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Part 2 – Contact Details

Administrator: Lynda George

Organisation: Cotton Catchment Communities CRC

Postal Address:

Ph: Fx: E-mail:

Principal Researcher: Janine Powell

Organisation: Industry & Investment NSW

Postal Address: Locked Bag 1001, Narrabri, NSW, 2390

Ph: 02 6799 2469 Fx: E-mail:

janine.powell@industry.nsw.gov.au

Researcher 2:

Organisation:

Postal Address:

Ph: Fx: E-mail:

Other Staff & Collaborators – Please list

Signature of Research Provider Representative: _____

**ECONOMIC IMPACT BY THE CRC IN IPM
THE SILVERLEAF WHITEFLY
THOMAS WATSON**

Introduction and background

Cotton is Australia's the fifth largest rural industry, and generates about \$1.5 b in revenues because almost of the cotton (>98%) is exported. The Cotton Catchment Communities CRC aims to develop, deliver and apply world's best practice management to ensure the ongoing viability and competitiveness of Australia's industry. Recent changes in the global cotton market mean that much of the spinning capacity is now concentrated in China and SE Asia. This has created stronger demand for high quality cotton suitable for the high speed ring-spinning machinery used in the Chinese cotton mills. Australia enjoys a reputation as a producer of clean, high quality cotton, and indeed this delivers a premium to Australian growers. However, an insect pest, the silver leaf whitefly poses a significant challenge to this reputation, as it secretes a sticky substance, known as honey-dew which can contaminate cotton fibre. This creates problems when the cotton mills attempt to spin contaminated fibre, as the honeydew causes the cotton to stick to rollers and other machinery parts, requiring mill shutdown while the machinery is cleaned. This lost time is a significant financial burden to mills and they will avoid buying sticky cotton if possible – hence delivery of sticky cotton to mills can result in a bad reputation for the sources region, making the lint difficult to market and reducing prices.

A key focus for the Cotton CRC is developing integrated pest management systems to efficiently and effectively deal with cotton pests, which impose a major problem on the crop. As the silverleaf whitefly has become a key pest in Australia, and can cause significant damage to the cotton industry, this pest has been a target for research. This research has emphasised valid sampling strategies to estimate whitefly abundance, economic thresholds to indicate when populations require control to prevent the risk of sticky cotton and guidelines for the selection of products to manage the pest most cost effectively. These management strategies aim to reduce economic loss, and prevent whitefly from developing resistance to the insecticides used for their control. Although these practices are not perfect, they do provide the best rational and scientifically based management plans.

The aim of this report was to evaluate the economic value of the provision of these whitefly management guidelines in the industries response to the southerly movement of this pest.

The CRC

The Cotton Catchment Communities Cooperative Research Centre (Cotton CRC) aims to undertake a multi-disciplinary and cutting edge research program to develop and have cotton growers adopt world's best practice in environmental and catchment management. The Cotton CRC provides access to experience, expert knowledge, and alerts the industry to potential problems and their relative magnitude. Their research and management program advises and helps farmers in all aspects of cotton production across the breadth of the industry. One major region of their investment is

in IPM (integrated pest management), which is targeted to provide the best and most efficient practices in pest management. The primary aim of IPM is to be able to maintain effective management of pests. This is achieved through conservation of natural enemies, management of weed pest hosts, use of pest resistant varieties, use of cultural techniques such as destruction of ground dwelling pest stages by cultivation, use of more selective pesticides, effective sampling and rationally based pest thresholds for control.

The Cotton CRC has two key targets in the IPM area;

- At least 50% of ha adopting industry best practice as defined by BMP guidelines on recommended sampling and thresholds
- At least 50% of ha selecting chemistry to conserve beneficial insect populations using published IPM guidelines

The co-ordinated regional response of the CRC is aimed to minimise of the economic loss caused by pests, in this case, the silverleaf whitefly. The CRC has devised scientifically valid IPM management strategies to deal with this particular threat to the cotton industry.

Potential Economic Impacts of the CRC

The investment of the CRC into IPM strategies to manage whitefly has assisted in the minimisation of the economic loss by:

- Reducing pesticide usage
- Using softer option sprays, rather than harder options, to preserve beneficial insects, and help avoid additional control costs
- Avoiding the economic impacts on growers, resulting from sticky cotton (caused by the whitefly) and damage to the international reputation
- Avoiding chemical resistance via the implementation of resistance management plans

Principles of IPM

Integrated pest management (IPM) utilises a number of effective, practical and economical strategies, with an ecological approach to minimise economic losses, reduce pesticide use and protect public health and the environment. Rencken (2006, pg. iii) says that this management system aims to calculate if the cost of controlling the pest is above or below the deficit in the crops productivity. This is referred to as the economic threshold level (ETL). If the ETL is high, then the natural beneficials are more likely to maintain control over the pest and prevent insecticides from being initially used. In contrast, if the ETL is low, beneficials (predators and parasites) may not effectively keep pests below damaging levels, and the use of pesticides is more likely to be justified, though this also increases risks of environmental contamination, outbreaks of secondary pests due to destruction of the beneficial insects that would control them and increased risk of selecting for resistance.

In such a situation the use of selective pesticides that do not disrupt natural enemy populations, supplementation of natural enemy populations or pest resistant varieties may be valuable. For instance, depending on the result of the predators and parasites,

an Insect Growth Regulator (IGR) may have to be used in order to keep control. The IGR, pyriproxifen, targets whitefly and has little negative effect on beneficial populations. The Cotton Pest Management Guide (2009, pg. 19) recommends that it should be applied between 1450 and 1625 day degrees, if thresholds are exceeded. If an IGR is applied too early, the product efficacy may have declined by the time there is vulnerable open cotton, and may require further control, adding to the cost..

Maintaining beneficials is part of the 'soft' option spray strategy, and is achieved by reducing the number of sprays, and using the least disruptive sprays available (CRC, 2001). 'Hard' insecticides are often efficacious and cheap, as most are older and off patent, but they tend to destroy rather than preserving beneficial insects. The advantage of using soft sprays, instead of hard, is the economic savings made with using less sprays, and optimisation of control by natural enemies.

Utilising an effective and sound IPM strategy is essential in crop management, and economic stability. Since 2005 when the current CRC began, insecticide expenditure in the Australian cotton industry has dropped from \$65 million to \$9 million (86% decrease). Whilst much of these savings have been a result of the introduction of BT cotton, a portion could be attributed to the CRC's development and implementation of thresholds, precise sampling as well as the promotion of softer chemicals and the preservation of beneficial insects. Pests and insects will continue to be a major problem for farmers, as some are not controlled by Bt-cotton, such as mirids, mites, whitefly and aphids, but the combination of Bt-cotton and improved IPM strategies have made the cotton industry far more efficient and the crops easier to manage.

Table 1.1 Insecticide expenditure for the total cotton area and on a per ha basis from 1999 to 2007. Data from CCA Surveys

Insecticide expenditure	All cotton area	Per ha.
1999	\$ 263,122,496	\$ 524.93
2000	\$ 192,116,590	\$ 424.16
2001	\$ 225,851,199	\$ 453.18
2002	\$ 134,769,996	\$ 335.25
2003	\$ 51,550,274	\$ 238.41
2004	\$ 65,404,054	\$ 360.11
2005	\$ 48,838,685	\$ 155.32
2006	\$ 37,661,897	\$ 126.46
2007	\$ 9,218,286	\$ 58.57

Silverleaf Whitefly

The silverleaf whitefly (SLW) is a small-sized hemipteran insect. It poses a great threat to the cotton industry, due to the contamination they cause on the cotton. The SLW suck the sap from the plant, and excrete a sticky residue called honeydew, which is the main problem regarding the SLW. Even though the honeydew affects the plant itself, the main problem is during the spinning process. This residue sticks to the cotton fibres, and during the process, it also sticks to the machine, which then requires maintenance and cleaning. In short, the honeydew slows down the spinning process considerably, and this is why there is such a high discount rate on cotton with honeydew present.

Scientifically known as *Bemisia tabaci* B-biotype, they were first discovered in Australia in the early 1990s, and by the 2001/02 season, the SLW had managed to devastate crops in central Queensland, causing significant problems to the agricultural community in the Emerald and Theodore regions. In the following season, local researchers had devised a sufficient and comprehensive management plan to deal with the SLW, through adaptation of research outcomes and strategies from the USA (principally Arizona), which were applied on a district wide level, notes Kelly (2003, pg. 1). This new management plan dramatically reduced the infestation of the SLW, and hence produced an adequate harvest that season.

Since then it has been recognised that direct use of the USA developed methods was not optimal due to differences in the distribution of the whitefly and in their population development. This issue has been addressed by extensive local research led by Dr Richard Sequiera (DEEDI QPI&F and Cotton CRC). Dr Sequiera sampled the within plant and between plant distribution of whitefly and developed quick accurate binomial (presence/absence) sampling strategies. He also studied the population trajectories of whitefly populations over several years for populations that did or did not lead to honeydew contamination of lint. He linked this information with the sampling strategy to provide a simple yet sophisticated sample and threshold system, combined with insecticide choice guidelines to ensure effective control of problem population with the least use of insecticides. Much of this research, analysis and the final development of the management strategy was completed during the early years of the current CRC.

Since the initial outbreaks SLW in the CQ region have been managed well, initially using USA derived strategies and more recently using the locally derived strategies. Apart from the sampling, threshold and insecticide control guidelines the whitefly strategy also emphasised conservation of parasites/predators to delay the build up of SLW, avoiding early use of disruptive insecticides and good farm hygiene to avoid providing overwinter hosts for the whitefly to survive on from one cotton season to the next. Another key issue was limitation of the use of the IGR, pyriproxifen to one spray per season to avoid SLW developing resistance to it.

Management of mirids however challenges these strategies. Mirids cause damage to young squares and bolls and can if in sufficient numbers cause reduced yield. However, cotton will often compensate completely for mirid damage by retaining excess fruit that would otherwise have been shed. Nevertheless, the difficulty in sampling mirids accurately makes growers and consultants prone to controlling mirids at sub-thresholds as a risk avoidance strategy. This combined with the broad-spectrum activity of most mirid control sprays means that poor mirid management can reduce beneficial populations and risk promoting survival and rapid development of SLW populations.

Even though the problem has been addressed and measures have been taken to deal with honeydew, the SLW are still an ongoing management issue within the agricultural parts of Australia. Therefore, research is continuing to maintain and control the SLW, and to preserve the protection of crops and plants.

Affected regions and results

SLW first occurred as a problem in the CQ region in 2001/02. By 2005 the first outbreaks had begun to occur in the Darling Downs and St George regions. Whilst SLW was recorded in the Namoi and Gwydir regions in the mid 1990's, outbreaks were not recorded until the 2008-09 cotton season. Rapid dissemination of information to consultants and growers, alerting them to the risk with SLW and also the provision of management recommendations meant that the industry in these regions was able to control SLW and avoid significant contamination of lint. No cotton received penalties for stickiness. The current CRC can claim significant responsibility for avoiding loss (in terms of discounts for honeydew) in these regions due to the co-ordinated response regarding the SLW, and the steps taken to provide farmers with comprehensive management plans which were available due to the work of Dr Sequiera. Below I describe an approach to analyse the economic value of the contribution of the Cotton CRC in preventing discounted cotton and preventing insecticide resistance.

Over the last 10 years, the number of hectares in the Lower Namoi and Gwydir regions has averaged at 37,435 ha and 50,180 ha respectively. The current yield, expressed as bales per hectare (one bale = 227 kg of lint), for these areas has gradually increased over the years. For this reason, the calculations were devised from the 2009 season yield figures, as the yield is not expected to dramatically fall, because of advances in management and varieties (which have averaged about 20% increase per decade for the past three decades), though it is recognised that some seasons may be more or less favourable.

Scientists within the cotton industry (Wilson pers coms) estimate that without the Cotton CRC's co-ordinated response and management strategies approximately 35%

of the cotton lint in the Gwydir and Namoi regions would be significantly contaminated with SLW honeydew. Also based on estimates, in this analysis I have assumed that with Cotton CRC's involvement approximately only 5% of lint will be affected in only one in four years. On occasion, in regions with a longer history of SLW, honeydew levels have been non-existent, which scientists believe is a result from both climatic conditions that have reduced the build up of SLW numbers and timely rain that can break down the honeydew sugars on the lint. However, as it is still not practical to forecast accurately a good or bad SLW season farmers should not make assumptions and still implement appropriate management strategies.

Based on the estimates of area and likely contaminated proportion, without management, a total of 30,665 hectares would be affected in the two regions, which amounts to approximately 331,000 bales.

Table 2a: Economic loss due to Whitefly in the case of No CRC

Without CRC	Ha	%	Ha Affected
Lower Namoi	37,435	35% (1 in 4 years)	13,102
Gwydir	50,180	35% (1 in 4 years)	17,563
Total Ha Affected			30,665
Av Bales / Ha			10.8
\$/ Bale Discount			\$ 143.03
Total Affected Bale Discount			\$ 47,367,563.94

Table 2b: Economic loss due to Whitefly in the case of the CRC

With CRC	Ha	%	Ha Affected
Lower Namoi	37,435	5% (1 in 4 years)	1,872
Gwydir	50,180	5% (1 in 4 years)	2,509
Total Ha Affected			4,381
Av Bales / Ha			10.8
\$/ Bale Discount			\$ 143.03
Total Affected Bale Discount			\$ 6,766,794.85

Cotton merchants discount the buying price of cotton based on a number of contributing factors, one of them being the presence of honeydew residue on the cotton lint. In the 2008/09 season, the three major Australian merchants had an average honeydew discount rate of 2000 points, or 20 US cents per pound, which works out to AU\$143.03 per bale, using the average exchange rate over the past 10 years. It should be noted that if the honeydew levels are too extreme, then the merchants can negate the contract as the lint is worthless and would take too much time, effort and money to be cleaned.

With the above assumptions, it can be calculated that around \$47 million would be lost if 35% of the cotton was affected, and \$7 million if CRC management was utilised, with only 5% being affected. The annual economic impact of the CRC being \$40 million of discounts avoided, and an un-estimated additional value due to the preservation of the industry's reputation from non-sticky cotton. In present value terms, over the next 20 years the estimated benefit from using CRC management is \$117 million, which is only if the SLW is a major issue every 4 years, due to cycles within the pest populations and climatic conditions.

Resistance

Pesticide resistance is a major issue within the cotton industry. Generally speaking, it's the adaptation made by pests to certain pesticides, which means that the effects of these chemicals will no longer give the desired result, that is, effective control. Insecticide resistance is a selective process in which a minority of the pests are initially immune to the chemical, at the dose applied, and therefore they survive. Their later generations are then also immune to the chemical, making that particular chemical ineffective. Cotton growers should also be aware of the insecticide grouping, and refer to these chemical groups when applying insecticides, in order to prevent resistance. Pesticides are grouped into various 'mode of action' groups based on the mode by which they intoxicate the pest, so diversification is the key here to avoid pest resistance by choosing the range of chemicals from contrasting mode of action groups. The CRC provides and implements effective resistant management strategies for the cotton industry, which aims to prolong the effective life of insecticides and prevent or manage pest resistance.

The increase in use of pesticides also increases the chances of adaptation. For example, if one application of Admiral is used in the wrong way, which is, sprayed too early in the season, and the effects are minimal, the population of the pest will have sufficient time to rebuild and increase. If this population is then retreated with Admiral then there is a risk that the proportion of resistant individuals has been increased. A single application on the other hand means that there is a chance that the field may be re-invaded by 'non-selected' or susceptible SLW which will dilute any resistance from the Admiral spray.

To measure the economic impact of the thresholds and resulting resistance management plans developed and implemented by the Cotton CRC, we looked at a 'with' and 'without' scenario. In the 'without' scenario "we have to consider the next-best alternative, which is usually the use of some other treatment" (Jetter et al., 2001), namely Pegasus, which would require 2 to 3 applications per season to deliver equivalent efficacy as Admiral. This number of sprays however dramatically increases the risk of resistance developing in SLW to Pegasus, so then another insecticide has to be used, such as Shield or a pyrethroid, which aren't very effective at all, only giving a week's worth of control, requiring more applications for potentially less effective management. These major problems can be avoided simply by using Admiral in the right way, once a season and at the right time, which will control the pest, and avoid the advent of resistance.

There are two likely consequences that would arise from a hypothetical resistance to Admiral. The first being the introduction of a new chemical, which would take over as the keystone of effective control (Maas, 2009, pg. 11). Hypothetically, since Admiral had become ineffective, and the next best alternatives don't suffice, the market is now open for a new chemical, which would take advantage of the opportunity in SLW control. As supply is low, and demand is high, this product could be priced 20% higher than Admiral and have very high usage, and cotton growers would still purchase this new insecticide. In reality, Admiral would still be used, as the new product would most probably have a different chemical group to that of Admiral, and the two would cross-work with each other, that is the option for rotation, and reduced reliance on Admiral may return it's efficacy, providing the best practical solution to SLW.

The second scenario to consider is regarding the excessive use of Pegasus, after Admiral has become inadequate, which is also a major pesticide used for control of mites and aphids. Assuming the new chemical mentioned above does not address these pests, after Pegasus has been used liberally, these mites and aphids can become resistant to the chemical, and therefore pose a threat to yield. Scientists estimate that 15% of bales would be affected by these insects, which averages at a \$640 loss per hectare.

Putting these two 'next best' scenarios together, that is, the increase of costs associated with the different and new insecticides, and the yield loss related to the resistance of the mites and aphids from Pegasus, there would be a definite increase in costs estimated over the next 10 years. Using the average number of hectares in Australia over the past 10 years, and assuming that 15% of the total area had this problem, the final loss calculates to a net present value of \$146 million for the next 20 years, using the same assumptions about the frequency of outbreaks as used above. This indicates the potential losses that have been avoided by the cotton industry implementing sufficient resistant management, based on the CRC's proficient best management practices.

Conclusion

The CRC developed integrated pest management programs for SLW, for preventing honeydew contamination and avoiding pesticide resistance have been put into practice. My analysis very conservatively shows the benefit of using such practices. The overall net present value regarding avoiding economic loss from SLW and the avoided loss from the implementation of resistance management plans calculates to approximately \$263 million, for the next 20 years. If the SLW were a more frequent problem eg one in two years or even every year this value would increase accordingly, e.g. \$526m or \$1,052m. This doesn't include the value of protecting Australia's reputation for sticky cotton, which would add substantial extra value. These IPM targets are only a small fraction of the overall CRC goals, which includes comprehensive research and extension, across the entire cotton industry. These management strategies have been accepted and endorsed by farmers, merchants and scientists, and have become a standard in controlling pests, and preventing economic losses, and will continue to be in the future.

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Tables

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