Flood

Prior to the major flood receding, this crop was partially inundated in a previous flood in early December (as were all the case study crops, however this field was notably affected by this initial event). After the second event the majority of the crop survived, but the period of time that new growth (recovery) was initiated was variable. Accordingly, a high slashing or tipping was thought to be the best strategy to promote uniform growth. The crop had 4-6 nodes removed by a mulcher with some control strips left for comparison (as is shown in figures 17 and 18).

Observations

This crop, like the others, showed signs of recovery virtually immediately after the treatment was applied. Throughout the season, it showed variable responses to slashing, with some plants recovering well and others less so. This variability was one of the major limitations in the crop, making management and other decisions difficult.

Figures 17 & 18: Slashing (tipping) operation

Plants that didn't initiate new growth immediately after tipping recovered poorly, but continued to fill or produce on the nodes that were unaffected by the tipping-out operation. Once these nodes had fully developed fruit, the plants then set new squares and growth above this fruit. Effectively, these plants had two different crops on the one plant, as the first crop was approximately 2 weeks earlier than the later one. This proved to be an issue as there were significant boll disorders (rots and tight locks) in the early fruit. The crop was best described by Paul Grundy and Steve Yeates as being "confused". However there were plants that showed immediate new growth and square production after tipping, similar to what was expected locally. The percentage of these plants was too low to significantly improve overall crop yield. Figures 19 and 20 show the response of the "confused" plants and the "good" plants.

Figures 19 & 20:

Plants showing variability of recovery poor (left) and good (right)

Data

The crop was assessed using a maturity pick to quantify boll numbers, weights and yield. The plots were picked weekly until there were no fruit remaining on the plant. Figures 21, 22 and 23 show the results of the maturity picks and the day degree accumulation for this treatment.

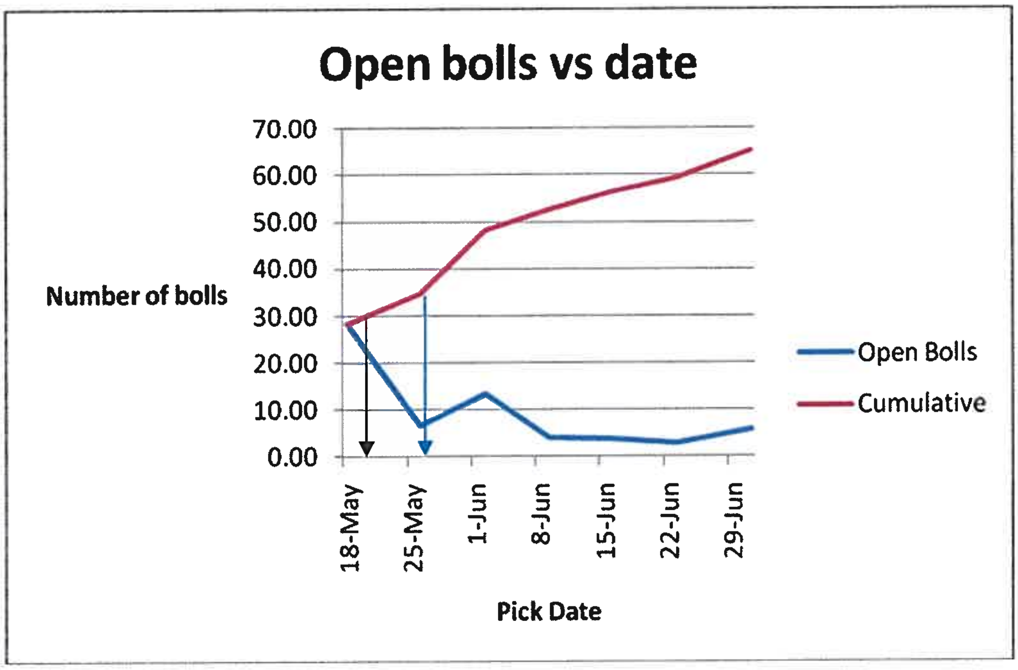


Figure 21: Maturity pick for CS3 showing boll number and date of opening. Black arrow is defoliation; blue arrow is 60% open cotton

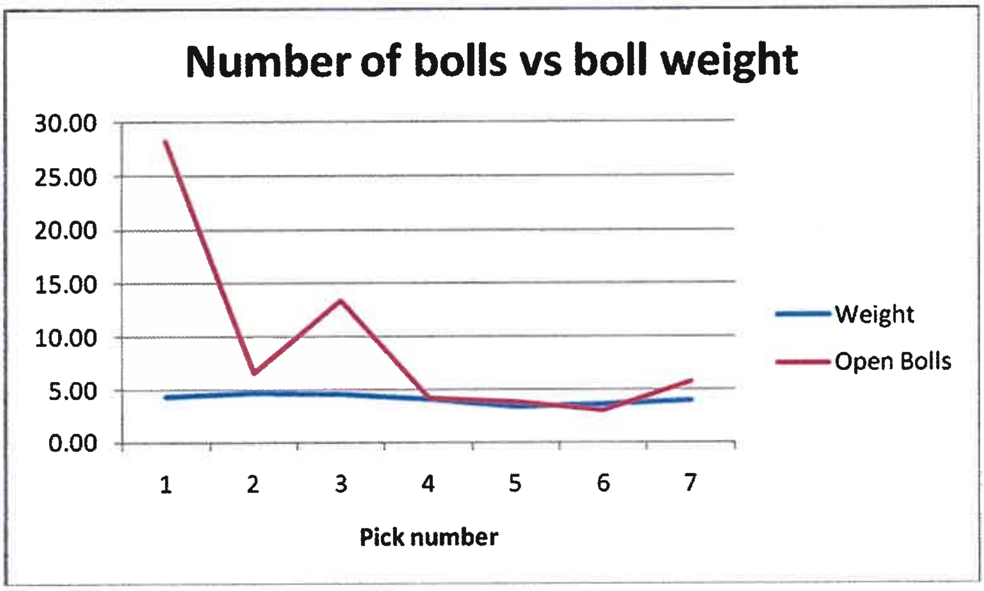


Figure 22: Maturity pick for CS3 showing boll number and average boll weight

Defoliation of this crop occurred prior to 60% open cotton, as was the case with the other case studies. The average boll weights were lower than the other crops, with the average boll weights for each weekly pick all being less than 5 grams per boll. The small plot yield was also lower at 4.58 bales per hectare.

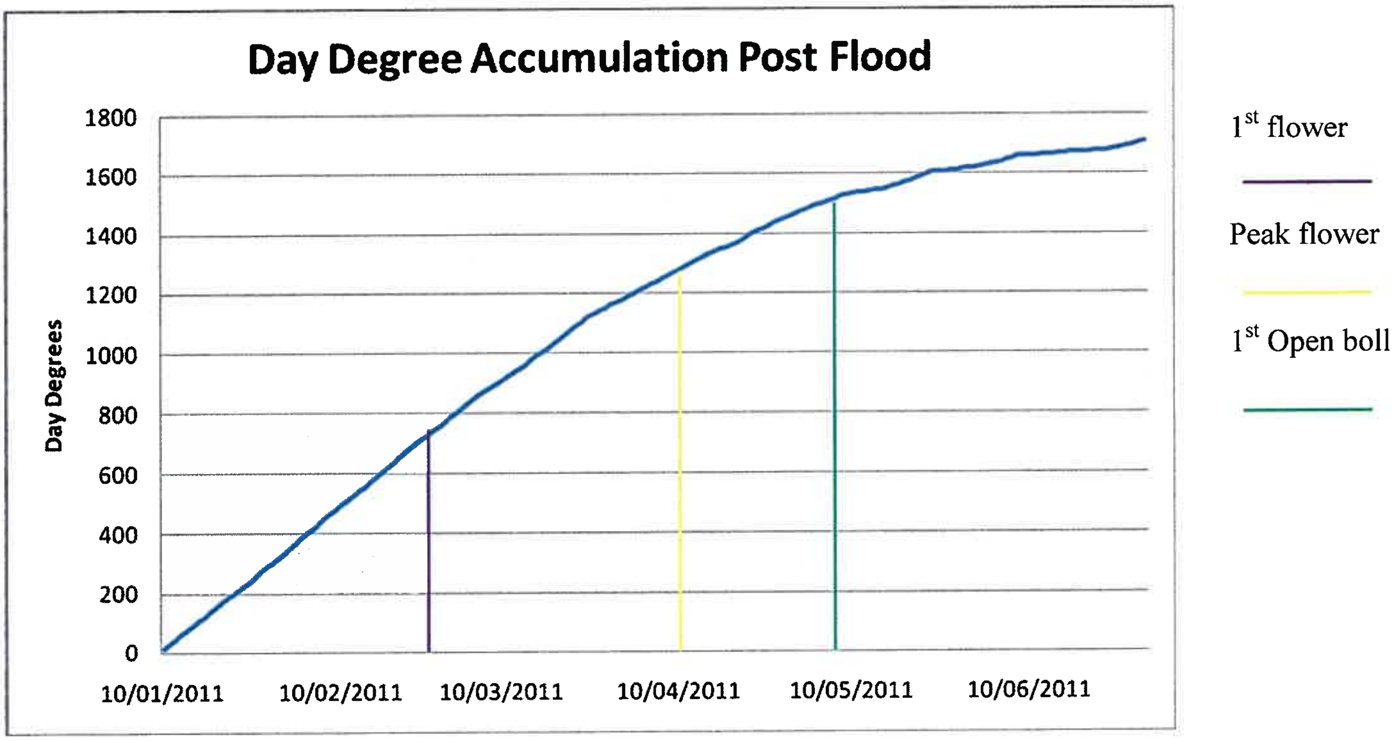


Figure 23: Day degree accumulation for CS3

The day degree accumulation was similar to that of the previous case study (CS2) which showed a tapering of the accumulation towards the end of the season. This is likely to have had an effect on developing bolls with respect to fibre quality and yield of the later fruit.

Classing Results – CS3

The classing results for CS3 are shown in the table below. This crop showed similar results to that of CS2, but was slightly more stable with some aspects of the quality, such as micronaire. This was probably because the crop had some fruit remaining on the plant prior to the "tipping" operation which would normally have filled in better conditions.

	Number of bales for each grade			
Length	**1 5/32**	**1 3/16**		
	87	176		
Strength	**29.0 - 31.9**	**28.0 - 28.9**	**25.0 - 27.9**	**Below 24.9**
	67	138	57	2
Uniformity	**80 & below**	**Above 80**		
	7	257		
Shorts	**12 & below**	**Above 12**		
	0	264		
Micronaire	**3.8 - 4.5**	**3.5 - 3.7**		
	239	25		
Colour	**21 SM White**			

Table 3: Classing data for CS3

Conclusions

This crop was yield limited due to several factors including the short season length, slow speed of recovery, and the variability in recovery of plants in the crop. Boll disorders such as boll rots and tight lock were more evident in this crop due to the staggered recovery of plants. After flooding, tipping should be avoided as a management strategy, as there is no evidence that yield, quality or management of the crop will improve.

Case Study 4 - No Leaf or fruit and untreated (CS4)

This crop had no green matter left and the browned main-stem was all that remained

Post Flood

This crop differed from the other treatments in that after flooding the crop was left alone (as predominantly these areas were only sections of the field) with no expectation of a favourable response. Sections of the flooded area began to re-shoot, similar to re-growth cotton after defoliation if it is left un-picked. The decision was then made to proceed with these areas through to harvest, and to determine the profitability of this decision.

Observations

The crop was slow to recover in comparison to all other treatments which, given the situation, was always likely to affect yield to some degree. Some plants responded well, quickly setting some fruit, whilst others never responded and set no new fruit at all. Plants that did respond produced little fruit.

Accordingly, the crop was terminated as it was unlikely to cover the cost of inputs (license fees, defoliation and contract picking costs). Therefore no quantitative (yield and quality) data was collected. Figures 24 & 25 show the variation throughout the field and the initial recovery.

Figure 24: first sign of recovery

Figure 25: Variation of recovery throughout the field

The abandoning of the crop re-iterated the importance of careful and early assessment of the potential plant survival before considering management options.

Case Study 5 - Re-planted conventional cotton (CS5)

Post flood

The Bollgard cotton crop that was initially planted in this field was totally destroyed in the floods. Due to contractual commitments, the decision was made to re-plant this field to conventional cotton, which occurred on the 17th of January. Yield expectations of this crop were very modest due to the lack of heat units and radiation for the remainder of the season.

Observations

This crop was judged by locals as being very "ambitious", however early stages of the season, the crop growth was very good. Being conventional cotton planted late in the season, insect pressure was a risk from the beginning and the risk quickly became a reality with the first insecticide being applied at 4 true leaves. There was limited opportunity for compensation resulting from tipped out growth which began at 3-4 true leaves.

Figures 26 & 27:

Late planted conventional cotton at various stages in the early season

Extremely high insect pressure occurred the season, the crop required 11 insecticide applications from planting to the 27th of April and all were applied to above threshold insect populations.
Being planted in the hotter part of the summer the day degree accumulation accelerated early crop growth. This accelerated growth was beneficial in gaining crop structure but to encourage the crop to reproduce, and not growth excessive vegetative matter, Mepiquat Chloride was applied four times throughout the season, at multiple low rates. These applications totaled 1.5 L/ha over four separate applications starting at first flower.

The crop progressed well through the season setting numerous fruit and maintained most positions despite, the high insect pressure (seen in figures 28 & 29). The weather began to influence decision making, mainly defoliation, as the crop was still growing actively into the winter months. The decision was made to begin the defoliation process earlier than 60% open cotton on the 6th of June, in order to mitigate the potential risk of frost damage, and the crop needed three applications of defoliant prior to picking.

Figures 28 & 29: Shows the fruit development and retention 104 days after flooding

Data

Boll number, weights and average small plot yield, were quantified with maturity picks out once a week during boll opening.

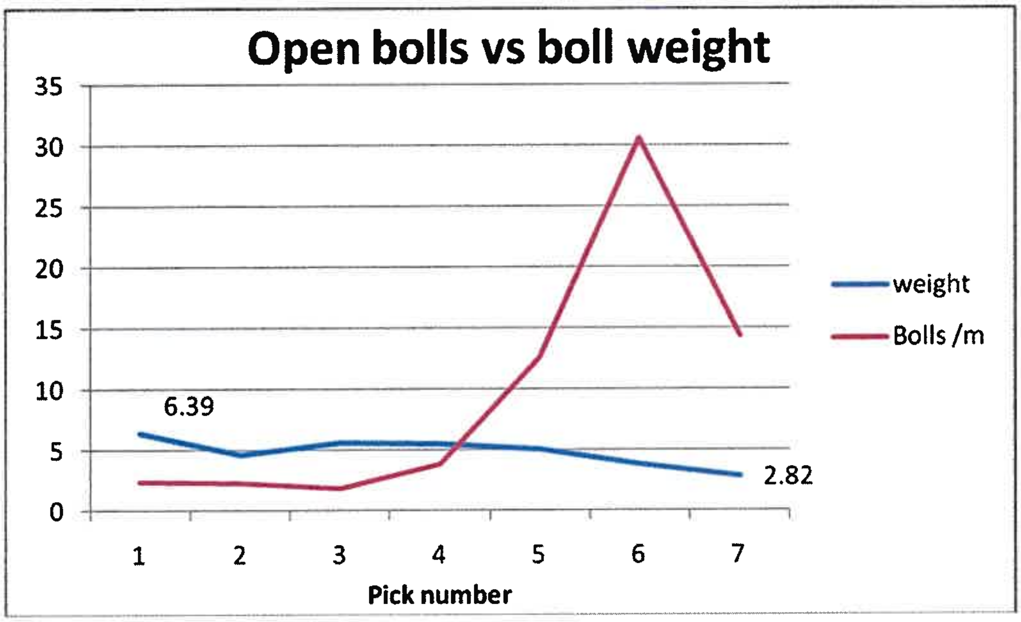


Figure 30: Maturity pick of CS5 showing boll weights and number of bolls per metre

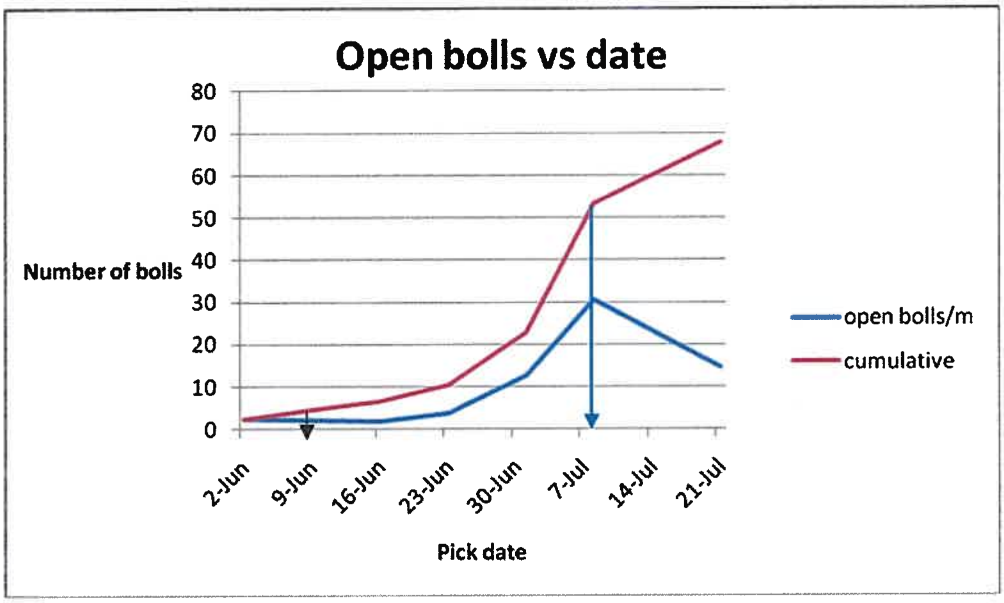


Figure 31: Maturity pick of CS5 showing open bolls vs. date. Black arrow is defoliation; blue arrow is 60% open cotton

Figure 31 shows that defoliation occurred very early due to the increasing risk of a frost event occurring further into winter the crop grew. In fact had the crop not been defoliated early, 60% open cotton would have occurred much later and the crop would have been at greater risk of impacts of potential frosts, substantial delays in picking and preparation for the next crop. Boll weights in this crop started high, and remained high for the majority of the maturity pick. However, boll weight rapidly decreased towards the top of the plant, with the average on the last pick being under 3 grams/boll. The small plot yield of this crop was 5.63 bales per hectare.

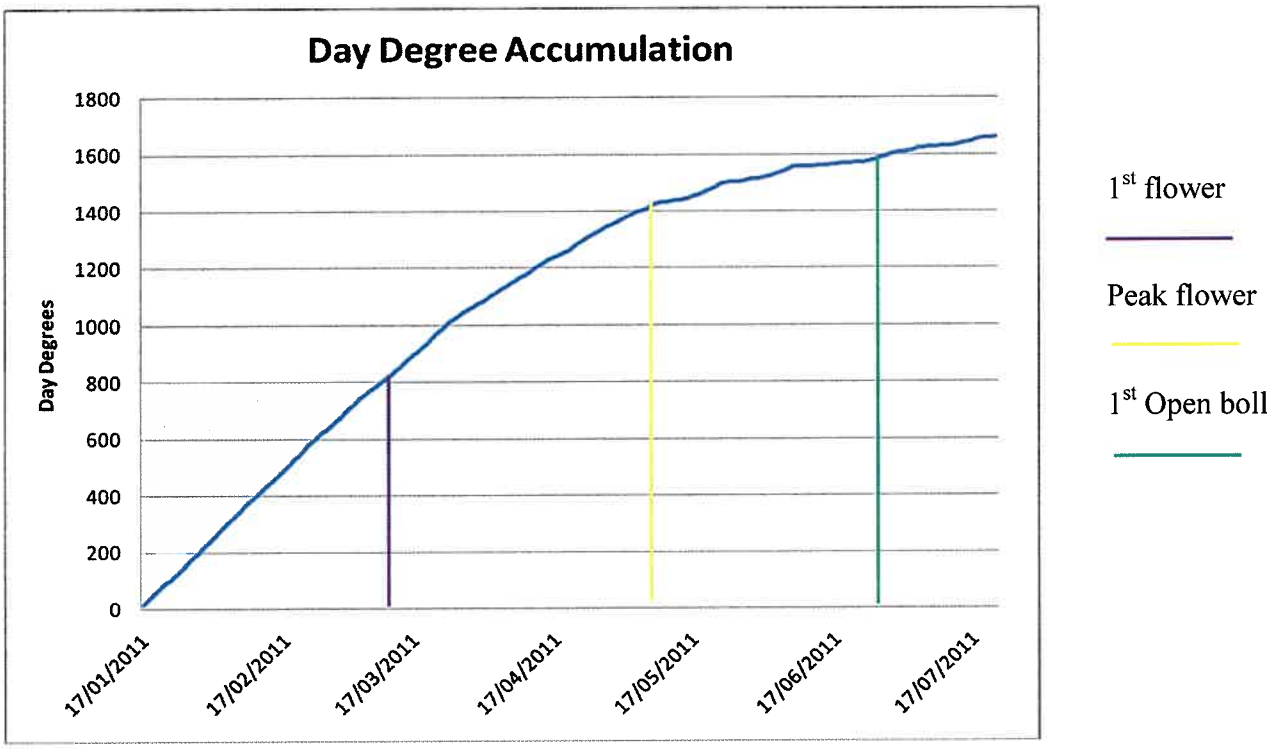


Figure 32: Day degree accumulation of CS5

Figure 32 shows the day degree accumulation from planting. The expectation was to see the graph plateau towards the end of the season due to the weather at the end of the season and this was the basis of the early defoliation decision. In hindsight, potentially some of the quality issues may have been avoided had defoliation been delayed for a longer period of time.

Classing Results – CS5

The classing results for the re-planted conventional cotton are shown in the below table.

	Number of bales for each grade			
Length	**1 1/32**	**1 3/32**	**1 1/8**	**1 5/32**
	154	160	56	1
Strength	**29.0 - 31.9**	**28.0 - 28.9**	**25.0 - 27.9**	
	1	27	343	
Uniformity	**80 & below**	**Above 80**		
	242	129		
Shorts	**12 & below**	**Above 12**		
	344	27		
Micronaire	**3.0 - 2.2**	**2.7 - 2.9**	**2.5 - 2.6**	**Below 2.4**
	1	35	152	183
Colour	**21 SM White**			

Table 4: Classing data for CS4

Fibre quality, mainly micronaire, was greatly reduced in this treatment. Significant discounts were incurred. Micronaire was the most noticeable issue, while length and strength were also low.

The season contributed to low cotton quality in this crop. Low temperatures during boll filling, high plant densities, high fruit retention and early defoliation can all affect the quality of the fibre. Given the lateness of this crop, it was inevitable a portion of the cotton was likely to be poor quality.

Conclusions

Although this crop had potential, the shorter season length, insect pressure and pre-emptive early defoliation, meant that this crop was did not reach its potential. This option has the most risk and decision making was made extremely difficult due to many decisions being made on the presumption of likely weather patterns and historical averages. As it turned out, such averages and forecasts should not have been used to make decisions as this may have slightly improved some of the quality issues that were observed. By far the most influencing factor was the short season, as the boll-filling period coincided with the cooler months, fibre quality was affected. In summary, a mid-late January planting has multiple risks associated with it and should be avoided where possible.

General conclusions

The case studies that were observed this season showed how resilient the cotton plant is in surviving adverse conditions. The flood event bought about numerous situations which had not been encountered on such a large scale in the region prior to the event occurring. Due to the nature of the flooding and the seasonal prices, the first priority was to attempt to see the crop through to harvest to fill any delivery contracts. The case studies were developed with consideration of the situation for each flooded field and the capacity to get the crop through to picking.

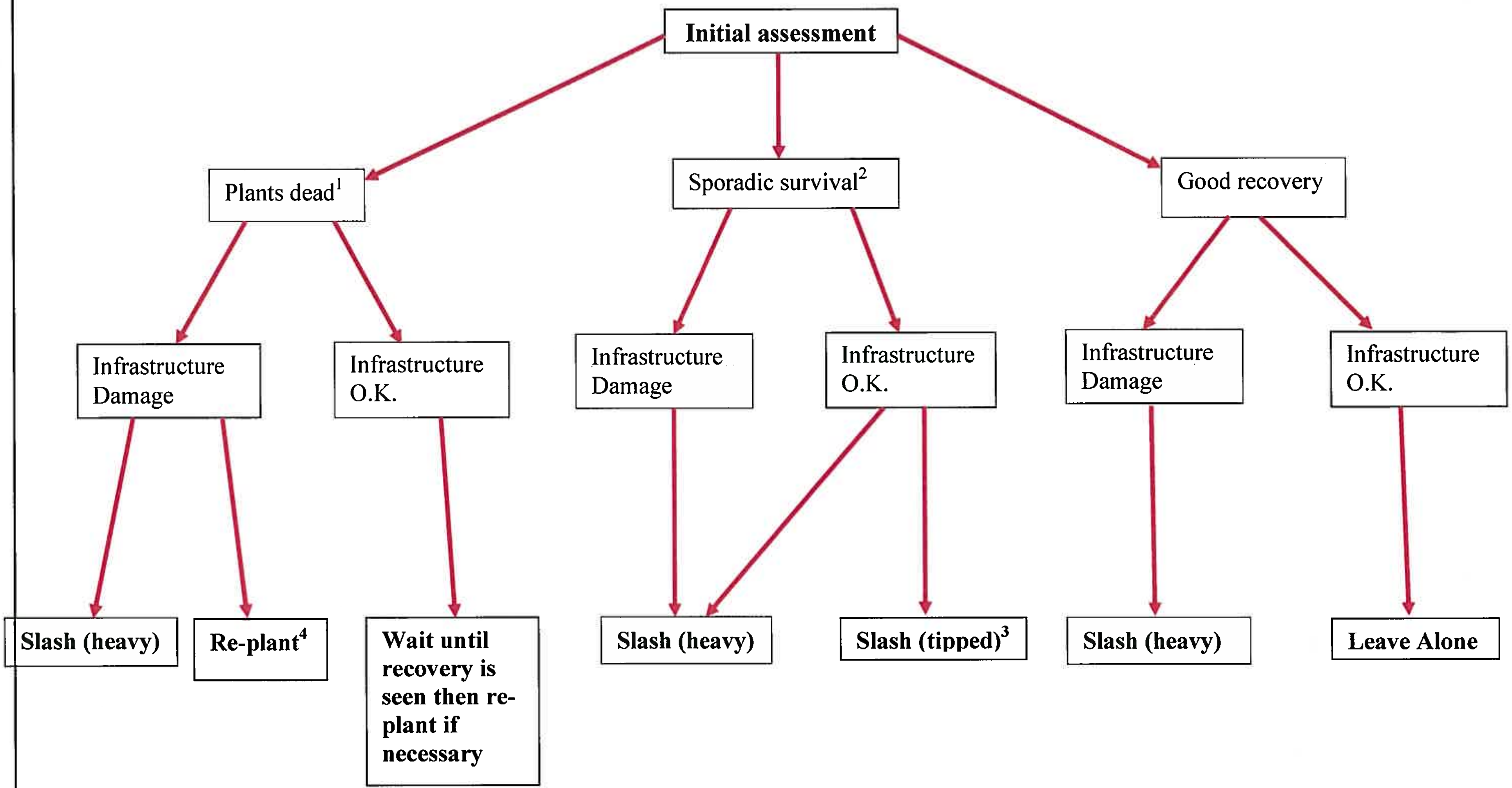
Were these studies worthwhile? It is a difficult question to answer. The growers that implemented these strategies would employ most of them again if faced with similar circumstances, with the exception of CS4 (No leaf or fruit and left untreated) as this crop failed to develop and subsequently was abandoned. The profitability of each treatment will vary depending on the current cotton price, the committed price, insect pressure and season length with however, the benefit of hindsight, different approaches would be used for certain treatments to potentially enhance yield and quality, for instance delaying defoliation, in late planted conventional cotton

In assessing post-flood management options, the first and most important priority is to make a careful and accurate field assessment of crop survival and potential recovery. This is the most critical part of the decision making process as it will influence how the crop is managed for the rest of the season. The best way to assess this is by looking at the root system of the plant. If the roots are fresh, white and seem to be actively growing, the survival of that plant is drastically increased compared to plants where the roots were dead and not foraging. If the plant has retained vegetative material, monitor the crop until such a time as new growth is observed. It may take a few days to a week to get a good idea as to how the crop will recover, but is vital to making a sound management decision.

The next step is to make an assessment of the capacity to manage the field with both nutrition and irrigation. This again will impact on the decision on how best to manage the crop after the flood event. If there is significant irrigation infrastructure damage, there are some management options (slashing or "tipping") which may assist in managing the crop while repairs are made.

Figure 33 is a flow chart designed to assist growers and consultants in making these difficult decisions. The chart outlines options in situations that are likely to be encountered after a flood event. It does not provide definitive answers, but may be useful as a guide.

It has become clear in this study that each flood event is different, and fields may respond differently. Decisions following a flood event should consider remaining season length, survival probability and management capacity. Importantly, these initial decisions should not be rushed as it may take some time before the answer becomes clear. Seasonal weather patterns will have a major influence on the end result.



1. Plant death - shows no signs of recovery, no re-growth, stems are discoloured
2. Sporadic survival – areas show good recovery, while in other areas plants have died
3. "Tipping" – is an option however results have been variable. Heavy slashing is less of a risk.
4. Depending on the remaining season, this can greatly affect the outcome of this treatment

Figure 33: A post-flood cotton management decision flow chart

Acknowledgements

This project was funded by the Cotton Research and Development Corporation.
I wish to thank the following people for their help and input into this project.

- Carl and Robyn Morawitz – Argoon, Comet
- Craig and Natalie Barsby – Currimundi, Comet
- Ross Keeley and Leon Allison – Goonoo Farms, Comet
- Paul Grundy – DEEDI, Toowoomba (formerly Ayr)
- Steven Yeates – CSIRO, Ayr
- Susan Maas – DEEDI, Emerald
- Tracey Leven – CRDC, Narrabri
- Greg Kauter – Cotton Australia, Narrabri

Spackman Iker Ag Consulting Pty Ltd
Independent Farm Management Consultants

Australian Government

Cotton Research and Development Corporation