CRC 1.1.14

Burdekin Cotton Research Summary 2004-2006

Report prepared for
Cotton Catchment Communities CRC
Qld Dept of Primary Industries and Fisheries
CSIRO

Paul Grundy (QDPI&F) & Stephen Yeates (CSIRO)

May 2006

Table of Contents

Executive Summary

The purpose of this CRC funded project was to provide scientific assistance to the Queensland Cotton (QC) commercial trial program in the Burdekin region. The focus of the QC trials was to demonstrate the potential of Bollgard/Roundup Ready cotton using BMP production principles to local growers who had expressed an interest in using cotton as a viable crop rotation with sugar cane. Our role within this program was to gather specific plant protection, agronomic and environmental data where possible that might be used to devise future crop management strategies as well as industry investment and development decisions.

From a plant protection perspective no significant pest, weed or disease impediments to growing cotton in the Burdekin were identified in the QC cotton trials. Silver leaf Whitefly *(Bemisia tabaci)* surveys indicated that this pest is likely to be active in Burdekin cotton crops. However, its pest status is potentially offset by the presence of *Eretmocerus* spp parasitoids and the use of a mid-summer planting window that ensures that as the crop matures, cooling temperatures going into winter will naturally suppress remaining whitefly populations as the crop opens bolls and would become susceptible to lint stickiness. It is likely that a similar set of circumstances would apply to other sucking pests such as aphids which could be abundant in some seasons.

Cluster caterpillars (*Spodoptera litura* F.) were prevalent during the 2005 trial plantings and required insecticide control. The presence of this pest and its ability to tolerate exposure to Bt cotton suggests that it should also be considered along with *Helicoverpa armigera* when designing a resistance management strategy relevant to north Queensland. Pests such as green mirids (*Creontiades dilutus*) and jassids were abundant in the region and will require judicious management as is the case for existing cotton production regions. Key consideration will need to be given to preserving parasitoids for whitefly and cluster caterpillars.

Weed and disease impacts are not well defined for the Burdekin and should also be a focus for future research. Sedges and grasses (Cyperaceae and Poaceae families) would appear to constitute the major weed groups of concern in the region. The impact of these and other weeds may be partially alleviated through the use of roundup ready technologies. *Alternaria* spp. caused major disease problems during the 2004 trial although this disease appears to be avoidable with the use of a mid-summer planting window. No other soil based diseases were detected during disease surveys conducted during the 2005 trials. A summer planting window is likely to reduce any potential expression of diseases such as Fusarium or black root rot.

A potential planting window from late December to the end of January has been identified from preliminary climatic analysis. Cotton planted later than January/early February is exposed to cool winter conditions during boll fill resulting in yield loss, defoliation difficulties and picking delays. Later planted crops were also found to be particularly susceptible to *Alternaria* disease epidemics causing significant leaf defoliation and yield loss. Under a Burdekin climate, cotton crops need to be ideally picked by July to escape *Alternaria* disease and adverse climatic impacts. This suggests that planting must occur prior to mid February. However, the Burdekin wet season that typically peaks during February also limits the sowing of cotton before late December. The use of a late December/January planting window will require the development of strategies aimed at minimising the potential difficulties associated with potential wet planting conditions, flood events, summer pest management. The January planted field in 2005 produced high yields and excellent quality cotton which concurs with these projections.

The environmental impacts of cotton in the Burdekin remain largely un-explored and will need to be investigated. The drainage of fertilisers and pesticides through soil profiles is likely to be markedly different between the mosaic of Berretta clay and loam soil types present throughout the region.

Education for prospective cotton growers in the region was undertaken in February 2005 and again in 2006. This program provided basic level information for 10 growers that included a day of presentations that spanned topics from crop agronomy to pest management followed by practical in field training in crop scouting and plant mapping. This education was enthusiastically received by local growers that have been seeking greater exposure to cotton industry information**.** The 2006 meeting focused more on Burdekin related issues and constraints and began investigating how cotton might be introduced to the local farming system should Monsanto's BG/RR registration attempt prove successful. Should a future industry commence in the region an intensive extension program that is specifically linked to research and industry organisations will need to be developed and implemented to ensure the adoption of best management practices.

All future research and investment in the Burdekin is now dependant on the success of Monsanto's bid to broaden the registration of BG/RR varieties to include regions above the 22^{o} parallel. A decision on registration is expected by the end of 2006. Should registration succeed, we initially advise a greater emphasis on a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase will focus assessing likely yield and quality, while accounting for climatic risk, compatibility with cane production and likely economic outcomes at farm and regional level. Commercial scale trials could continue in parallel with this research or after its completion.

Background for CRC 1.1.14

With the demise in prosperity of North Queensland's sugar industry over the last decade there was growing impetus for cane growers to diversify into new or alternate crops. Cotton was seen as an attractive alternate irrigation crop that may fit well within the Burdekin farming system. On this basis a group of growers approached Queensland Cotton (QC) with an interest in exploring the possibility for growing cotton as an adjunct to cane production in the Burdekin region during the summer of 2003/04.

At the commencement of this project in 2004 QC had already proceeded with Bollgard plantings at two trial sites situated near Giru and Clare. The initial aim for the project was to begin assessing potential pest problems that might be associated with cotton in the region. During 2005 it was agreed that QC and the CRC should collaborate more formally with a broader view to experimentation to investigate a range of agronomic, plant protection and environmental issues.

Historically, the expansion of cotton production into northern Australia has been hindered by insect, environment and location-derived problems. However, development of improved transgenic cotton varieties has increased the potential for the development of sustainable and environmentally sound cotton production systems for northern Australia. The Burdekin region is an already established agricultural area that has several advantages that may favour the establishment of a future cotton industry.

The Rydge Partners report (2005) suggested that the Burdekin region had the following advantages as distinct from 12 other regions within NQ:

- 20-30,000ha of freehold land potentially suitable for cotton production.
- Annual allocation of 585,000ML of water for agriculture with 95% reliability.
- Potentially suitable climate.
- Excellent existing agricultural infrastructure and service industries.
- Land values that are lower or on par with current market values for existing cotton properties in conventional regions.
- More favourable and accepting political climate compared with other northern centres.
- Downturns within the local sugar industry over the last decade have made diversification options more attractive.
- Potential for an additional 200,000ML of water if Sunwater proceed with proposed dam wall height raising works

The Rydge Partners report strongly suggested that further research should be undertaken in the Burdekin with a view to future industry development.

2004-2006 Research and Results Brief

2004 Cotton Plantings

In 2004 Queensland cotton leased 26 hectares of farmland between two sites (14 Ha Roy Young's & 12 Ha Lindsay Hall's) to trial the growing of BG/RR varieties.

Four varieties (CSX 414, DP 546, 289BR & DP556) were planted dry and watered up in Mid-May. This planting date was much later than desired due to delays in gaining government permit approval. The "Young" site consisted of a loam soil type with sodic patches whilst the "Hall" site was a heavy Berrata clay type soil both typical of the region. Nutrition and irrigation was managed by QC according to typical industry practices used in central Queensland.

The 2004 season was notably cool with 71 cold shock days recorded (where night time temps drop below 12^{o}C) compared to the long term median of 25 days. The cold temperatures severely limited crop yields through physiological disruption to flowering and fruit set (Figure 1) as well as precipitating a major outbreak of disease and leaf drop due to the *Alternaria* spp. pathogen which has been recorded in other northern regions during cold seasons.

Figure 1. Example of pollen and bud distortion caused by un-seasonally cool conditions.

The colder than average temperatures greatly reduced the incidence of a range of pest insects known to inhabit the region including *Helicoverpa* spp, mirids, jassids and aphids. Silver leaf whitefly SLW (*Bemisia tabaci*) were abundant immediately after sowing upon crop emergence, although the ensuing cold conditions largely capped population development. The presence of endemic *Eretmocerus* parasitoids in the cotton crops was encouraging as these had not been previously reported to be abundant in the region during surveys of vegetable crops conducted several years prior (P. Debarrow pers com).

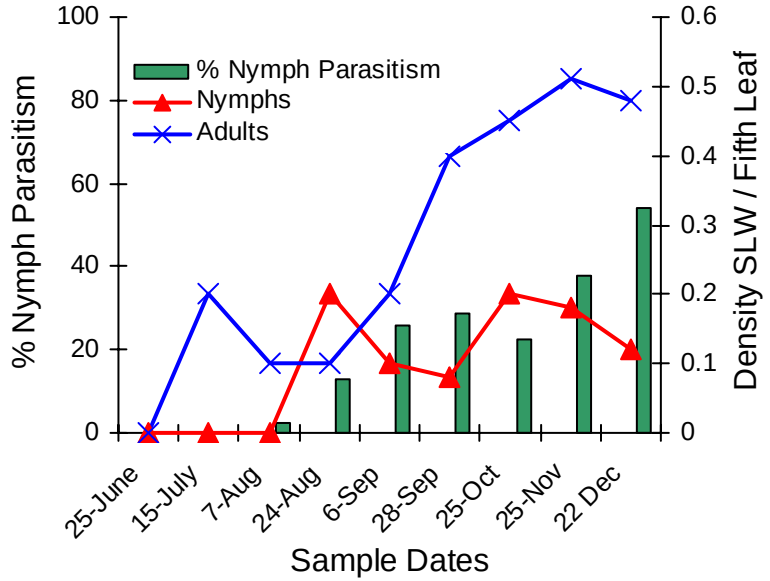

Figure 2. Mean density of whitefly on cotton and percentage nymph parasitism during 2004. Note cool weather suppression during July-September and increased parasitoid activity in spring.

Due to the cold conditions, crop development was significantly delayed. Substantial yield losses occurred due to the cold conditions that caused poor pollination and predicated the *Alternaria* spp. disease outbreaks which further stressed the crops due to significant canopy loss. The crops were finally picked during late December/early January after some compensatory growth had occurred over spring. Crop yield was less than ideal due to the loss of yield over winter and the limited ability of the plants to compensate during the following spring.

2005 Cotton Plantings

In 2005 Queensland cotton leased farmland from Mulgowrie farms. Several varieties (Sicala 60BR, CSX 613-1, Sicot 71) were planted at four different dates during the middle of January, February, March and April. The first planting was sown in a single field under centre pivot overhead irrigation on a well drained red earth. The February and March plantings were grown in a second field under flood irrigation and the April planting was sown in another field also under flood irrigation both on a moderate to heavy clay soil type.

These planting dates were not replicated as previously planned which limited the opportunity to collect more quantitative data and soil samples for monitoring chemical movements were not taken due to a last minute change of co-operators for the trial.

The January – March plantings were grown through to yield whilst the April planting was ploughed out due to its growth notably suffering from the onset of cooler conditions as the crop entered a reproductive phase and the presence of *Alternaria* spp..

Silver Leaf Whitefly were very abundant in the plantings after sowing but numbers were significantly curtailed due to the rapid establishment of *Eretmocerus* parasitoids (Figure 2) and then the onset of cooling temperatures as the crops matured.

Cluster caterpillar, *Spodoptera litura* (F) were prevalent in the cotton plots until the end of March. Larvae in the January planting required control (Synosad 150mL/Ha) to prevent extensive defoliation. Green mirids (*Creontiades dilutus*) required control on several occasions in each of the plantings. Jassids were also a pest of significance, with high populations in the February-March plantings causing foliage distortion and discolouration (Figure 3).

A survey for disease suggested no evidence of soil borne pathogens associated with Fusarium wilt or black root rot.

The January planting was picked in late June and the February/March plantings were picked in August. The January planting was a very high yielding crop that had satisfactory fibre characteristics for colour, micronaire and staple length. The February sowing produced yields similar to the Australian Average for 2005.

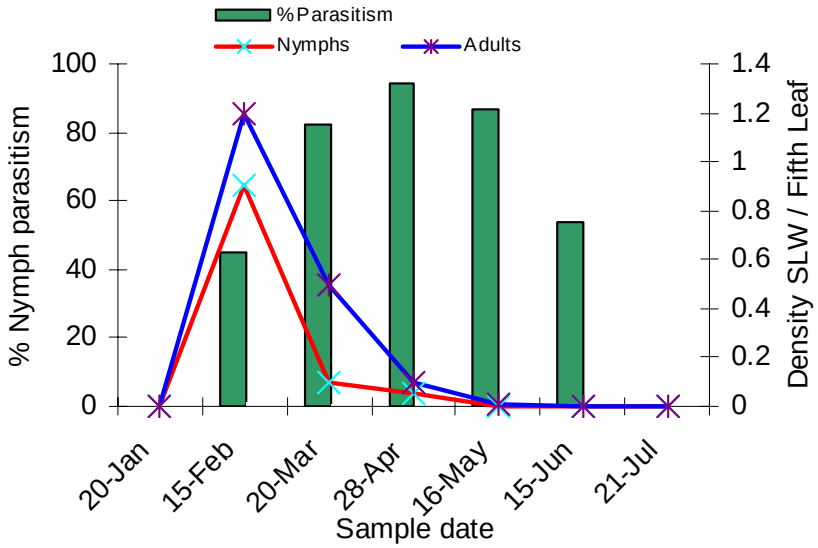

Figure 2. Whitefly adults and nymphs together with their parasitoids for the 2005 January cotton planting. Parasitoids during late summer effectively suppressed whitefly population expansion within two months of planting negating the need for control. Cooler conditions after May further depressed whitefly populations to below detectable levels.

Figure 3. Jassid damage to the foliage. Note the considerable impact to leaf quality.

General Conclusions from the 2004 & 2005 Cotton Trials

A potential planting window from late December to the end of January has been generally identified. Cotton planted later than January/early February is exposed to cooler winter conditions during flowering and boll fill resulting yield loss combined with increased susceptibility to diseases such as *Alternaria*. Conversely modelling suggests that planting earlier than late December increases the risks of exposing the crop to wet and overcast conditions during peak flowering which would also have detrimental effects on crop yield. The risk of rain on open bolls is also greater when sowing occurs prior to late December.

Silver leaf Whitefly surveys indicated that this pest is likely to be active in Burdekin cotton crops. However, its pest status is potentially offset by the presence of parasitoids and the use of a mid-summer planting window that ensures that as the crop matures, cooling temperatures going into winter will naturally suppress remaining whitefly populations as the crop opens bolls and would then become susceptible to lint stickiness. It is likely that a similar set of circumstances would apply to other sucking pests such as aphids which could be abundant in some seasons.

Cluster caterpillars (*Spodoptera litura* F.) were prevalent during the 2005 trial plantings. The presence of this pest and its ability to tolerate exposure to Bt cotton suggests that it should also be considered along with *Helicoverpa armigera* when designing a resistance management strategy relevant to north Queensland.

Pests such as green mirids and jassids will require judicious management as in existing production areas with consideration given to minimising disruption to parasitoid complexes that assist with whitefly suppression.

No other soil based diseases were detected during a disease survey conducted during the 2005 trials. A summer planting window is likely to reduce any potential expression of diseases such as Fusarium or black root rot.

The lint yield and quality characteristics for cotton planted in January 2005 were excellent.

Burdekin Cotton Research 2006

The QC cotton program in the Burdekin was not continued during 2006 as Monsanto was not enthusiastic to support northern cotton research whilst at the same time seeking broader registration for BG/RR varieties north of the 22^{o} parallel.

Without access to transgenic varieties, a small experiment was conducted to examine the potential for utilising stubble cover to aid in cotton establishment during a wet season planting window. Similar research conducted at Kununurra in WA suggested that the use of cover crops was beneficial for maintaining bed integrity prior to sowing during high intensity rainfall events as well as allowing the timelier sowing of cotton after the wet season. The concept is to establish the preferred stubble mulch prior to planting and either spray it out at cotton sowing or when the foliage reaches a predetermined height (whichever comes first). The foliage serves to maintain bed formation, extract excess soil water and ease sowing in the event of wet conditions.

Cover crops of forage sorghum, french millet and mungbeans were compared to a bare earth control. The mulches were sown on 1st December 2005 in a 1 hectare field site located on the property of Steve Hazelton between Clare and Giru. Four rows of each treatment were sown per bed on 1.5M centres (Figure 4). The treatment plots were 8 beds wide by 50 metres in length. Each treatment was replicated four times within a randomised block design.

The treatments were watered up after planting and again 14 days later. Within a month of planting the treatments had exhibited significant growth with the sorghum exceeding 750mm in height followed by the millet at 500mm and mungbeans at 300mm (Figure 5). Conventional cotton seed was sown into the living mulches on 3 January after which the mulches were treated with Glyphosate and watered up. Only half of each plot was initially sown to cotton with the latter half of each plot sown three weeks later when the mulches had died from herbicide treatment.

Assessments of cotton emergence, population and vigour were made 1 month after each planting (figure 6). No significant differences were observed between treatments in terms of population establishment and early crop vigour compared with the bare earth control in relation to the mulch treatments (Figures 7-8).

Figure 4. Planting the living mulch treatments.

Figure 5. Established mulch treatments. French millet in the foreground.

Figure 6. Cotton growing through stubble mulch cover.

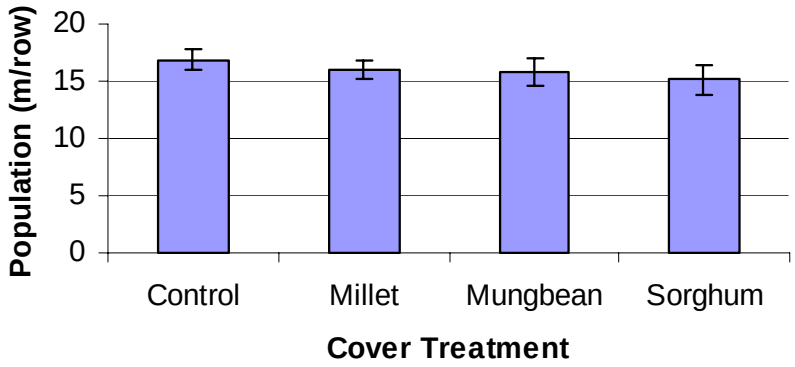

Figure 7. Mean seedling population per metre of crop row in the three cover treatments and bare earth control. Bars denote sem.

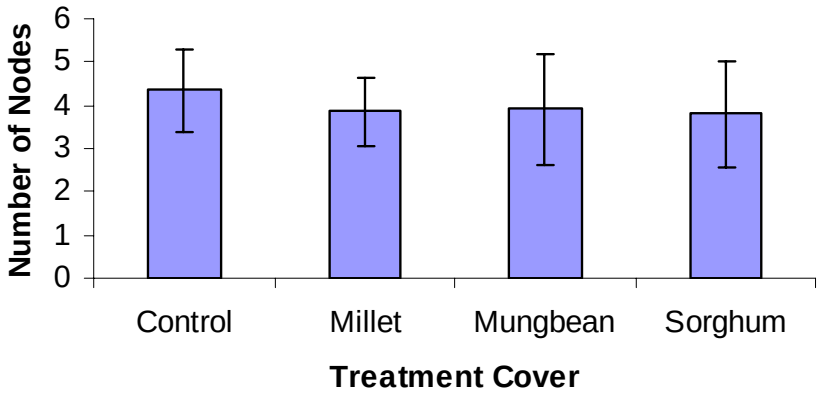

Figure 8. Mean number of nodes in the three cover treatments and bare earth control. Bars denote sem.

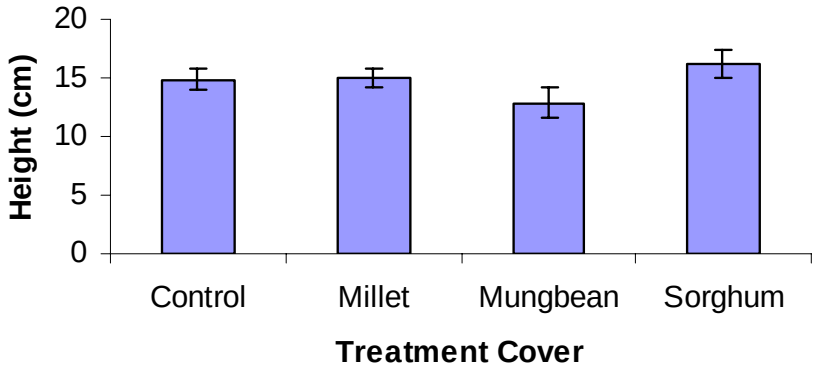

Figure 9. Mean cotton plant height in the three cover treatments and bare earth control. Bars denote sem.

Stubble Mulch Conclusions

The cover crops did not appear to impart any significant advantage or disadvantage to the over sown cotton crop in terms of population establishment or seedling vigour.

The use of mulch cover in the Burdekin has limitations compared to more northerly centres. Experience from 2005 and recently completed simulations using the OZCOT model suggest that cotton should ideally be planted as soon as practically possible after 20 December which is near the start of the wet season. This differs significantly from more northerly centres where cotton is planted as soon as practically possible at the end of the wet season. One of the primary advantages for using stubble covers in Kununurra and Katherine was for the preservation of soil during the wet season and to facilitate trafficability as early as possible after the last wet season rainfall. In the case of the Burdekin, it is likely that a cotton crop sown in December/early January will already provide some level of cover by February which is historically the wettest month and therefore trafficability for the purpose of planting is less likely to be an issue.

However, in our experiment it was noted that the soil structure was improved and trafficability was much greater for the stubble treatments compared to a bare fallow in wet conditions which may impart some other management advantages such as being able to side dress nitrogen more easily during wet conditions to minimise water logging effects.

No significant rainfall events occurred during the short time that the experiment was conducted so the impact of the stubble on soil retention was untested.

It would appear that retaining some level of stubble cover from a previous crop would be desirable strategy for increasing trafficability during the wetter months of February and March, although the specific sowing of a stubble cover for the Burdekin climate using pre-wet season planting dates would require a much more specific cost benefit comparison. It is likely within a cane/cotton rotation that an intermediate crop from which stubble could be retained might be sown after the removal of cane and growing of cotton.

Future Industry Research Directions

Despite significant achievements, the research conducted over the last 3 seasons has been restricted and limited in scope. Attempting to conduct research within commercial partner fields, planted primarily for the purpose of grower demonstration sites, has prevented rigorous scientific evaluation of crop growth and management and severely limited the number of research questions that can be considered.

Should transgenic BG/RR varieties gain registration in the north and the development of an industry be considered, a range of basic research and extension activities would need to be conducted and a more appropriate model for conducting research and development required.

Research and Development priorities should include:

- Validation of the late December early January planting window.
- A more rigorous climatic risk assessment, to dermine probable seasonal variability of yield and quality and likely constraints to operations such as timely sowing and picking. This would require the validation of the OZCOT model and other tools.
- Development of agronomic strategies that contend with wet season crop establishment, nutrition and PIX management.
- Irrigation management with regard to diverse soil types within the Burdekin irrigation area.
- Investigations into the compatibility of cotton and cane production systems. This would include nutrition following cane and assign the economic impact of the cotton seasonal cycle on the cane ratoon cycle.
- Development of pest management programs that control secondary pests such as jassids, mirids and aphids without flaring the parasitoids of silver leaf whitefly
- The development of a Bt resistance management strategy that encompasses lepidopterous pests other than Heliothis such as cluster caterpillar.
- A locally tailored weed management package that takes advantage of Round Up ready technologies.
- Investigation of environmental impacts of cotton in the Burdekin environment with regard to chemical and fertiliser movement within water and soil.
- Grower extension program with an emphasis on providing existing agronomic information, gaining experience in growing cotton, as well as extending and demonstrating local research findings.
- Community engagement program to proactively and positively communicate the activities of the CCC CRC and promote the cotton industry within the local community.

We advise starting with a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase will focus on assessing likely yield and quality, while accounting for climatic risk, compatibility with cane production issues and likely economic outcomes at farm and regional level. Commercial scale trials could continue in parallel with this research or after its completion.

Proposed Model for Future Research

We propose in this first phase of R&D to conduct some basic agronomic studies in the Burdekin and surrounding regions (e.g. Collinsville) to gain basic crop development, yield and fibre quality data in relation to the local climate and soils which can then be used to validate outputs from the OZCOT and other risk assessment models.

One of the most problematic factors associated with the production of cotton in the Burdekin is the lack of a low-risk planting window. The proposed late December – January planting window ideally manages the inherent cool climate risks associated with the Burdekin winter and avoids rain at picking. However, for a proportion of seasons that are wetter than average, this planting window creates a risk of yield reductions due to lower radiation and water logging. Moreover this risk is variable and its frequency cannot be quantified without further research. Having better cotton growth data collected under local conditions over several seasons would enable more accurate projections to be made as to the likely risks and inherent yield penalties.

The market advantage that the Burdekin might enjoy due to its reliable water availability is offset by the risk of late wet conditions in some seasons that can potentially decrease yield and forward selling capacity. Developing a yield risk profile is an essential step before widespread industry investment could be considered. It is our opinion that this data should also be developed for the nearby Collinsville region that is perhaps climatically more suitable than the lower Burdekin but at this time lacks necessary infrastructure for any immediate future industry development (infrastructure such as the Urannah dam has been proposed for the Collinsville region within the next 8-10 years which would provide significant water for agriculture, see Rydge Report 2005).

To further illustrate the potential for climatic influences on yield, Figure 10 shows the yield projection contrast as generated by the OZCOT model when comparing the previous decade (dominated by below-average rainfall) with the previous 40 years during which higher rainfall wet seasons were recorded in some years. The model output suggests that the simulated yields from the last decade are higher than those that might have been achieved over the longer term. The model also suggests that planting in late December – January would have maximised yield potential for the last 50 years.

Research to confirm model performance with real field data over a range of seasonal conditions will provide a risk analysis that will greatly assist local growers and others deciding to diversify into cotton.

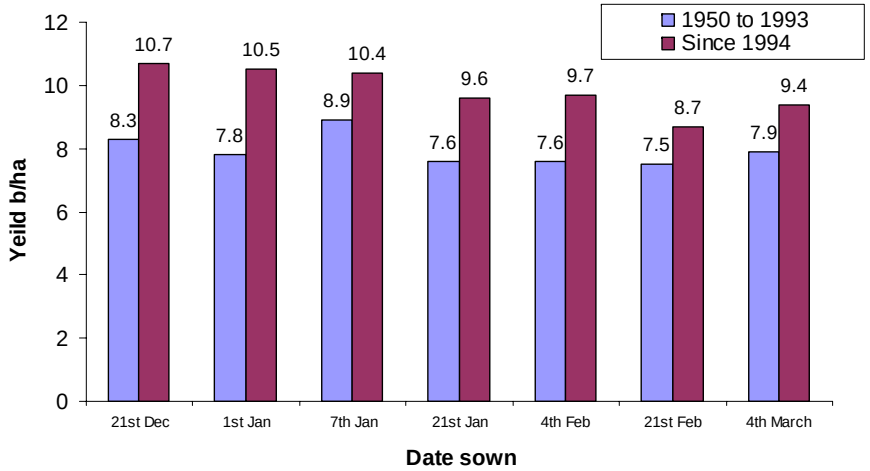

Figure 10. Yield simulations from the OZCOT model comparing predicted yields for the period between 1950-1993 and the last decade. The higher yield predictions for the last decade is largely due to drier than average conditions compared with the wetter previous 40 years. This highlights the potential influence and need to accurately quantify the impacts climatic conditions on crop yield for the Burdekin.

A meeting with interested growers in February identified that despite the recent rise in sugar prices, growers were still interested in and committed to further exploring the possibility for using cotton as part of a cane/cotton rotation farming system.

The key questions and concerns raised by meeting participants were:

1. The need for compatibility with a cane system, (e.g. timing of seasons, 24D, nutrition following cane).

2. The transition from cane and meeting the narrow cotton sowing window (dry planting etc).

3. A better quantification of likely returns and their seasonal variability would help the decision to diversify.

4. The cost of the learning phase (e.g. no gin until stable area, but no stable area until proven returns).

We recommend a CRC supported project that focuses on points 1-3. As discussed earlier we recommend starting with a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase will focus assessing likely yield and quality, while accounting for climatic risk, compatibility with cane production issues and likely economic outcomes at farm and regional level. Commercial scale trials could continue in parallel with this research or after its completion.

This research should use smaller scale trials to 1. Validate / calibrate modelling tools for crop development, yield and quality on the two main soil types and at Collinsville if practicable and 2. Evaluate cane/cotton rotation issues. Modelling analysis will be made toward the end of the project.

Concluding Remarks

Any future R&D investment in the Burdekin is dependent on the successful registration of Bollgard and Roundup Ready technologies in Northern Australia. An outcome on the registration process will not be known until December 2006.

Should registration prove successful, the Rydge Report which examined the likelihood and potential for establishing a cotton industry at various sites throughout north Queensland recommended that R&D priority be given to the Burdekin and nearby regions (eg Collinsville) as each of these sites had a range of intrinsic advantages suited to future industry development.

Growers in the Burdekin region remain interested in investigating the potential for growing cotton as a crop rotation with sugar cane. Whilst broader interest in cotton has decreased in light of recent surges in world sugar prices, a number of larger growers recognise that this volatility is regular feature of world commodities and that having an investment spread over more than one product would be a prudent strategy for underpinning future business profitability. It is also recognised by several growers that the current upsurge in sugar prices provides an additional opportunity in terms of greater cash flow that can be used to fund farm diversification.

With a view to future investment in the Burdekin region, the primary challenge beyond registration is that the climatic and rotation crop compatibility risks associated with diversifying into cotton for this region are currently unclear.

This is because:

- The yield and quality variability associated with the proposed optimum sowing window are not defined from the previous research data.
- A comparative analysis of the viability of cotton compared to the existing staple of sugar cane can't yet be made.
- There is a chicken and egg scenario whereby it is costly to test cotton without a local gin but a gin requires significant areas of cotton that growers won't commit to while production risks are not known or there is no financial support to underwrite potential risk.

We recommend initially that greater emphasis be placed on a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase would focus on:

1. Assessing likely yield and quality, while accounting for climatic risk by validating / calibrating and then applying relevant models (e.g. OZCOT).
2. Compatibility with cane production issues.
3. Forecasting likely economic outcomes at farm and regional level.

This research **would not be dependent** on commercial scale trials run by a commercial partner, but instead would be **complimentary** to any such research. Industry collaborators and co-investors within this project would provide an optimal process for developing results and applying them within a future industry. Potential project partners and co-investors might include companies that might

have interests in a future Burdekin industry. These might include but not be limited to organisations such as Queensland Cotton, Monsanto, Cotton Seed Distributors, Deltapine, Sunwater, Cotton Australia and Cane Growers Australia.

The results from this type of project would have broader benefits beyond the context of the Burdekin region. Data collected will enhance basic knowledge of the effect of high night temperatures (respiration) and low radiation on fruit retention, fruit size, plant partitioning and yield of high retention (Bollgard) cotton. The 2005/6 southern cotton season asked many questions as to the effect of these climatic factors on yield and quality. Unfortunately because hot cloudy weather occurs erratically in southern Australia it is difficult to conduct a structured research program that can quantify the physiological consequences of such weather. This research at the Burdekin can provide an opportunity to reliably obtain some of this knowledge.

This research will also permit extrapolation of modelling analysis to nearby potential 'wet season' growing areas such as Collinsville, the upper Burdekin and Atherton / Mareeba.

Whilst registration is pending, we plan to utilise the interim period to develop a full R&D strategy for the above project outline and investigate opportunities for industry collaboration and co-investment with a view to commencing operations in the 2007/08 financial year.

Acknowledgements

We would like to acknowledge and thank the following people and organisations for their contributions to this project.

Mr Steve Hazelton for provision of a field site and access to his farming equipment for the 2006 experiment.

Mr Mark Hickman who helped organise and presented at the February 2005 grower training days.

Ms Kelly Mellor for her advice, assistance with checking field sites and organising consumables as well as helping to organise the 2006 grower meetings.

Mr John Marshall for assisting with the 2006 February meeting and CSD for the provision of trial seed.

Dr Joe Kochman and his technical staff who assisted with disease surveys.

2007 Burdekin Cotton Program

Addendum to Final Report CRC 1.1.14

Paul Grundy & Steve Yeates

Background

The approval of Monsanto's Bollgard II and Roundup Ready Flex traits in Northern Australia in late 2006 and Queensland's lack of moratoria on GM crops has now cleared the way for growers to begin making their own assessment of cotton in the Burdekin. Building on previous activity several growers indicated a desire to plant small areas of cotton (albeit at very short notice) for the 2007 season and Queensland Cotton, together with members from the Cotton Catchment Communities CRC, Monsanto, CSD and Deltapine stepped up to lend support to these efforts as part of a longer term strategy to begin assessing the feasibility of cotton in the Burdekin. This report is an Addendum to the Final Report for project 1.1.14 submitted in 1996. Remaining funds from this project were carried forward into 2007 to assist with the 2007 Burdekin cotton activity until such time as the new Burdekin Cotton project commenced on 1 July 2007. The purpose of these carry forward funds was to provide an extension program for local growers during the 2007 crop and to make preparations so that the new project could rapidly commence.

2007 Trial Plantings

The way was clear for planting this year on the 16th January when the Australian Veterinary Pesticides and Medicines Authority (APVMA) approved the resistance management strategy for northern Australia. This date proved later than initially anticipated and coincided with the start of the wet season. Despite wet conditions, 52ha of cotton were sown between 3 growers spanning Jan 17th – Feb 21st. The bulk of the area was planted to CSD's Sicot 80BF with a little 60BF and Deltapine's DP12BRF sown at one site. The plantings were subject to more than 400mm of rain during late January / early February with little apparent ill effect apart from precipitating early rank growth. Each of the crops demonstrated excellent vigour and commenced flowering in March.

The cotton emerges rapidly in the Burdekin with plants appearing within 4 days of watering up.

Graham Boulton a consultant from the Darling Downs provided agronomic advice for the 2007 season. For a number of years Graham has provided agronomic services to the region's horticultural crops during the winter months and as such was well placed to provide management advice for the three cotton crops. In terms of inputs much of this season has been flown somewhat blind with estimates of required inputs being based on experience from southern areas. Nutrition requirements for cotton on local soil types was largely unknown so a similar PKN approach as that used for local maize was generally applied. Weed control was achieved at some sites with the use of Stomp(R) at planting followed by 2-3 in-field applications of Roundup Ready® herbicide up until inter-row closure. Weeds mainly consisted of a range of barnyard grasses as well as black pigweed and vine species. Insecticide applications were required for mirids and aphids as well as silver leaf whitefly at one of the sites. Bollgard II provided good control of *Helicoverpa* throughout the season although limited survival was observed during April after a short period of extreme oviposition pressure. *Spodoptera litura* were prevalent in all crops during March and April and whilst causing no direct damage, are a pest of that will need to be considered going into the future from a resistance management perspective and will be the focus of project efforts in 2008.

2-4D boom contamination was a problem encountered this season which has proven to be a great lesson for local growers to learn on relatively small areas. One planting was very badly affected by 2-

4D through boom contamination and considered for abandonment but the grower, Lindsay Hall decided to continue growing the crop for experience sake.

One of the sites badly affected by 2-4D spray equipment contamination. Despite the large setback the crop grew on to yield over 2 bales/acre.

Climatically the crops experienced a much wetter than average start but entered March-May with relatively dry conditions and warm temperatures that were ideal for boll formation. The crops which were sown a month later than what is considered to be ideal then slowed considerably as cool wet conditions were encountered in June and July. North Qld experienced mean temperatures 3^{o}C below the long term average for June and July whist breaking all previous rainfall records with over 150mm in June compared to the long term average of 26mm. With the late plant, 2-4D damage, some nutritional difficulties, June rain, very cold winter temperatures (exacerbating the late start) and the relative inexperience of the three growers, the results for this season make it difficult to generalise about crop performance.

Rank growth which was a problem at one of the sites due to untimely rainfall and short term pix unavailability compound the impacts of unseasonable rain in June in terms of increasing the level of tight loch and boll rots. This was disappointing as up until the June rain this crop had shown considerable yield promise.

After a drawn out finish, picking was commenced during the third week in August. Yields were low with field averages varying between 1.3-2.5/acre. All quality parameters in terms of length, strength and colour were good with the exception of low micronaire which was largely due to the late plant resulting in the crop finishing during very cool winter conditions. Whilst obviously low, the yields need to be viewed in the context that most of this seasons limiting factors related to late planting, nutrition application difficulties, pix management, 2-4D contamination should be potentially preventable from the outset going into 2008.

Two weeks of wet weather that delivered over 6 inches of rain to the Burdekin in June broke all previous records (long term average is 26mm) and caused losses on an already very late finishing crops due to due to boll rots and tight loch.

Plant mapping sheds provided some context for the crop yields. Maps were made in two areas of Paul Villas's crop to compare the rank half of the field with the short portion and on Aaron Sanderson's crop who planted Sicot 80 and 60BRF. The importance of managing the crop canopy was highlighted in Paul's crop with the rank cotton growing >500mm taller for the similar number of nodes and having >20% fewer bolls due to rots and tight locking. The boll counts in Aaron's crop demonstrate that the crop did not reach its potential yield, due primarily to its very late plant and cold finish (Table 1).

Table 1. Mean Number of Bolls retained per metre, nodes and height for the short and rank cotton (cv at P. Villas and Sicot 60 & 80 at A. Sanderson's.

Treatment	FP1	FP2	FP3	Total Bolls/M	Nodes	Height (mm)
Villas Short	52.3	29.5	19.3	101	23.7	1049
Villas Rank	40.4	22.5	3.9	67	24.6	1519
Sanderson Sicot 60	48	18.7	10	76	17.8	814
Sanderson Sicot 80	46.8	21.1	9.9	78	19.5	985

Grower Extension

Given that the 2007 trials were always going to be on the back foot due to the unexpectedly late approval to plant, the trial sites were used for maximum advantage to educate local growers at monthly field days. Five field days were held in total and these events provided an opportunity for local growers to observe the various stages of production and get a feel for the inputs and crop management decisions that had been made along the way. These events have been increasingly well attended as interest in cotton has spread amongst the local grower community. After starting with a core group of about a dozen growers that have attended field days in previous years, numbers peaked at around 25 for the picking field day held on 10th August.

Numbers grew from the first field walk soon after planting to the picking field day was well attended by about 25 locals.

A Burdekin steering committee (NORCOM) was convened for the first time in May 2007 to discuss a pathway forward for coming seasons. Representation on the committee included Burdekin growers, Queensland Cotton, QDPI&F, CSIRO, Black Earth Cotton Co, Monsanto, CSD, Deltapine, CRDC, Cotton Australia, ACGRA and TIMS. This committee will provide guidance to the R&D program and proactively counter industry development issues. It was generally agreed during the first meeting that there are many agronomic unknowns and that local growers will need considerable support during a pre-commercial phase until the feasibility of cotton becomes clear. This will involve varied forms of assistance from the different industry stakeholders. Early indications from growers suggest up to 800ha of cotton may be planted in the 2008 season. NORCOM will meet in October to map a path for this seasons crop.

Conclusions

Whilst the 2007 yields were low, when placed into context that most of this seasons limiting factors related to late planting, nutrition application difficulties, pix management, 2-4D contamination there is significant room for improvement going forward into 2008. The extension program was effective in raising awareness on cotton production and this is evidenced by the rapid increase in interest from local growers heading into 2008. Firming estimates suggest that 14 growers will plant a combined total of 900 hectares of cotton for the coming season. 35 local growers have also now completed BG and RR accreditation in anticipation of trialling cotton at some future point. Another development has been the recent purchase of farms in the Burdekin by southern growers to grow

cotton and other crops. At this stage three farms have been purchased by growers originating from the Darling Downs. 500ha of the cotton likely to be grown in 2008 will rest between these 3 growers. The new Burdekin CRC funded project is underway and will play a pivotal role in assessing the feasibility of cotton production in the Burdekin in tandem with industry development efforts.

CRC 1.1.14

Burdekin Cotton Research Summary 2004-2006

Report prepared for
Cotton Catchment Communities CRC
Qld Dept of Primary Industries and Fisheries
CSIRO

Paul Grundy (QDPI&F) & Stephen Yeates (CSIRO)

May 2006

Table of Contents

Executive Summary

The purpose of this CRC funded project was to provide scientific assistance to the Queensland Cotton (QC) commercial trial program in the Burdekin region. The focus of the QC trials was to demonstrate the potential of Bollgard/Roundup Ready cotton using BMP production principles to local growers who had expressed an interest in using cotton as a viable crop rotation with sugar cane. Our role within this program was to gather specific plant protection, agronomic and environmental data where possible that might be used to devise future crop management strategies as well as industry investment and development decisions.

From a plant protection perspective no significant pest, weed or disease impediments to growing cotton in the Burdekin were identified in the QC cotton trials. Silver leaf Whitefly *(Bemisia tabaci)* surveys indicated that this pest is likely to be active in Burdekin cotton crops. However, its pest status is potentially offset by the presence of *Eretmocerus* spp parasitoids and the use of a mid-summer planting window that ensures that as the crop matures, cooling temperatures going into winter will naturally suppress remaining whitefly populations as the crop opens bolls and would become susceptible to lint stickiness. It is likely that a similar set of circumstances would apply to other sucking pests such as aphids which could be abundant in some seasons.

Cluster caterpillars (*Spodoptera litura* F.) were prevalent during the 2005 trial plantings and required insecticide control. The presence of this pest and its ability to tolerate exposure to Bt cotton suggests that it should also be considered along with *Helicoverpa armigera* when designing a resistance management strategy relevant to north Queensland. Pests such as green mirids (*Creontiades dilutus*) and jassids were abundant in the region and will require judicious management as is the case for existing cotton production regions. Key consideration will need to be given to preserving parasitoids for whitefly and cluster caterpillars.

Weed and disease impacts are not well defined for the Burdekin and should also be a focus for future research. Sedges and grasses (Cyperaceae and Poaceae families) would appear to constitute the major weed groups of concern in the region. The impact of these and other weeds may be partially alleviated through the use of roundup ready technologies. *Alternaria* spp. caused major disease problems during the 2004 trial although this disease appears to be avoidable with the use of a mid-summer planting window. No other soil based diseases were detected during disease surveys conducted during the 2005 trials. A summer planting window is likely to reduce any potential expression of diseases such as Fusarium or black root rot.

A potential planting window from late December to the end of January has been identified from preliminary climatic analysis. Cotton planted later than January/early February is exposed to cool winter conditions during boll fill resulting in yield loss, defoliation difficulties and picking delays. Later planted crops were also found to be particularly susceptible to *Alternaria* disease epidemics causing significant leaf defoliation and yield loss. Under a Burdekin climate, cotton crops need to be ideally picked by July to escape *Alternaria* disease and adverse climatic impacts. This suggests that planting must occur prior to mid February. However, the Burdekin wet season that typically peaks during February also limits the sowing of cotton before late December. The use of a late December/January planting window will require the development of strategies aimed at minimising the potential difficulties associated with potential wet planting conditions, flood events, summer pest management. The January planted field in 2005 produced high yields and excellent quality cotton which concurs with these projections.

The environmental impacts of cotton in the Burdekin remain largely un-explored and will need to be investigated. The drainage of fertilisers and pesticides through soil profiles is likely to be markedly different between the mosaic of Berretta clay and loam soil types present throughout the region.

Education for prospective cotton growers in the region was undertaken in February 2005 and again in 2006. This program provided basic level information for 10 growers that included a day of presentations that spanned topics from crop agronomy to pest management followed by practical in field training in crop scouting and plant mapping. This education was enthusiastically received by local growers that have been seeking greater exposure to cotton industry information**.** The 2006 meeting focused more on Burdekin related issues and constraints and began investigating how cotton might be introduced to the local farming system should Monsanto's BG/RR registration attempt prove successful. Should a future industry commence in the region an intensive extension program that is specifically linked to research and industry organisations will need to be developed and implemented to ensure the adoption of best management practices.

All future research and investment in the Burdekin is now dependant on the success of Monsanto's bid to broaden the registration of BG/RR varieties to include regions above the 22^{o} parallel. A decision on registration is expected by the end of 2006. Should registration succeed, we initially advise a greater emphasis on a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase will focus assessing likely yield and quality, while accounting for climatic risk, compatibility with cane production and likely economic outcomes at farm and regional level. Commercial scale trials could continue in parallel with this research or after its completion.

Background for CRC 1.1.14

With the demise in prosperity of North Queensland's sugar industry over the last decade there was growing impetus for cane growers to diversify into new or alternate crops. Cotton was seen as an attractive alternate irrigation crop that may fit well within the Burdekin farming system. On this basis a group of growers approached Queensland Cotton (QC) with an interest in exploring the possibility for growing cotton as an adjunct to cane production in the Burdekin region during the summer of 2003/04.

At the commencement of this project in 2004 QC had already proceeded with Bollgard plantings at two trial sites situated near Giru and Clare. The initial aim for the project was to begin assessing potential pest problems that might be associated with cotton in the region. During 2005 it was agreed that QC and the CRC should collaborate more formally with a broader view to experimentation to investigate a range of agronomic, plant protection and environmental issues.

Historically, the expansion of cotton production into northern Australia has been hindered by insect, environment and location-derived problems. However, development of improved transgenic cotton varieties has increased the potential for the development of sustainable and environmentally sound cotton production systems for northern Australia. The Burdekin region is an already established agricultural area that has several advantages that may favour the establishment of a future cotton industry.

The Rydge Partners report (2005) suggested that the Burdekin region had the following advantages as distinct from 12 other regions within NQ:

- 20-30,000ha of freehold land potentially suitable for cotton production.
- Annual allocation of 585,000ML of water for agriculture with 95% reliability.
- Potentially suitable climate.
- Excellent existing agricultural infrastructure and service industries.
- Land values that are lower or on par with current market values for existing cotton properties in conventional regions.
- More favourable and accepting political climate compared with other northern centres.
- Downturns within the local sugar industry over the last decade have made diversification options more attractive.
- Potential for an additional 200,000ML of water if Sunwater proceed with proposed dam wall height raising works

The Rydge Partners report strongly suggested that further research should be undertaken in the Burdekin with a view to future industry development.

2004-2006 Research and Results Brief

2004 Cotton Plantings

In 2004 Queensland cotton leased 26 hectares of farmland between two sites (14 Ha Roy Young's & 12 Ha Lindsay Hall's) to trial the growing of BG/RR varieties.

Four varieties (CSX 414, DP 546, 289BR & DP556) were planted dry and watered up in Mid-May. This planting date was much later than desired due to delays in gaining government permit approval. The "Young" site consisted of a loam soil type with sodic patches whilst the "Hall" site was a heavy Berrata clay type soil both typical of the region. Nutrition and irrigation was managed by QC according to typical industry practices used in central Queensland.

The 2004 season was notably cool with 71 cold shock days recorded (where night time temps drop below 12^{o}C) compared to the long term median of 25 days. The cold temperatures severely limited crop yields through physiological disruption to flowering and fruit set (Figure 1) as well as precipitating a major outbreak of disease and leaf drop due to the *Alternaria* spp. pathogen which has been recorded in other northern regions during cold seasons.

Figure 1. Example of pollen and bud distortion caused by un-seasonally cool conditions.

The colder than average temperatures greatly reduced the incidence of a range of pest insects known to inhabit the region including *Helicoverpa* spp, mirids, jassids and aphids. Silver leaf whitefly SLW (*Bemisia tabaci*) were abundant immediately after sowing upon crop emergence, although the ensuing cold conditions largely capped population development. The presence of endemic *Eretmocerus* parasitoids in the cotton crops was encouraging as these had not been previously reported to be abundant in the region during surveys of vegetable crops conducted several years prior (P. Debarrow pers com).

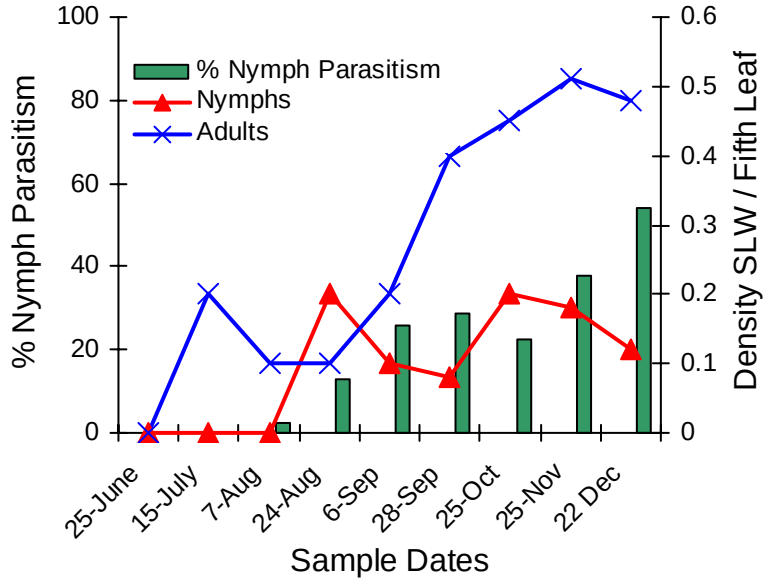

Figure 2. Mean density of whitefly on cotton and percentage nymph parasitism during 2004. Note cool weather suppression during July-September and increased parasitoid activity in spring.

Due to the cold conditions, crop development was significantly delayed. Substantial yield losses occurred due to the cold conditions that caused poor pollination and predicated the *Alternaria* spp. disease outbreaks which further stressed the crops due to significant canopy loss. The crops were finally picked during late December/early January after some compensatory growth had occurred over spring. Crop yield was less than ideal due to the loss of yield over winter and the limited ability of the plants to compensate during the following spring.

2005 Cotton Plantings

In 2005 Queensland cotton leased farmland from Mulgowrie farms. Several varieties (Sicala 60BR, CSX 613-1, Sicot 71) were planted at four different dates during the middle of January, February, March and April. The first planting was sown in a single field under centre pivot overhead irrigation on a well drained red earth. The February and March plantings were grown in a second field under flood irrigation and the April planting was sown in another field also under flood irrigation both on a moderate to heavy clay soil type.

These planting dates were not replicated as previously planned which limited the opportunity to collect more quantitative data and soil samples for monitoring chemical movements were not taken due to a last minute change of co-operators for the trial.

The January – March plantings were grown through to yield whilst the April planting was ploughed out due to its growth notably suffering from the onset of cooler conditions as the crop entered a reproductive phase and the presence of *Alternaria* spp..

Silver Leaf Whitefly were very abundant in the plantings after sowing but numbers were significantly curtailed due to the rapid establishment of *Eretmocerus* parasitoids (Figure 2) and then the onset of cooling temperatures as the crops matured.

Cluster caterpillar, *Spodoptera litura* (F) were prevalent in the cotton plots until the end of March. Larvae in the January planting required control (Synosad 150mL/Ha) to prevent extensive defoliation. Green mirids (*Creontiades dilutus*) required control on several occasions in each of the plantings. Jassids were also a pest of significance, with high populations in the February-March plantings causing foliage distortion and discolouration (Figure 3).

A survey for disease suggested no evidence of soil borne pathogens associated with Fusarium wilt or black root rot.

The January planting was picked in late June and the February/March plantings were picked in August. The January planting was a very high yielding crop that had satisfactory fibre characteristics for colour, micronaire and staple length. The February sowing produced yields similar to the Australian Average for 2005.

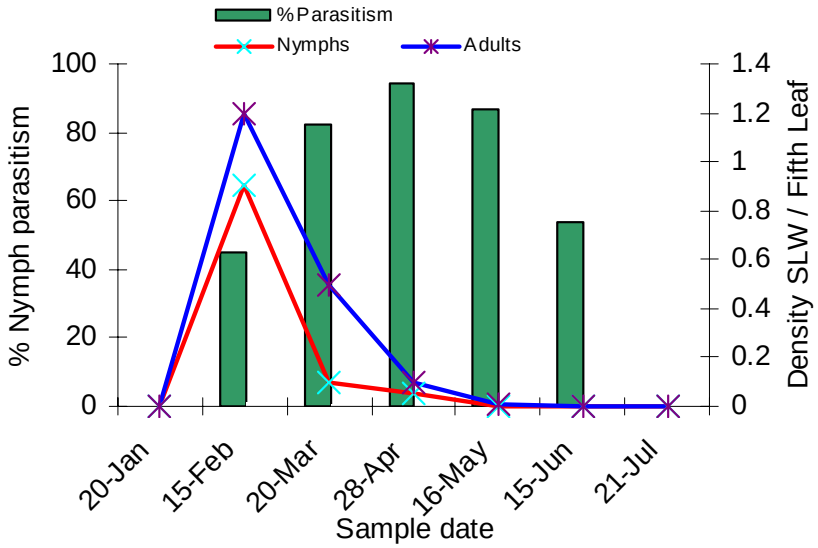

Figure 2. Whitefly adults and nymphs together with their parasitoids for the 2005 January cotton planting. Parasitoids during late summer effectively suppressed whitefly population expansion within two months of planting negating the need for control. Cooler conditions after May further depressed whitefly populations to below detectable levels.

Figure 3. Jassid damage to the foliage. Note the considerable impact to leaf quality.

General Conclusions from the 2004 & 2005 Cotton Trials

A potential planting window from late December to the end of January has been generally identified. Cotton planted later than January/early February is exposed to cooler winter conditions during flowering and boll fill resulting yield loss combined with increased susceptibility to diseases such as *Alternaria*. Conversely modelling suggests that planting earlier than late December increases the risks of exposing the crop to wet and overcast conditions during peak flowering which would also have detrimental effects on crop yield. The risk of rain on open bolls is also greater when sowing occurs prior to late December.

Silver leaf Whitefly surveys indicated that this pest is likely to be active in Burdekin cotton crops. However, its pest status is potentially offset by the presence of parasitoids and the use of a mid-summer planting window that ensures that as the crop matures, cooling temperatures going into winter will naturally suppress remaining whitefly populations as the crop opens bolls and would then become susceptible to lint stickiness. It is likely that a similar set of circumstances would apply to other sucking pests such as aphids which could be abundant in some seasons.

Cluster caterpillars (*Spodoptera litura* F.) were prevalent during the 2005 trial plantings. The presence of this pest and its ability to tolerate exposure to Bt cotton suggests that it should also be considered along with *Helicoverpa armigera* when designing a resistance management strategy relevant to north Queensland.

Pests such as green mirids and jassids will require judicious management as in existing production areas with consideration given to minimising disruption to parasitoid complexes that assist with whitefly suppression.

No other soil based diseases were detected during a disease survey conducted during the 2005 trials. A summer planting window is likely to reduce any potential expression of diseases such as Fusarium or black root rot.

The lint yield and quality characteristics for cotton planted in January 2005 were excellent.

Burdekin Cotton Research 2006

The QC cotton program in the Burdekin was not continued during 2006 as Monsanto was not enthusiastic to support northern cotton research whilst at the same time seeking broader registration for BG/RR varieties north of the 22^{o} parallel.

Without access to transgenic varieties, a small experiment was conducted to examine the potential for utilising stubble cover to aid in cotton establishment during a wet season planting window. Similar research conducted at Kununurra in WA suggested that the use of cover crops was beneficial for maintaining bed integrity prior to sowing during high intensity rainfall events as well as allowing the timelier sowing of cotton after the wet season. The concept is to establish the preferred stubble mulch prior to planting and either spray it out at cotton sowing or when the foliage reaches a predetermined height (whichever comes first). The foliage serves to maintain bed formation, extract excess soil water and ease sowing in the event of wet conditions.

Cover crops of forage sorghum, french millet and mungbeans were compared to a bare earth control. The mulches were sown on 1st December 2005 in a 1 hectare field site located on the property of Steve Hazelton between Clare and Giru. Four rows of each treatment were sown per bed on 1.5M centres (Figure 4). The treatment plots were 8 beds wide by 50 metres in length. Each treatment was replicated four times within a randomised block design.

The treatments were watered up after planting and again 14 days later. Within a month of planting the treatments had exhibited significant growth with the sorghum exceeding 750mm in height followed by the millet at 500mm and mungbeans at 300mm (Figure 5). Conventional cotton seed was sown into the living mulches on 3 January after which the mulches were treated with Glyphosate and watered up. Only half of each plot was initially sown to cotton with the latter half of each plot sown three weeks later when the mulches had died from herbicide treatment.

Assessments of cotton emergence, population and vigour were made 1 month after each planting (figure 6). No significant differences were observed between treatments in terms of population establishment and early crop vigour compared with the bare earth control in relation to the mulch treatments (Figures 7-8).

Figure 4. Planting the living mulch treatments.

Figure 5. Established mulch treatments. French millet in the foreground.

Figure 6. Cotton growing through stubble mulch cover.

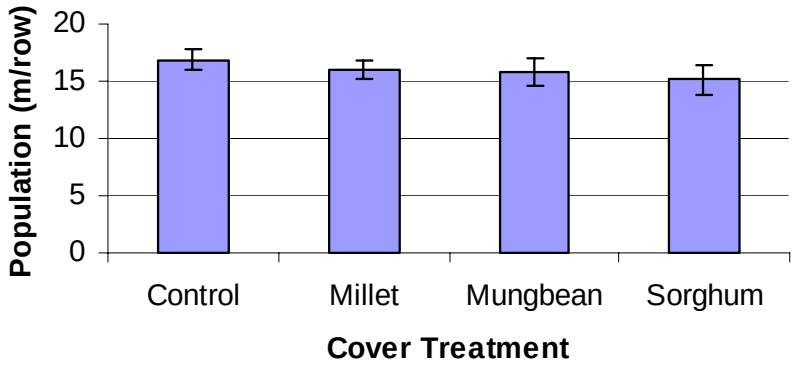

Figure 7. Mean seedling population per metre of crop row in the three cover treatments and bare earth control. Bars denote sem.

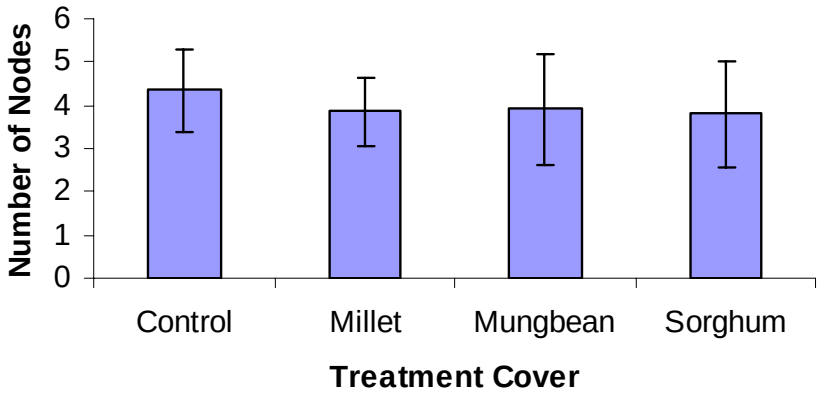

Figure 8. Mean number of nodes in the three cover treatments and bare earth control. Bars denote sem.

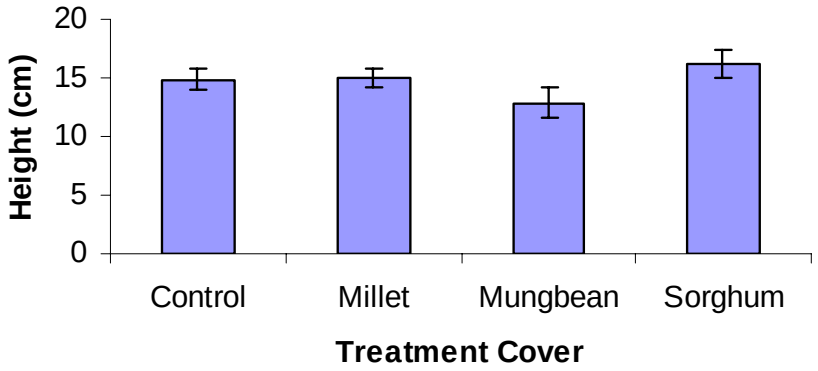

Figure 9. Mean cotton plant height in the three cover treatments and bare earth control. Bars denote sem.

Stubble Mulch Conclusions

The cover crops did not appear to impart any significant advantage or disadvantage to the over sown cotton crop in terms of population establishment or seedling vigour.

The use of mulch cover in the Burdekin has limitations compared to more northerly centres. Experience from 2005 and recently completed simulations using the OZCOT model suggest that cotton should ideally be planted as soon as practically possible after 20 December which is near the start of the wet season. This differs significantly from more northerly centres where cotton is planted as soon as practically possible at the end of the wet season. One of the primary advantages for using stubble covers in Kununurra and Katherine was for the preservation of soil during the wet season and to facilitate trafficability as early as possible after the last wet season rainfall. In the case of the Burdekin, it is likely that a cotton crop sown in December/early January will already provide some level of cover by February which is historically the wettest month and therefore trafficability for the purpose of planting is less likely to be an issue.

However, in our experiment it was noted that the soil structure was improved and trafficability was much greater for the stubble treatments compared to a bare fallow in wet conditions which may impart some other management advantages such as being able to side dress nitrogen more easily during wet conditions to minimise water logging effects.

No significant rainfall events occurred during the short time that the experiment was conducted so the impact of the stubble on soil retention was untested.

It would appear that retaining some level of stubble cover from a previous crop would be desirable strategy for increasing trafficability during the wetter months of February and March, although the specific sowing of a stubble cover for the Burdekin climate using pre-wet season planting dates would require a much more specific cost benefit comparison. It is likely within a cane/cotton rotation that an intermediate crop from which stubble could be retained might be sown after the removal of cane and growing of cotton.

Future Industry Research Directions

Despite significant achievements, the research conducted over the last 3 seasons has been restricted and limited in scope. Attempting to conduct research within commercial partner fields, planted primarily for the purpose of grower demonstration sites, has prevented rigorous scientific evaluation of crop growth and management and severely limited the number of research questions that can be considered.

Should transgenic BG/RR varieties gain registration in the north and the development of an industry be considered, a range of basic research and extension activities would need to be conducted and a more appropriate model for conducting research and development required.

Research and Development priorities should include:

- Validation of the late December early January planting window.
- A more rigorous climatic risk assessment, to dermine probable seasonal variability of yield and quality and likely constraints to operations such as timely sowing and picking. This would require the validation of the OZCOT model and other tools.
- Development of agronomic strategies that contend with wet season crop establishment, nutrition and PIX management.
- Irrigation management with regard to diverse soil types within the Burdekin irrigation area.
- Investigations into the compatibility of cotton and cane production systems. This would include nutrition following cane and assign the economic impact of the cotton seasonal cycle on the cane ratoon cycle.
- Development of pest management programs that control secondary pests such as jassids, mirids and aphids without flaring the parasitoids of silver leaf whitefly
- The development of a Bt resistance management strategy that encompasses lepidopterous pests other than Heliothis such as cluster caterpillar.
- A locally tailored weed management package that takes advantage of Round Up ready technologies.
- Investigation of environmental impacts of cotton in the Burdekin environment with regard to chemical and fertiliser movement within water and soil.
- Grower extension program with an emphasis on providing existing agronomic information, gaining experience in growing cotton, as well as extending and demonstrating local research findings.
- Community engagement program to proactively and positively communicate the activities of the CCC CRC and promote the cotton industry within the local community.

We advise starting with a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase will focus on assessing likely yield and quality, while accounting for climatic risk, compatibility with cane production issues and likely economic outcomes at farm and regional level. Commercial scale trials could continue in parallel with this research or after its completion.

Proposed Model for Future Research

We propose in this first phase of R&D to conduct some basic agronomic studies in the Burdekin and surrounding regions (e.g. Collinsville) to gain basic crop development, yield and fibre quality data in relation to the local climate and soils which can then be used to validate outputs from the OZCOT and other risk assessment models.

One of the most problematic factors associated with the production of cotton in the Burdekin is the lack of a low-risk planting window. The proposed late December – January planting window ideally manages the inherent cool climate risks associated with the Burdekin winter and avoids rain at picking. However, for a proportion of seasons that are wetter than average, this planting window creates a risk of yield reductions due to lower radiation and water logging. Moreover this risk is variable and its frequency cannot be quantified without further research. Having better cotton growth data collected under local conditions over several seasons would enable more accurate projections to be made as to the likely risks and inherent yield penalties.

The market advantage that the Burdekin might enjoy due to its reliable water availability is offset by the risk of late wet conditions in some seasons that can potentially decrease yield and forward selling capacity. Developing a yield risk profile is an essential step before widespread industry investment could be considered. It is our opinion that this data should also be developed for the nearby Collinsville region that is perhaps climatically more suitable than the lower Burdekin but at this time lacks necessary infrastructure for any immediate future industry development (infrastructure such as the Urannah dam has been proposed for the Collinsville region within the next 8-10 years which would provide significant water for agriculture, see Rydge Report 2005).

To further illustrate the potential for climatic influences on yield, Figure 10 shows the yield projection contrast as generated by the OZCOT model when comparing the previous decade (dominated by below-average rainfall) with the previous 40 years during which higher rainfall wet seasons were recorded in some years. The model output suggests that the simulated yields from the last decade are higher than those that might have been achieved over the longer term. The model also suggests that planting in late December – January would have maximised yield potential for the last 50 years.

Research to confirm model performance with real field data over a range of seasonal conditions will provide a risk analysis that will greatly assist local growers and others deciding to diversify into cotton.

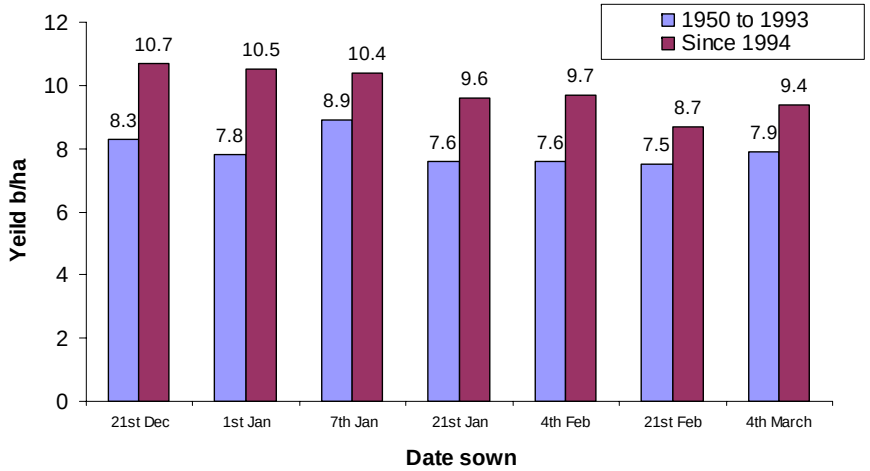

Figure 10. Yield simulations from the OZCOT model comparing predicted yields for the period between 1950-1993 and the last decade. The higher yield predictions for the last decade is largely due to drier than average conditions compared with the wetter previous 40 years. This highlights the potential influence and need to accurately quantify the impacts climatic conditions on crop yield for the Burdekin.

A meeting with interested growers in February identified that despite the recent rise in sugar prices, growers were still interested in and committed to further exploring the possibility for using cotton as part of a cane/cotton rotation farming system.

The key questions and concerns raised by meeting participants were:

1. The need for compatibility with a cane system, (e.g. timing of seasons, 24D, nutrition following cane).

2. The transition from cane and meeting the narrow cotton sowing window (dry planting etc).

3. A better quantification of likely returns and their seasonal variability would help the decision to diversify.

4. The cost of the learning phase (e.g. no gin until stable area, but no stable area until proven returns).

We recommend a CRC supported project that focuses on points 1-3. As discussed earlier we recommend starting with a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase will focus assessing likely yield and quality, while accounting for climatic risk, compatibility with cane production issues and likely economic outcomes at farm and regional level. Commercial scale trials could continue in parallel with this research or after its completion.

This research should use smaller scale trials to 1. Validate / calibrate modelling tools for crop development, yield and quality on the two main soil types and at Collinsville if practicable and 2. Evaluate cane/cotton rotation issues. Modelling analysis will be made toward the end of the project.

Concluding Remarks

Any future R&D investment in the Burdekin is dependent on the successful registration of Bollgard and Roundup Ready technologies in Northern Australia. An outcome on the registration process will not be known until December 2006.

Should registration prove successful, the Rydge Report which examined the likelihood and potential for establishing a cotton industry at various sites throughout north Queensland recommended that R&D priority be given to the Burdekin and nearby regions (eg Collinsville) as each of these sites had a range of intrinsic advantages suited to future industry development.

Growers in the Burdekin region remain interested in investigating the potential for growing cotton as a crop rotation with sugar cane. Whilst broader interest in cotton has decreased in light of recent surges in world sugar prices, a number of larger growers recognise that this volatility is regular feature of world commodities and that having an investment spread over more than one product would be a prudent strategy for underpinning future business profitability. It is also recognised by several growers that the current upsurge in sugar prices provides an additional opportunity in terms of greater cash flow that can be used to fund farm diversification.

With a view to future investment in the Burdekin region, the primary challenge beyond registration is that the climatic and rotation crop compatibility risks associated with diversifying into cotton for this region are currently unclear.

This is because:

- The yield and quality variability associated with the proposed optimum sowing window are not defined from the previous research data.
- A comparative analysis of the viability of cotton compared to the existing staple of sugar cane can't yet be made.
- There is a chicken and egg scenario whereby it is costly to test cotton without a local gin but a gin requires significant areas of cotton that growers won't commit to while production risks are not known or there is no financial support to underwrite potential risk.

We recommend initially that greater emphasis be placed on a smaller scale research phase that can make recommendations on the likely success of commercial development should it occur in the future. Research during this phase would focus on:

1. Assessing likely yield and quality, while accounting for climatic risk by validating / calibrating and then applying relevant models (e.g. OZCOT).
2. Compatibility with cane production issues.
3. Forecasting likely economic outcomes at farm and regional level.

This research **would not be dependent** on commercial scale trials run by a commercial partner, but instead would be **complimentary** to any such research. Industry collaborators and co-investors within this project would provide an optimal process for developing results and applying them within a future industry. Potential project partners and co-investors might include companies that might

have interests in a future Burdekin industry. These might include but not be limited to organisations such as Queensland Cotton, Monsanto, Cotton Seed Distributors, Deltapine, Sunwater, Cotton Australia and Cane Growers Australia.

The results from this type of project would have broader benefits beyond the context of the Burdekin region. Data collected will enhance basic knowledge of the effect of high night temperatures (respiration) and low radiation on fruit retention, fruit size, plant partitioning and yield of high retention (Bollgard) cotton. The 2005/6 southern cotton season asked many questions as to the effect of these climatic factors on yield and quality. Unfortunately because hot cloudy weather occurs erratically in southern Australia it is difficult to conduct a structured research program that can quantify the physiological consequences of such weather. This research at the Burdekin can provide an opportunity to reliably obtain some of this knowledge.

This research will also permit extrapolation of modelling analysis to nearby potential 'wet season' growing areas such as Collinsville, the upper Burdekin and Atherton / Mareeba.

Whilst registration is pending, we plan to utilise the interim period to develop a full R&D strategy for the above project outline and investigate opportunities for industry collaboration and co-investment with a view to commencing operations in the 2007/08 financial year.

Acknowledgements

We would like to acknowledge and thank the following people and organisations for their contributions to this project.

Mr Steve Hazelton for provision of a field site and access to his farming equipment for the 2006 experiment.

Mr Mark Hickman who helped organise and presented at the February 2005 grower training days.

Ms Kelly Mellor for her advice, assistance with checking field sites and organising consumables as well as helping to organise the 2006 grower meetings.

Mr John Marshall for assisting with the 2006 February meeting and CSD for the provision of trial seed.

Dr Joe Kochman and his technical staff who assisted with disease surveys.

2007 Burdekin Cotton Program

Addendum to Final Report CRC 1.1.14

Paul Grundy & Steve Yeates

Background

The approval of Monsanto's Bollgard II and Roundup Ready Flex traits in Northern Australia in late 2006 and Queensland's lack of moratoria on GM crops has now cleared the way for growers to begin making their own assessment of cotton in the Burdekin. Building on previous activity several growers indicated a desire to plant small areas of cotton (albeit at very short notice) for the 2007 season and Queensland Cotton, together with members from the Cotton Catchment Communities CRC, Monsanto, CSD and Deltapine stepped up to lend support to these efforts as part of a longer term strategy to begin assessing the feasibility of cotton in the Burdekin. This report is an Addendum to the Final Report for project 1.1.14 submitted in 1996. Remaining funds from this project were carried forward into 2007 to assist with the 2007 Burdekin cotton activity until such time as the new Burdekin Cotton project commenced on 1 July 2007. The purpose of these carry forward funds was to provide an extension program for local growers during the 2007 crop and to make preparations so that the new project could rapidly commence.

2007 Trial Plantings

The way was clear for planting this year on the 16th January when the Australian Veterinary Pesticides and Medicines Authority (APVMA) approved the resistance management strategy for northern Australia. This date proved later than initially anticipated and coincided with the start of the wet season. Despite wet conditions, 52ha of cotton were sown between 3 growers spanning Jan 17th – Feb 21st. The bulk of the area was planted to CSD's Sicot 80BF with a little 60BF and Deltapine's DP12BRF sown at one site. The plantings were subject to more than 400mm of rain during late January / early February with little apparent ill effect apart from precipitating early rank growth. Each of the crops demonstrated excellent vigour and commenced flowering in March.

The cotton emerges rapidly in the Burdekin with plants appearing within 4 days of watering up.

Graham Boulton a consultant from the Darling Downs provided agronomic advice for the 2007 season. For a number of years Graham has provided agronomic services to the region's horticultural crops during the winter months and as such was well placed to provide management advice for the three cotton crops. In terms of inputs much of this season has been flown somewhat blind with estimates of required inputs being based on experience from southern areas. Nutrition requirements for cotton on local soil types was largely unknown so a similar PKN approach as that used for local maize was generally applied. Weed control was achieved at some sites with the use of Stomp(R) at planting followed by 2-3 in-field applications of Roundup Ready® herbicide up until inter-row closure. Weeds mainly consisted of a range of barnyard grasses as well as black pigweed and vine species. Insecticide applications were required for mirids and aphids as well as silver leaf whitefly at one of the sites. Bollgard II provided good control of *Helicoverpa* throughout the season although limited survival was observed during April after a short period of extreme oviposition pressure. *Spodoptera litura* were prevalent in all crops during March and April and whilst causing no direct damage, are a pest of that will need to be considered going into the future from a resistance management perspective and will be the focus of project efforts in 2008.

2-4D boom contamination was a problem encountered this season which has proven to be a great lesson for local growers to learn on relatively small areas. One planting was very badly affected by 2-

4D through boom contamination and considered for abandonment but the grower, Lindsay Hall decided to continue growing the crop for experience sake.

One of the sites badly affected by 2-4D spray equipment contamination. Despite the large setback the crop grew on to yield over 2 bales/acre.

Climatically the crops experienced a much wetter than average start but entered March-May with relatively dry conditions and warm temperatures that were ideal for boll formation. The crops which were sown a month later than what is considered to be ideal then slowed considerably as cool wet conditions were encountered in June and July. North Qld experienced mean temperatures 3^{o}C below the long term average for June and July whist breaking all previous rainfall records with over 150mm in June compared to the long term average of 26mm. With the late plant, 2-4D damage, some nutritional difficulties, June rain, very cold winter temperatures (exacerbating the late start) and the relative inexperience of the three growers, the results for this season make it difficult to generalise about crop performance.

Rank growth which was a problem at one of the sites due to untimely rainfall and short term pix unavailability compound the impacts of unseasonable rain in June in terms of increasing the level of tight loch and boll rots. This was disappointing as up until the June rain this crop had shown considerable yield promise.

After a drawn out finish, picking was commenced during the third week in August. Yields were low with field averages varying between 1.3-2.5/acre. All quality parameters in terms of length, strength and colour were good with the exception of low micronaire which was largely due to the late plant resulting in the crop finishing during very cool winter conditions. Whilst obviously low, the yields need to be viewed in the context that most of this seasons limiting factors related to late planting, nutrition application difficulties, pix management, 2-4D contamination should be potentially preventable from the outset going into 2008.

Two weeks of wet weather that delivered over 6 inches of rain to the Burdekin in June broke all previous records (long term average is 26mm) and caused losses on an already very late finishing crops due to due to boll rots and tight loch.

Plant mapping sheds provided some context for the crop yields. Maps were made in two areas of Paul Villas's crop to compare the rank half of the field with the short portion and on Aaron Sanderson's crop who planted Sicot 80 and 60BRF. The importance of managing the crop canopy was highlighted in Paul's crop with the rank cotton growing >500mm taller for the similar number of nodes and having >20% fewer bolls due to rots and tight locking. The boll counts in Aaron's crop demonstrate that the crop did not reach its potential yield, due primarily to its very late plant and cold finish (Table 1).

Table 1. Mean Number of Bolls retained per metre, nodes and height for the short and rank cotton (cv at P. Villas and Sicot 60 & 80 at A. Sanderson's.

Treatment	FP1	FP2	FP3	Total Bolls/M	Nodes	Height (mm)
Villas Short	52.3	29.5	19.3	101	23.7	1049
Villas Rank	40.4	22.5	3.9	67	24.6	1519
Sanderson Sicot 60	48	18.7	10	76	17.8	814
Sanderson Sicot 80	46.8	21.1	9.9	78	19.5	985

Grower Extension

Given that the 2007 trials were always going to be on the back foot due to the unexpectedly late approval to plant, the trial sites were used for maximum advantage to educate local growers at monthly field days. Five field days were held in total and these events provided an opportunity for local growers to observe the various stages of production and get a feel for the inputs and crop management decisions that had been made along the way. These events have been increasingly well attended as interest in cotton has spread amongst the local grower community. After starting with a core group of about a dozen growers that have attended field days in previous years, numbers peaked at around 25 for the picking field day held on 10th August.

Numbers grew from the first field walk soon after planting to the picking field day was well attended by about 25 locals.

A Burdekin steering committee (NORCOM) was convened for the first time in May 2007 to discuss a pathway forward for coming seasons. Representation on the committee included Burdekin growers, Queensland Cotton, QDPI&F, CSIRO, Black Earth Cotton Co, Monsanto, CSD, Deltapine, CRDC, Cotton Australia, ACGRA and TIMS. This committee will provide guidance to the R&D program and proactively counter industry development issues. It was generally agreed during the first meeting that there are many agronomic unknowns and that local growers will need considerable support during a pre-commercial phase until the feasibility of cotton becomes clear. This will involve varied forms of assistance from the different industry stakeholders. Early indications from growers suggest up to 800ha of cotton may be planted in the 2008 season. NORCOM will meet in October to map a path for this seasons crop.

Conclusions

Whilst the 2007 yields were low, when placed into context that most of this seasons limiting factors related to late planting, nutrition application difficulties, pix management, 2-4D contamination there is significant room for improvement going forward into 2008. The extension program was effective in raising awareness on cotton production and this is evidenced by the rapid increase in interest from local growers heading into 2008. Firming estimates suggest that 14 growers will plant a combined total of 900 hectares of cotton for the coming season. 35 local growers have also now completed BG and RR accreditation in anticipation of trialling cotton at some future point. Another development has been the recent purchase of farms in the Burdekin by southern growers to grow

cotton and other crops. At this stage three farms have been purchased by growers originating from the Darling Downs. 500ha of the cotton likely to be grown in 2008 will rest between these 3 growers. The new Burdekin CRC funded project is underway and will play a pivotal role in assessing the feasibility of cotton production in the Burdekin in tandem with industry development efforts.